POLYESTER COMPOSITIONS WHICH COMPRISE CYCLOBUTANEDIOL AND CERTAIN THERMAL STABILIZERS, AND/OR REACTION PRODUCTS THEREOF

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to: United States Provisional Application Serial No. 60/731,454 filed on October 28, 2005; United States Provisional Application Serial No. 60/731,389, filed on October 28, 2005; United States Provisional Application Serial No. 60/739,058, filed on November 22, 2005; United States Provisional Application Serial No. 60/738,869, filed on November 22, 2005; United States Provisional Application Serial No. 60/750,692 filed on December 15, 2005, United States Provisional Application Serial No. 60/750,693, filed on December 15, 2005, United States Provisional Application Serial No. 60/750,682, filed on December 15, 2005, and United States Provisional Application Serial No. 60/750,547, filed on December 15, 2005, United States Application Serial No. 11/390,672 filed on March 28, 2006; United States Application Serial No. 11/390,752 filed on March 28, 2006; United States Application Serial No. 11/390,794 filed on March 28, 2006; United States Application Serial No. 11/391,565 filed on March 28, 2006; United States Application Serial No. 11/390,671 filed on March 28, 2006; United States Application Serial No. 11/390,853 filed on March 28, 2006; United States Application Serial No. 11/390,631 filed on March 28, 2006; and United States Application Serial No. 11/390,655 filed on March 28, 2006; United States Application Serial No. 11/391,125 filed on March 28, 2006; United States Application Serial No. 11/390,751 filed March 28, 2006; United States Application Serial No. 11/390,955 filed March 28, 2006; United States Application Serial No. 11/390,827 filed March 28, 2006; United States Application Serial No. 60/786,572 filed March 28, 2006; United States Application Serial No. 60/786,596 filed March 28, 2006; United States Application Serial No. 60/786,547 filed March 28, 2006; United States Application Serial No. 60/786,571 filed March 28, 2006; United States Application Serial No. 60/786,598 filed March 28, 2006; United States

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FIELD OF THE INVENTION

[0002] The present invention generally relates to polyester compositions made from terephthalic acid, or an ester thereof, and mixtures thereof, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and cyclohexanedimethanol, and certain thermal stabilizers, reaction products thereof, and mixtures thereof, having a certain combination of two or more of high impact strengths, high glass transition temperature (T_g), toughness, certain inherent viscosities, low ductile-to-brittle transition temperatures, good color and clarity, low densities, chemical resistance, hydrolytic stability, and long crystallization half-times, which allow them to be easily formed into articles.

BACKGROUND OF THE INVENTION

[0003] Poly(1,4-cyclohexylenedimethylene) terephthalate (PCT), a polyester based solely on terephthalic acid or an ester thereof and cyclohexanedimethanol, is known in the art and is commercially available. This polyester crystallizes rapidly upon cooling from the melt, making it very difficult to form amorphous articles by methods known in the art such as extrusion, injection molding, and the like. In order to slow down the crystallization rate of PCT, copolyesters can be prepared containing additional dicarboxylic acids or glycols such as isophthalic acid or ethylene glycol residues. These ethylene glycol residues- or isophthalic acid-modified PCTs are also known in the art and are commercially available.

[0004] One common copolyester used to produce films, sheeting, and molded articles is made from terephthalic acid, 1,4-cyclohexanedimethanol, and ethylene glycol residues. While these copolyesters are useful in many end-use applications, they exhibit deficiencies in properties such as glass transition temperature and impact strength when sufficient modifying ethylene glycol residues is included in the formulation to provide for long crystallization half-times. For example, copolyesters made from terephthalic acid, 1,4-cyclohexanedimethanol, and ethylene glycol residues with sufficiently long crystallization half-times can provide amorphous products that exhibit what is

believed to be undesirably higher ductile-to-brittle transition temperatures and lower glass transition temperatures than the compositions revealed herein.

[0005] The polycarbonate of 4,4'-isopropylidenediphenol (bisphenol A polycarbonate) has been used as an alternative for polyesters known in the art and is a well known engineering molding plastic. Bisphenol A polycarbonate is a clear, high-performance plastic having good physical properties such as dimensional stability, high heat resistance, and good impact strength. Although bisphenol-A polycarbonate has many good physical properties, its relatively high melt viscosity leads to poor melt processability and the polycarbonate exhibits poor chemical resistance. It is also difficult to thermoform.

[0006] Polymers containing 2,2,4,4-tetramethyl-1,3-cyclobutanediol have also been generally described in the art. Generally, however, these polymers exhibit high inherent viscosities, high melt viscosities and/or high Tgs (glass transition temperatures or T_g) such that the equipment used in industry can be insufficient to manufacture or post polymerization process these materials.

[0007] Thus, there is a need in the art for comprising at least one polymer having a combination of two or more properties, chosen from at least one of the following: toughness, high glass transition temperatures, high impact strength, hydrolytic stability, chemical resistance, long crystallization half-times, low ductile to brittle transition temperatures, good color, and clarity, lower density and/or thermoformability of polyesters while achieving processability on the standard equipment used in the industry.

[0008] In addition, in one embodiment, there is a need in the art for a process which makes it easier to produce the polyesters of the inventions without at least one of the following occurring: bubbling, splay formation, color formation, foaming, off-gassing, and erratic melt levels, i.e., pulsating of the polyester or the polyester's production and processing systems. There is also a need in the art for a process which makes it easier to produce the polyesters of the invention in large quantities (for example, pilot run scale and/or commercial production) without at least one of the aforesaid difficulties occurring.

SUMMARY OF THE INVENTION

[0009] It is believed that certain polyester compositions formed from terephthalic acid, an ester thereof, and/or mixtures thereof, cyclohexanedimethanol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol comprising certain thermal stabilizers, reaction products thereof, and mixtures thereof, are superior to polyesters known in the art and to polycarbonate with respect to one or more of high impact strengths, hydrolytic stability, toughness, chemical resistance, good color and clarity, long crystallization half-times, low ductile to brittle transition temperatures, lower specific gravity, and thermoformability. These compositions are believed to be similar to polycarbonate in heat resistance and are more processable on the standard industry equipment. Also, these polyesters have enhanced thermal stability allowing for easier manufacture and enhanced downstream material processing.

[0010] In one embodiment, it is believed that when at least one thermal stabilizer comprising at least one phosphorus compound described herein are used during the processes of making the polyesters according to the present invention, the polyesters can be more easily produced without at least one of the following occurring: bubbling, splay formation, color formation, foaming, off-gassing, and erratic melt levels, i.e., pulsating of the polyester or the polyester's production and processing systems. In another embodiment, it is believed that at least one process of the invention provides a means to more easily produce the polyesters useful in the invention in large quantities (for example, pilot run scale and/or commercial production) without at least one of the aforesaid difficulties occurring.

[0011] The term "large quantities" as used herein includes quantities of polyester(s) useful in the invention which are produced in quantities larger than 100 pounds. In one embodiment, the term "large quantities, as used herein, includes quantities of polyester(s) useful in the invention which are produced in quantities larger than 1000 pounds.

[0012] In one aspect, the processes of making the polyesters useful in the invention can comprise a batch or continuous process.

[0013] In one aspect, the processes of making the polyesters useful in the invention comprise a continuous process.

[0014] In one aspect, the invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof.

[0015] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.10 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 200°C.

[0016] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt)phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C ; and wherein the polyester has a Tg from 85 to 200°C.

[0017] In one aspect, the invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85°C to 200°C.

[0018] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 200°C.

[0019] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 200°C.

[0020] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 55 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 45 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 85 to 200°C.

[0021] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 50 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 85 to 200°C.

[0022] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 45 to 55 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 45 to 55 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 85 to 200°C.

[0023] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(c) at least one branching agent or residues thereof; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt)phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C ; and wherein the polyester has a Tg from 85 to 200°C.

[0024] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 100 to 200°C.

[0025] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0026] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0027] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 55 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 45 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 110 to 200°C.

[0028] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 50 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 110 to 200°C.

[0029] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 45 to 55 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 45 to 55 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 110 to 200°C.

[0030] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0031] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.70 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0032] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0033] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(ii) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to less than 0.70 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the polyester has a Tg from 110 to 200°C.

[0034] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 200°C.

[0035] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 160°C.

[0036] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 150°C.

[0037] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 120 to 135°C.

[0038] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 120 to 135°C.

[0039] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(ii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0040] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(ii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0041] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(ii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.70 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0042] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.58 to 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0043] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.58 to less than 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0044] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.58 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0045] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.58 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0046] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0047] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to less than 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0048] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0049] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 130 to 145°C.

[0050] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 127°C to 200°C.

[0051] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 80 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 20 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 127°C to 200°C.

[0052] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from greater than 148°C up to 200°C.

[0053] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from greater than 148°C up to 200°C.

[0054] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 64.9 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35.1 to 60 mole % of cyclohexanedimethanol residues; and

(iii) 0.10 to less than 15 mole % a modifying glycol chosen from at least one of the following: ethylene glycol residues, propylene glycol, butanediol, and mixtures thereof; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 85 to 200°C.

[0055] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C;

wherein the polyester has a Tg from 85 to 200°C and

optionally, wherein one or more branching agents is added prior to or during the polymerization of the polymer.

[0056] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 64.9 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35.1 to 60 mole % of cyclohexanedimethanol residues; and

(iii) 0.01 to less than 15 mole % of a modifying glycol chosen from at least one of the following: ethylene glycol residues, propylene glycol, butanediol, and mixtures thereof; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g or less as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 110 to 200°C.

[0057] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C;

wherein the polyester has a Tg from 110 to 200°C; and

optionally, wherein one or more branching agents is added prior to or during the polymerization of the polymer.

[0058] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt)phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C;

wherein the polyester has a Tg from 110 to 200°C.

[0059] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 60 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt)phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C;

wherein the polyester has a Tg from 110 to 200°C.

[0060] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 40 to 64.9 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 35 to 59.9 mole % of cyclohexanedimethanol residues; and

(iii) 0.01 to less than 15 mole % of a modifying glycol chosen from at least one of the following: ethylene glycol residues, propylene glycol, butanediol, and mixtures thereof; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g or less as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 110 to 200°C.

[0061] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C;
wherein the polyester has a Tg from 110 to 200°C and
optionally, wherein one or more branching agents is added prior to or during the polymerization of the polymer.

[0062] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(c) at least one branching agent; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt)phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C ; and wherein the polyester has a Tg from 110 to 200°C.

[0063] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) greater than 40 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to less than 60 mole % of cyclohexanedimethanol residues;

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.10 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; wherein the polyester has a Tg from 85 to 200°C;

wherein if ethylene glycol residues is present in the glycol component, it is present in the polyester at less than 15 mole %.

[0064] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) from 10 to 100 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) up to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %.

[0065] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 100 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) up to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and wherein the amorphous polyester has a glass transition temperature (T_g) of greater than 120°C.

[0066] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.10 to less than 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 125°C.

[0067] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.10 to less than 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0068] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 125°C.

[0069] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0070] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0071] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95°C to 115°C.

[0072] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to less than 1 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95°C to 115°C.

[0073] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 125°C.

[0074] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 120°C.

[0075] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0076] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0077] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity is from 0.50 to 0.8 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0078] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0079] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 100 to 120°C.

[0080] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 100 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0081] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[0082] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[0083] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[0084] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 125°C.

[0085] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0086] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.60 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0087] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.65 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0088] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.68 to 0.78 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

[0089] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 0.8 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0090] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.8 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 120°C. In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0091] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0092] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0093] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 17 to 28 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 72 to 83 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.65 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.
In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0094] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 17 to 28 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 72 to 83 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.65 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 100 to 120°C.
In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0095] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 17 to 28 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 72 to 83 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.7 to 0.8 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85 to 120°C.

In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0096] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 17 to 28 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 72 to 83 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.7 to 0.8 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 100 to 120°C.

In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0097] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 17 to 28 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 72 to 83 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.65 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 100 to 115°C.
In one embodiment, the Tg of the polyester is from 100 to 120°C.

[0098] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 5 to less than 50 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) greater than 50 to 95 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[0099] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 10 to 30 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 70 to 90 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[00100] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[00101] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 15 to 25 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 75 to 85 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 95 to 115°C.

[00102] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) optionally, cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00103] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 4.5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

iii) optionally, cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00104] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 4 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) optionally, cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00105] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 3 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00106] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 2.0 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) optionally, cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00107] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00108] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to110°C.

[00109] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 15 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00110] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 15 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 70 to 99.98 mole % ethylene glycol residues, and

(iii) 0.01 to 15 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00111] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 10 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00112] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 10 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 80 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 10 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00113] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00114] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 90 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00115] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 4.5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00116] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 4 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00117] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 3 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00118] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 2.0 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof; and

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00119] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00120] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) ethylene glycol residues, and

(iii) cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00121] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 90 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00122] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) greater than 90 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00123] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 4 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 91 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00124] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 3 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 92 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00125] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 2 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 93 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00126] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 94 to 99.98 mole % of ethylene glycol residues, and

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00127] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 0.01 to less than 1 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) greater than 94 to 99.98 mole % of ethylene glycol

(iii) 0.01 to 5 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 60 to 110°C.

[00128] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00129] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00130] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00131] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00132] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00133] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00134] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00135] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00136] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00137] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00138] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to .72 dL/g determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00139] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to .72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00140] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00141] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00142] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00143] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00144] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00145] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00146] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00147] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00148] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00149] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00150] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg

[00151] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00152] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 25 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00153] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00154] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00155] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00156] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.7 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00157] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00158] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.682 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00159] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00160] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00161] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 28 to 38 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 62 to 72 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00162] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00163] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 75 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00164] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00165] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00166] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00167] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00168] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00169] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00170] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00171] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00172] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00173] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00174] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00175] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 128 to 130°C.

[00176] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00177] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00178] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 35 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 65 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00179] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00180] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00181] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00182] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00183] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the polyester has a Tg from 110 to 126°C.

[00184] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00185] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.5 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00186] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00187] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00188] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00189] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00190] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 120°C.

[00191] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 130°C.

[00192] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 128°C.

[00193] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 126°C.

[00194] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110 to 123°C.

[00195] In one aspect, this invention relates to a polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 30 to 40 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues;

(ii) 60 to 70 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.6 to 0.68 dL/g as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the polyester has a Tg from 110 to 120°C.

[00196] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of:

(i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00197] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of: (i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00198] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of: (i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of a final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00199] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00200] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of:

(i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal

stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 250°C to 305°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00201] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of:

(i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 250°C to 305°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the final polyester has a Tg from 85 to 200°C.

[00202] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 250°C to 305°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the final polyester has a Tg from 85 to 200°C.

[00203] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 250°C to 305°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00204] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of: (i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00205] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of:

(i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal

stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof; to form a polyester; and

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the final polyester has a Tg from 85 to 200°C.

[00206] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof; to form a polyester; and

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25ºC; and wherein the final polyester has a Tg from 85 to 200°C.

[00207] In one aspect, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.05-1.15/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof; to form a polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

[00208] In one aspect, the polyesters useful in the invention can comprise at least one phosphate ester whether or not present as a thermal stabilizer.

[00209] In one aspect, the polyesters useful in the invention can comprise at least one phosphate ester described herein which is present as a thermal stabilizer.

[00210] In one aspect, the polyesters and/or polyester compositions useful in the invention can comprise phosphorus atoms.

[00211] In one aspect, the polyesters and/or polyester compositions useful in the invention can comprise tin atoms.

[00212] In one aspect, the polyester compositions of the invention contain at least one polycarbonate.

[00213] In one aspect, the polyester compositions of the invention contain no polycarbonate.

[00214] In one aspect, the polyesters useful in the invention contain less than 15 mole % ethylene glycol residues, such as, for example, 0.01 to less than 15 mole % ethylene glycol residues.

[00215] In one aspect, the polyesters useful in the invention contain ethylene glycol residues.

[00216] In one aspect, the polyesters useful in the invention contain no ethylene glycol residues.

[00217] In one aspect, the polyesters useful in the invention contain 50 to 99.99 mole % ethylene glycol residues.

[00218] In one aspect, the polyesters useful in the invention contain no branching agent, or alternatively, at least one branching agent is added either prior to or during polymerization of the polyester.

[00219] In one aspect, the polyesters useful in the invention contain at least one branching agent without regard to the method or sequence in which it is added.

[00220] In one aspect, the polyesters useful in the invention are made from no 1, 3-propanediol, or, 1, 4-butanediol, either singly or in combination. In other aspects, 1,3-propanediol or 1, 4-butanediol, either singly or in combination, may be used in the making of the polyesters useful in this invention.

[00221] In one aspect of the invention, the mole % of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol useful in certain polyesters useful in the invention is greater than 50 mole % or greater than 55 mole % of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol or greater than 70 mole % of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol; wherein the total mole percentage of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol and trans-2,2,4,4-tetramethyl-1,3-cyclobutanediol is equal to a total of 100 mole %.

[00222] In one aspect of the invention, the mole % of the isomers of 2,2,4,4-tetramethyl-1,3-cyclobutanediol useful in certain polyesters useful in the invention is from 30 to 70 mole % of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol or from 30 to 70 mole % of trans-2,2,4,4-tetramethyl-1,3-cyclobutanediol, or from 40 to 60 mole % of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol or from 40 to 60 mole % of trans-2,2,4,4-tetramethyl-1,3-cyclobutanediol, wherein the total mole percentage of cis-2,2,4,4-tetramethyl-1,3-cyclobutanediol and trans-2,2,4,4-tetramethyl-1,3-cyclobutanediol is equal to a total of 100 mole %.

[00223] In one aspect, certain polyesters useful in the invention may be amorphous or semicrystalline. In one aspect, certain polyesters useful in the invention can have a relatively low crystallinity. Certain polyesters useful in the invention can thus have a substantially amorphous morphology, meaning that the polyesters comprise substantially unordered regions of polymer.

[00224] In one aspect, the polyesters useful in the invention can comprise at least one thermal stabilizer which comprises at least one phosphorus compound.

[00225] In one aspect, the polyesters useful in the invention can comprise phosphorus atoms and tin atoms.

[00226] In one aspect, any of the polyester compositions of the invention may comprise at least one tin compound and at least one titanium compound.

[00227] In one aspect, any of the processes of making the polyesters useful in the invention may be prepared using at least one tin compound and at least one titanium compound.

[00228] In one aspect, the phosphorus compounds useful in the invention comprise phosphoric acid, phosphorous acid, phosphonic acid, phosphinic acid, phosphonous acid, and various esters and salts thereof. The esters can be alkyl, branched alkyl, substituted alkyl, difunctional alkyl, alkyl ethers, aryl, and substituted aryl.

[00229] In one aspect, the phosphorus compounds useful in the invention comprise at least one thermal stabilizer chosen from at least one of substituted or unsubstituted alkyl phosphate esters, substituted or unsubstituted aryl phosphate esters, substituted or unsubstituted mixed alkyl aryl phosphate esters, diphosphites, salts of phosphoric acid, phosphine oxides, and mixed alkyl aryl

phosphites, reaction products thereof, and mixtures thereof. The phosphate esters include esters in which the phosphoric acid is fully esterified or only partially esterified.

[00230] In one aspect, the phosphorus compounds useful in the invention comprise at least one thermal stabilizer chosen from at least one of substituted or unsubstituted alkyl phosphate esters, substituted or unsubstituted aryl phosphate esters, mixed substituted or unsubstituted alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof. The phosphate esters include esters in which the phosphoric acid is fully esterified or only partially esterified.

[00231] In one aspect, the phosphorus compounds useful in the invention are chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products, thereof, and mixtures thereof.

[00232] In one aspect, any of the polyester compositions of the invention may comprise at least one aryl phosphate ester.

[00233] In one aspect, any of the polyester compositions of the invention may comprise at least one unsubstituted aryl phosphate ester.

[00234] In one aspect, any of the polyester compositions of the invention may comprise at least one aryl phosphate ester which is not substituted with benzyl groups.

[00235] In one aspect, any of the polyester compositions of the invention may comprise at least one triaryl phosphate ester.

[00236] In one aspect, any of the polyester compositions of the invention may comprise at least one triaryl phosphate ester which is not substituted with benzyl groups.

[00237] In one aspect, any of the polyester compositions of the invention may comprise at least one alkyl phosphate ester.

[00238] In one aspect, any of the polyester compositions of the invention may comprise triphenyl phosphate and/or Merpol A. In one embodiment, any of the polyester compositions of the invention may comprise triphenyl phosphate.

In one aspect, any of processes described herein for making the polyester compositions and/or polyesters comprise at least one of the phosphorus compounds described herein.

[00239] It is believed that any of the processes of making the polyesters useful in the invention may be used to make any of the polyesters useful in the invention.

[00240] In one aspect, the pressure used in Step (I) of any of the processes of the invention consists of at least one pressure chosen from 0 psig to 75 psig. In one embodiment, the pressure used I Step (I) of any of the processes of the invention consists of at least one pressure chosen from 0 psig to 75 psig.

[00241] In one aspect, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 20 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 10 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 5 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 3 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 20 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 10 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 5 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 3 torr absolute to 0.1 torr absolute.

[00242] In one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.0-1.5/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.5/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.3/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid

component added in Step (I) of any of the processes of the invention is 1.01-1.2/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.15/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.10/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.5/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.3/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.2/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.15/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.10/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.5/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.3/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.2/1.0; in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.15/1.0; and in one aspect, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.10/1.0.

[00243] In any of the process embodiments for making the polyesters useful in the invention, the heating time of Step (II) may be from 1 to 5 hours. In any of the process embodiments for making the polyesters useful in the invention, the heating time of Step (II) may be from 1 to 4 hours. In any of the process embodiments for making the polyesters useful in the invention, the heating time of Step (II) may be from 1 to 3 hours. In any of the process embodiments for

making the polyesters useful in the invention, the heating time of Step (II) may be from 1.5 to 3 hours. In any of the process embodiments for making the polyesters useful in the invention, the heating time of Step (II) may be from 1 to 2 hours.

[00244] In another aspect, any of the polyester compositions and/or processes of the invention may comprise at least one tin compound as described herein.

[00245] In one aspect, any of the polyester compositions and/or processes of the invention may comprise at least one tin compound and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide.

[00246] In one embodiment, any of the polyester compositions and/or processes of making the polyesters useful in the invention may be prepared using at least one tin compound and at least one catalyst chosen from titanium compound as catalysts.

[00247] In one embodiment, the addition of the phosphorus compound(s) in the process(es) of the invention can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 2-10:1. In one embodiment, the addition of the phosphorus compound(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 5-9:1. In one embodiment, the addition of the phosphorus compound(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 6-8:1. In one embodiment, the addition of the phosphorus compound(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 7:1. For example, the weight of tin atoms and phosphorus atoms present in the final polyester can be measured in ppm and can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of any of the aforesaid weight ratios.

[00248] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 15 to 400 ppm tin atoms based on the weight of the final polyester.

[00249] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

[00250] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

[00251] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

[00252] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester.

[00253] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester.

[00254] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester.

[00255] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 15 to 400 ppm tin atoms based on the weight of the final polyester.

[00256] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

[00257] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final

polyester can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

[00258] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

[00259] In one aspect, any of the processes described herein for making any of the polyester compositions and/or polyesters can comprise in addition to at least one phosphate ester at least one mixed alkyl aryl phosphite, such as, for example, bis(2,4-dicumylphenyl)pentaerythritol diphosphite also known as Doverphos S-9228 (Dover Chemicals, CAS# 154862-43-8).

[00260] In one aspect, any of the processes described herein for making any of the polyester compositions and/or polyesters can comprise in addition to at least one phosphate ester, at least one one phosphine oxide.

[00261] In one aspect, any of the processes described herein for making any of the polyester compositions and/or polyesters can comprise in addition to at least one phosphate ester, at least one salt of phosphoric acid such as, for example, KH_2PO_4 and $Zn_3(PO_4)_2$.

[00262] In one aspect, the polyester compositions are useful in articles of manufacture including, but not limited to, extruded, calendered, and/or molded articles including, but not limited to, injection molded articles, extruded articles, cast extrusion articles, profile extrusion articles, melt spun articles, thermoformed articles, extrusion molded articles, injection blow molded articles, injection stretch blow molded articles, extrusion blow molded articles and extrusion stretch blow molded articles. These articles can include, but are not limited to, films, bottles, containers, sheet and/or fibers.

[00263] In one aspect, the polyester compositions useful in the invention may be used in various types of film and/or sheet, including but not limited to extruded film(s) and/or sheet(s), calendered film(s) and/or sheet(s), compression molded film(s) and/or sheet(s), solution casted film(s) and/or sheet(s). Methods of

making film and/or sheet include but are not limited to extrusion, calendering, compression molding, and solution casting.

[00264] Also, in one aspect, use of these particular polyester compositions minimizes and/or eliminates the drying step prior to melt processing and/or thermoforming.

BRIEF DESCRIPTION OF THE DRAWINGS

[00265] Figure 1 is a graph showing the effect of comonomer on the fastest crystallization half-times of modified PCT copolyesters.

[00266] Figure 2 is a graph showing the effect of comonomer on the brittle-to-ductile transition temperature (T_{bd}) in a notched Izod impact strength test (ASTM D256, 1/8-in thick, 10-mil notch).

[00267] Figure 3 is a graph showing the effect of 2,2,4,4-tetramethyl-1,3-cyclobutanediol composition on the glass transition temperature (Tg) of the copolyester.

DETAILED DESCRIPTION OF THE INVENTION

[00268] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention and the working examples. In accordance with the purpose(s) of this invention, certain embodiments of the invention are described in the Summary of the Invention and are further described herein below. Also, other embodiments of the invention are described herein.

[00269] It is believed that polyesters and/or polyester composition(s) of the invention can have a unique combination of two or more physical properties such as moderate or high impact strengths, high glass transition temperatures, chemical resistance, hydrolytic stability, toughness, low ductile-to-brittle transition temperatures, good color and clarity, low densities, and long crystallization half-times, and good processability thereby easily permitting them to be formed into articles. In some of the embodiments of the invention, the polyesters have a unique combination of the properties of good impact strength, heat resistance,

chemical resistance, density and/or the combination of the properties of good impact strength, heat resistance, and processability and/or the combination of two or more of the described properties, that have never before been believed to be present in the polyester compositions useful in the invention which comprise the polyester(s) as disclosed herein.

[00270] In one embodiment, it is believed that when at least one thermal stabilizer comprising at least one phosphorus compound described herein are used during the processes of making the polyesters according to the present invention, the polyesters can be more easily produced without at least one of the following occurring: bubbling, splay formation, color formation, foaming, off-gassing, and erratic melt levels, i.e., pulsating of the polyester or the polyester's production and processing systems. In another embodiment, it is believed that at least one process of the invention provides a means to more easily produce the polyesters useful in the invention in large quantities (for example, pilot run scale and/or commercial production) without at least one of the aforesaid difficulties occurring.

[00271] The term "large quantities" as used herein includes quantities of polyester(s) useful in the invention which are produced in quantities larger than 100 pounds. In one embodiment, the term "large quantities, as used herein, includes quantities of polyester(s) useful in the invention which are produced in quantities larger than 1000 pounds.

[00272] In one embodiment, the processes of making the polyesters useful in the invention can comprise a batch or continuous process.

[00273] In one embodiment, the processes of making the polyesters useful in the invention comprise a continuous process.

[00274] When tin is added to to the polyesters and/or polyester compositions and/or process of making the polyesters of the invention, it is added to the process of making the polyester in the form of a tin compound. The amount of the tin compound added to the polyesters of the invention and/or polyester compositions of the invention and/or processes of the invention can be measured in the form of tin atoms present in the final polyester, for example, by weight measured in ppm

[00275] When phosphorus is added to to the polyesters and/or polyester compositions and/or process of making the polyesters of the invention, it is added to the process of making the polyester in the form of a phosphorus compound. In one embodiment, this phosphorus compound can comprise at least one phosphate ester(s). The amount of phosphorus compound, [for example, phosphate ester(s)] added to the polyesters of the invention and/or polyester compositions of the invention and/or processes of the invention can be measured in the form of phosphorus atoms present in the final polyester, for example, by weight measured in ppm.

[00276] The term "polyester", as used herein, is intended to include "copolyesters" and is understood to mean a synthetic polymer prepared by the reaction of one or more difunctional carboxylic acids and/or multifunctional carboxylic acids with one or more difunctional hydroxyl compounds and/or multifunctional hydroxyl compounds, for example, branching agents. Typically the difunctional carboxylic acid can be a dicarboxylic acid and the difunctional hydroxyl compound can be a dihydric alcohol such as, for example, glycols and diols. The term "glycol" as used herein includes, but is not limited to, diols, glycols, and/or multifunctional hydroxyl compounds, for example, branching agents. Alternatively, the difunctional carboxylic acid may be a hydroxy carboxylic acid such as, for example, p-hydroxybenzoic acid, and the difunctional hydroxyl compound may be an aromatic nucleus bearing 2 hydroxyl substituents such as, for example, hydroquinone. The term "residue", as used herein, means any organic structure incorporated into a polymer through a polycondensation and/or an esterification reaction from the corresponding monomer. The term "repeating unit", as used herein, means an organic structure having a dicarboxylic acid residue and a diol residue bonded through a carbonyloxy group. Thus, for example, the dicarboxylic acid residues may be derived from a dicarboxylic acid monomer or its associated acid halides, esters, salts, anhydrides, and/or mixtures thereof. Furthermore, as used herein, the term "diacid" includes multifunctional acids, for example, branching agents. As used herein, therefore, the term "dicarboxylic acid" is intended to include dicarboxylic acids and any derivative of a dicarboxylic acid, including its associated acid halides, esters, half-esters, salts,

half-salts, anhydrides, mixed anhydrides, and/or mixtures thereof, useful in a reaction process with a diol to make polyester. As used herein, the term "terephthalic acid" is intended to include terephthalic acid itself and residues thereof as well as any derivative of terephthalic acid, including its associated acid halides, esters, half-esters, salts, half-salts, anhydrides, mixed anhydrides, and/or mixtures thereof or residues thereof useful in a reaction process with a diol to make polyester.

[00277] The polyesters used in the present invention typically can be prepared from dicarboxylic acids and diols which react in substantially equal proportions and are incorporated into the polyester polymer as their corresponding residues. The polyesters of the present invention, therefore, can contain substantially equal molar proportions of acid residues (100 mole%) and diol (and/or multifunctional hydroxyl compound) residues (100 mole%) such that the total moles of repeating units is equal to 100 mole%. The mole percentages provided in the present disclosure, therefore, may be based on the total moles of acid residues, the total moles of diol residues, or the total moles of repeating units. For example, a polyester containing 30 mole% isophthalic acid, based on the total acid residues, means the polyester contains 30 mole% isophthalic acid residues out of a total of 100 mole% acid residues. Thus, there are 30 moles of isophthalic acid residues among every 100 moles of acid residues. In another example, a polyester containing 30 mole% 2,2,4,4-tetramethyl-1,3-cyclobutanediol, based on the total diol residues, means the polyester contains 30 mole% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues out of a total of 100 mole% diol residues. Thus, there are 30 moles of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues among every 100 moles of diol residues.

[00278] In other aspects of the invention, the Tg of the polyesters useful in the polyester compositions of the invention can be at least one of the following ranges: 60 to 200°C; 60 to 190°C; 60 to 180°C; 60 to 170°C; 60 to 160°C; 60 to 155°C; 60 to 150°C; 60 to 145°C; 60 to 140°C; 60 to 138°C; 60 to 135°C; 60 to 130°C; 60 to 125°C; 60 to 120°C; 60 to 115°C; 60 to 110°C; 60 to 105°C; 60 to 100°C; 60 to 95°C; 60 to 90°C; 60 to 85°C; 60 to 80°C; 60 to 75°C; 65 to 200°C; 65 to 190°C; 65 to 180°C; 65 to 170°C; 65 to 160°C; 65 to 155°C; 65 to 150°C;

65 to 145°C; 65 to 140°C; 65 to 138°C; 65 to 135°C; 65 to 130°C; 65 to 125°C; 65 to 120°C; 65 to 115°C; 65 to 110°C; 65 to 105°C; 65 to 100°C; 65 to 95°C; 65 to 90°C; 65 to 85°C; 65 to 80°C; 65 to 75°C; 70 to 200°C; 70 to 190°C; 70 to 180°C; 70 to 170°C; 70 to 160°C; 70 to 155°C; 70 to 150°C; 70 to 145°C; 70 to 140°C; 70 to 138°C; 70 to 135°C; 70 to 130°C; 70 to 125°C; 70 to 120°C; 70 to 115°C; 70 to 110°C; 70 to 105°C; 70 to 100°C; 70 to 95°C; 70 to 90°C; 70 to 85°C; 70 to 80°C; 70 to 75°C; 75 to 200°C; 75 to 190°C; 75 to 180°C; 75 to 170°C; 75 to 160°C; 75 to 155°C; 75 to 150°C; 75 to 145°C; 75 to 140°C; 75 to 138°C; 75 to 135°C; 75 to 130°C; 75 to 125°C; 75 to 120°C; 75 to 115°C; 75 to 110°C; 75 to 105°C; 75 to 100°C; 75 to 95°C; 75 to 90°C; 75 to 85°C; 75 to 80°C; 80 to 200°C; 80 to 190°C; 80 to 180°C; 80 to 170°C; 80 to 160°C; 80 to 155°C; 80 to 150°C; 80 to 145°C; 80 to 140°C; 80 to 138°C; 80 to 135°C; 80 to 130°C; 80 to 125°C; 80 to 120°C; 80 to 115°C; 80 to 110°C; 80 to 105°C; 80 to 100°C; 80 to 95°C; 80 to 90°C; 80 to 85°C; 85 to 200°C; 85 to 190°C; 85 to 180°C; 85 to 170°C; 85 to 160°C; 85 to 155°C; 85 to 150°C; 85 to 145°C; 85 to 140°C; 85 to 138°C; 85 to 135°C; 85 to 130°C; 85 to 125°C; 85 to 120°C; 85 to 115°C; 85 to 110°C; 85 to 105°C; 85 to 100°C; 85 to 95°C; 85 to 90°C; 90 to 200°C; 90 to 190°C; 90 to 180°C; 90 to 170°C; 90 to 160°C; 90 to 155°C; 90 to 150°C; 90 to 145°C; 90 to 140°C; 90 to 138°C; 90 to 135°C; 90 to 130°C; 90 to 125°C; 90 to 120°C; 90 to 115°C; 90 to 110°C; 90 to 105°C; 90 to 100°C; 90 to 95°C; 95 to 200°C; 95 to 190°C; 95 to 180°C; 95 to 170°C; 95 to 160°C; 95 to 155°C; 95 to 150°C; 95 to 145°C; 95 to 140°C; 95 to 138°C; 95 to 135°C; 95 to 130°C; 95 to 125°C; 95 to 120°C; 95 to 115°C; 95 to 110°C; 95 to 105°C; 95 to 100°C; 100 to 200°C; 100 to 190°C; 100 to 180°C; 100 to 170°C; 100 to 160°C; 100 to 155°C; 100 to 150°C; 100 to 145°C; 100 to 140°C; 100 to 138°C; 100 to 135°C; 100 to 130°C; 100 to 125°C; 100 to 120°C; 100 to 115°C; 100 to 110°C; 105 to 200°C; 105 to 190°C; 105 to 180°C; 105 to 170°C; 105 to 160°C; 105 to 155°C; 105 to 150°C; 105 to 145°C; 105 to 140°C; 105 to 138°C; 105 to 135°C; 105 to 130°C; 105 to 125°C; 105 to 120°C; 105 to 115°C; 105 to 110°C; 110 to 200°C; 110 to 190°C; 110 to 180°C; 110 to 170°C; 110 to 160°C; 110 to 155°C; 110 to 150°C; 110 to 145°C; 110 to 140°C; 110 to 138°C; 110 to 135°C; 110 to 130°C; 110 to 125°C; 110 to 120°C; 110 to 115°C; 115 to 200°C; 115 to 190°C; 115 to 180°C;

115 to 170°C; 115 to 160°C; 115 to 155°C; 115 to 150°C; 115 to 145°C; 115 to 140°C; 115 to 138°C; 115 to 135°C; 110 to 130°C; 115 to 125°C; 115 to 120°C; 120 to 200°C; 120 to 190°C; 120 to 180°C; 120 to 170°C; 120 to 160°C; 120 to 155°C; 120 to 150°C; 120 to 145°C; 120 to 140°C; 120 to 138°C; 120 to 135°C; 120 to 130°C; 125 to 200°C; 125 to 190°C; 125 to 180°C; 125 to 170°C; 125 to 165°C; 125 to 160°C; 125 to 155°C; 125 to 150°C; 125 to 145°C; 125 to 140°C; 125 to 138°C; 125 to 135°C; 127 to 200°C; 127 to 190°C; 127 to 180°C; 127 to 170°C; 127 to 160°C; 127 to 150°C; 127 to 145°C; 127 to 140°C; 127 to 138°C; 127 to 135°C; 130 to 200°C; 130 to 190°C; 130 to 180°C; 130 to 170°C; 130 to 160°C; 130 to 155°C; 130 to 150°C; 130 to 145°C; 130 to 140°C; 130 to 138°C; 130 to 135°C; 135 to 200°C; 135 to 190°C; 135 to 180°C; 135 to 170°C; 135 to 160°C; 135 to 155°C; 135 to 150°C; 135 to 145°C; 135 to 140°C; 140 to 200°C; 140 to 190°C; 140 to 180°C; 140 to 170°C; 140 to 160°C; 140 to 155°C; 140 to 150°C; 140 to 145°C; 148 to 200°C; 148 to 190°C; 148 to 180°C; 148 to 170°C; 148 to 160°C; 148 to 155°C; 148 to 150°C; greater than 148 to 200°C; greater than 148 to 190°C; greater than 148 to 180°C; greater than 148 to 170°C; greater than 148 to 160°C; greater than 148 to 155°C; 150 to 200°C; 150 to 190°C; 150 to 180°C; 150 to 170°C; 150 to 160; 155 to 190°C; 155 to 180°C; 155 to 170°C; and 155 to 165°C.

[00279] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 1 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 99 mole % cyclohexanedimethanol; 1 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 99 mole % cyclohexanedimethanol; 1 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 99 mole % cyclohexanedimethanol; 1 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 99 mole % cyclohexanedimethanol; 1 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 99 mole % cyclohexanedimethanol, 1 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 99 mole % cyclohexanedimethanol; 1 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 99 mole % cyclohexanedimethanol; 1 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 99 mole %

cyclohexanedimethanol; 1 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 99 mole % cyclohexanedimethanol; 1 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 99 mole % cyclohexanedimethanol; 1 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 99 mole % cyclohexanedimethanol; 1 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 99 mole % cyclohexanedimethanol; 1 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 99 mole % cyclohexanedimethanol; 1 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 99 mole % cyclohexanedimethanol; 1 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 99 mole % cyclohexanedimethanol; 1 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 99 mole % cyclohexanedimethanol; 1 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 99 mole % cyclohexanedimethanol; 1 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 99 mole % cyclohexanedimethanol; 1 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 99 mole % cyclohexanedimethanol; and 1 to 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95 to 99 mole % cyclohexanedimethanol.

[00280] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 3 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 97 mole % cyclohexanedimethanol; 3 to 9 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 91 to 97 mole % cyclohexanedimethanol; and 3 to 8 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 92 to 97 mole % cyclohexanedimethanol.

[00281] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 5 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 95 mole % cyclohexanedimethanol; 5 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 95 mole % cyclohexanedimethanol; 5 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 95 mole % cyclohexanedimethanol; 5 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 95 mole % cyclohexanedimethanol; 5 to 80 mole %

2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 95 mole % cyclohexanedimethanol, 5 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 95 mole % cyclohexanedimethanol; 5 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 95 mole % cyclohexanedimethanol; 5 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 95 mole % cyclohexanedimethanol; 5 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 95 mole % cyclohexanedimethanol; 5 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 95 mole % cyclohexanedimethanol; and 5 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 95 mole % cyclohexanedimethanol.

[00282] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 5 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 95 mole % cyclohexanedimethanol; 5 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 95 mole % cyclohexanedimethanol; 5 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 95 mole % cyclohexanedimethanol; 5 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 95 mole % cyclohexanedimethanol; 5 to less than 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 65 to 95 mole % cyclohexanedimethanol; 5 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 95 mole % cyclohexanedimethanol; 5 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 95 mole % cyclohexanedimethanol; 5 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 95 mole % cyclohexanedimethanol ; 5 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 95 mole % cyclohexanedimethanol; 5 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 95 mole % cyclohexanedimethanol; greater than 5 to less than 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and less than 90 to greater than 95 mole % cyclohexanedimethanol; 5.5 mole % to 9.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 94.5 mole % to 90.5 mole % cyclohexanedimethanol; and 6 to 9 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 94 to 91 mole % cyclohexanedimethanol.

[00283] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 10 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 90 mole % cyclohexanedimethanol; 10 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 90 mole % cyclohexanedimethanol; 10 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 90 mole % cyclohexanedimethanol; 10 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 90 mole % cyclohexanedimethanol; 10 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 90 mole % cyclohexanedimethanol; 10 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 90 mole % cyclohexanedimethanol; 10 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 90 mole % cyclohexanedimethanol; 10 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 90 mole % cyclohexanedimethanol; 10 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 90 mole % cyclohexanedimethanol; 10 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 90 mole % cyclohexanedimethanol; 10 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 90 mole % cyclohexanedimethanol; 10 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 90 mole % cyclohexanedimethanol; 10 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 90 mole % cyclohexanedimethanol; 10 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 90 mole % cyclohexanedimethanol; 10 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 90 mole % cyclohexanedimethanol; 10 to less than 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 65 to 90 % cyclohexanedimethanol; 10 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 90 mole % cyclohexanedimethanol; 10 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 90 mole % cyclohexanedimethanol; 10 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 90 mole % cyclohexanedimethanol; and 10 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 90 mole % cyclohexanedimethanol.

[00284] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the

following combinations of ranges: 10 to 100 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 0 to 90 mole % cyclohexanedimethanol; greater than 10 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to less than 90 mole % cyclohexanedimethanol; greater than 10 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to less than 90 mole % cyclohexanedimethanol; 10 to less than 34 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 66 to 90 % cyclohexanedimethanol; greater than 10 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to less than 90 mole % cyclohexanedimethanol; greater than 10 to 20 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 80 to less than 90 mole % cyclohexanedimethanol; and greater than 10 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to less than 90 mole % cyclohexanedimethanol.

[00285] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 11 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 89 mole % cyclohexanedimethanol; 11 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 89 mole % cyclohexanedimethanol; 11 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 89 mole % cyclohexanedimethanol; 11 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 89 mole % cyclohexanedimethanol; 11 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 89 mole % cyclohexanedimethanol; 11 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 89 mole % cyclohexanedimethanol; 11 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 89 mole % cyclohexanedimethanol; 11 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 89 mole % cyclohexanedimethanol; 11 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 89 mole % cyclohexanedimethanol; 11 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 89 mole % cyclohexanedimethanol; 11 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 89 mole % cyclohexanedimethanol; 11 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 89 mole % cyclohexanedimethanol; 11 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 89 mole % cyclohexanedimethanol; 11 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 89 mole % cyclohexanedimethanol; 11 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 89 mole % cyclohexanedimethanol; 11 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 89 mole % cyclohexanedimethanol; 11 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 89 mole % cyclohexanedimethanol; and 11 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 89 mole % cyclohexanedimethanol.

[00286] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the

following combinations of ranges: 12 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 88 mole % cyclohexanedimethanol; 12 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 88 mole % cyclohexanedimethanol; 12 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 88 mole % cyclohexanedimethanol; 12 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 88 mole % cyclohexanedimethanol; 12 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 88 mole % cyclohexanedimethanol; 12 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 88 mole % cyclohexanedimethanol; 12 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 88 mole % cyclohexanedimethanol; 12 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 88 mole % cyclohexanedimethanol; 12 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 88 mole % cyclohexanedimethanol; 12 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 88 mole % cyclohexanedimethanol; 12 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 88 mole % cyclohexanedimethanol; 12 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 88 mole % cyclohexanedimethanol; 12 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 88 mole % cyclohexanedimethanol; 12 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 88 mole % cyclohexanedimethanol; 12 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 88 mole % cyclohexanedimethanol; 12 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 88 mole % cyclohexanedimethanol; 12 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 88 mole % cyclohexanedimethanol; and 12 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 88 mole % cyclohexanedimethanol.

[00287] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 13 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 87 mole % cyclohexanedimethanol; 13 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 87 mole % cyclohexanedimethanol; 13 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 87 mole % cyclohexanedimethanol; 13 to 85 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 15 to 87 mole % cyclohexanedimethanol; 13 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 87 mole % cyclohexanedimethanol; 13 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 87 mole % cyclohexanedimethanol; 13 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 87 mole % cyclohexanedimethanol; 13 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 87 mole % cyclohexanedimethanol; 13 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 87 mole % cyclohexanedimethanol; 13 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 87 mole % cyclohexanedimethanol; 13 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 87 mole % cyclohexanedimethanol; 13 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 87 mole % cyclohexanedimethanol; 13 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 87 mole % cyclohexanedimethanol; 13 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 87 mole % cyclohexanedimethanol; 13 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 87 mole % cyclohexanedimethanol; 13 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 87 mole % cyclohexanedimethanol; 13 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 87 mole % cyclohexanedimethanol; and 13 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 87 mole % cyclohexanedimethanol.

[00288] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 14 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 86 mole % cyclohexanedimethanol; 14 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 86 mole % cyclohexanedimethanol; 14 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 86 mole % cyclohexanedimethanol; 14 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 86 mole % cyclohexanedimethanol; 14 to 80mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 86 mole % cyclohexanedimethanol; 14 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 86 mole % cyclohexanedimethanol; 14 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 86 mole % cyclohexanedimethanol; 14

to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 86 mole % cyclohexanedimethanol; 14 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 86 mole % cyclohexanedimethanol; 14 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 86 mole % cyclohexanedimethanol; 14 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 86 mole % cyclohexanedimethanol; 14 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 86 mole % cyclohexanedimethanol; 14 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 86 mole % cyclohexanedimethanol; 14 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 86 mole % cyclohexanedimethanol; 14 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 86 mole % cyclohexanedimethanol; 14 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 86 mole % cyclohexanedimethanol; 14 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 86 mole % cyclohexanedimethanol; and 14 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 86 mole % cyclohexanedimethanol.

[00289] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 15 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 85 mole % cyclohexanedimethanol; 15 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 85 mole % cyclohexanedimethanol; 15 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 85 mole % cyclohexanedimethanol; 15 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 85 mole % cyclohexanedimethanol; 15 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 85 mole % cyclohexanedimethanol; 15 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 85 mole % cyclohexanedimethanol; 15 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 85 mole % cyclohexanedimethanol; 15 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 85 mole % cyclohexanedimethanol; 15 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 85 mole % cyclohexanedimethanol; 15 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 85 mole % cyclohexanedimethanol; 15 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 85 mole %

cyclohexanedimethanol; 15 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 85 mole % cyclohexanedimethanol; 15 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 85 mole % cyclohexanedimethanol; 15 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 85 mole % cyclohexanedimethanol; 15 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 85 mole % cyclohexanedimethanol; 15 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 85 mole % cyclohexanedimethanol; 15 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 85 mole % cyclohexanedimethanol; and 15 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 85 mole % cyclohexanedimethanol.

[00290] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 20 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 80 mole % cyclohexanedimethanol; 20 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 80 mole % cyclohexanedimethanol; 20 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 80 mole % cyclohexanedimethanol; 20 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 80 mole % cyclohexanedimethanol; 20 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 80 mole % cyclohexanedimethanol; 20 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 80 mole % cyclohexanedimethanol; 20 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 80 mole % cyclohexanedimethanol; 20 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 80 mole % cyclohexanedimethanol; 20 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 80 mole % cyclohexanedimethanol; 20 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 80 mole % cyclohexanedimethanol; 20 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 80 mole % cyclohexanedimethanol; 20 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 80 mole % cyclohexanedimethanol; 20 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 80 mole % cyclohexanedimethanol; 20 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 80 mole % cyclohexanedimethanol; 20 to 35 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 65 to 80 mole % cyclohexanedimethanol; 20 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 80 mole % cyclohexanedimethanol; and 20 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 80 mole % cyclohexanedimethanol.

[00291] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 25 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 75 mole % cyclohexanedimethanol; 25 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 75 mole % cyclohexanedimethanol; 25 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 75 mole % cyclohexanedimethanol; 25 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 75 mole % cyclohexanedimethanol; 25 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 75 mole % cyclohexanedimethanol; 25 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 75 mole % cyclohexanedimethanol; 25 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 75 mole % cyclohexanedimethanol; 25 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 75 mole % cyclohexanedimethanol; 25 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 75 mole % cyclohexanedimethanol; 25 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 75 mole % cyclohexanedimethanol; 25 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 75 mole % cyclohexanedimethanol; 25 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 75 mole % cyclohexanedimethanol; 25 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 75 mole % cyclohexanedimethanol; 25 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 75 mole % cyclohexanedimethanol; 25 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 75 mole % cyclohexanedimethanol; and 25 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 75 mole % cyclohexanedimethanol.

[00292] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 30 to 99 mole % 2,2,4,4-tetramethyl-1,3-

cyclobutanediol and 1 to 70 mole % cyclohexanedimethanol; 30 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 70 mole % cyclohexanedimethanol; 30 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 70 mole % cyclohexanedimethanol; 30 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 70 mole % cyclohexanedimethanol; 30 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 70 mole % cyclohexanedimethanol; 30 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 70 mole % cyclohexanedimethanol; 30 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 70 mole % cyclohexanedimethanol; 30 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 70 mole % cyclohexanedimethanol; 30 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 70 mole % cyclohexanedimethanol; 30 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 70 mole % cyclohexanedimethanol; 30 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 70 mole % cyclohexanedimethanol; 30 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 70 mole % cyclohexanedimethanol; 30 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 70 mole % cyclohexanedimethanol; 30 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 70 mole % cyclohexanedimethanol; 30 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 70 mole % cyclohexanedimethanol.

[00293] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 35 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 65 mole % cyclohexanedimethanol; 35 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 65 mole % cyclohexanedimethanol; 35 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 65 mole % cyclohexanedimethanol; 35 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 65 mole % cyclohexanedimethanol; 35 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 65 mole % cyclohexanedimethanol; 35 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 65 mole % cyclohexanedimethanol; 35 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 65 mole % cyclohexanedimethanol; 35

to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 65 mole % cyclohexanedimethanol; 35 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 65 mole % cyclohexanedimethanol; 35 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 65 mole % cyclohexanedimethanol; 35 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 65 mole % cyclohexanedimethanol; 35 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 65 mole % cyclohexanedimethanol; 35 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 65 mole % cyclohexanedimethanol; 35 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 65 mole % cyclohexanedimethanol.

[00294] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 40.1 to 100 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 59.9 mole % cyclohexanedimethanol 40 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 60 mole % cyclohexanedimethanol; 40 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 60 mole % cyclohexanedimethanol; 40 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 60 mole % cyclohexanedimethanol; 40 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 60 mole % cyclohexanedimethanol; 40 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 60 mole % cyclohexanedimethanol; 40 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 60 mole % cyclohexanedimethanol; 40 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 60 mole % cyclohexanedimethanol; 40 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 60 mole % cyclohexanedimethanol; 40 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 60 mole % cyclohexanedimethanol; 40 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 60 mole % cyclohexanedimethanol; 40 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 60 mole % cyclohexanedimethanol; 40 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 60 mole % cyclohexanedimethanol; and 40 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 60 mole % cyclohexanedimethanol.

[00295] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 45 to 100 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 0 to 55 mole % cyclohexanedimethanol; 45 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 55 mole % cyclohexanedimethanol; 45 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 55 mole % cyclohexanedimethanol; 45 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 55 mole % cyclohexanedimethanol; 45 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 55 mole % cyclohexanedimethanol; 45 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 55 mole % cyclohexanedimethanol; 45 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 55 mole % cyclohexanedimethanol; 45 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 55 mole % cyclohexanedimethanol; 45 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 55 mole % cyclohexanedimethanol; 45 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 55 mole % cyclohexanedimethanol; greater than 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to less than 55 mole % cyclohexanedimethanol; 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 55 mole % cyclohexanedimethanol; and 45 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 60 mole % cyclohexanedimethanol.

[00296] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: greater than 50 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to less than 50 mole % cyclohexanedimethanol; greater

than 50 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to less than 50 mole % cyclohexanedimethanol; greater than 50 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to less than 50 mole % cyclohexanedimethanol.

[00297] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: greater than 51 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to less than 49 mole % cyclohexanedimethanol; greater than 51 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to less than 49 mole % cyclohexanedimethanol.

[00298] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 55 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 45 mole % cyclohexanedimethanol; 55 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 45 mole % cyclohexanedimethanol; 55 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 45 mole % cyclohexanedimethanol; 55 to 85 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 15 to 45 mole % cyclohexanedimethanol; 55 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 45 mole % cyclohexanedimethanol; 55 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 45 mole % cyclohexanedimethanol; 55 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 45 mole % cyclohexanedimethanol; 55 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 45 mole % cyclohexanedimethanol; and 55 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 45 mole % cyclohexanedimethanol.

[00299] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 60 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 40 mole % cyclohexanedimethanol; 60 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 40 mole % cyclohexanedimethanol; 60 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 40 mole % cyclohexanedimethanol; 60 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 40 mole % cyclohexanedimethanol; 60 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 40 mole % cyclohexanedimethanol; 60 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 40 mole % cyclohexanedimethanol; and 60 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 40 mole % cyclohexanedimethanol.

[00300] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 65 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 35 mole % cyclohexanedimethanol; 65 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 35 mole % cyclohexanedimethanol; 65 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 35 mole % cyclohexanedimethanol; 65 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 35 mole % cyclohexanedimethanol; 65 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 35 mole % cyclohexanedimethanol; 65 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 35 mole % cyclohexanedimethanol; and 65 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 35 mole % cyclohexanedimethanol.

[00301] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 70 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 30 mole % cyclohexanedimethanol; 70 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 30 mole % cyclohexanedimethanol; 70 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 30 mole % cyclohexanedimethanol; 70 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 30 mole % cyclohexanedimethanol; 70 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 30 mole % cyclohexanedimethanol; 70 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 30 mole % cyclohexanedimethanol.

[00302] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 75 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 25 mole % cyclohexanedimethanol; 75 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 25 mole % cyclohexanedimethanol; 75 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 25 mole % cyclohexanedimethanol; and 75 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 25 mole % cyclohexanedimethanol.

[00303] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 80 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 20 mole % cyclohexanedimethanol; 80 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 20 mole % cyclohexanedimethanol; 80 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 20 mole % cyclohexanedimethanol.

[00304] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges 37 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 63 mole % cyclohexanedimethanol; 40 to less than 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 55 to 60 mole % cyclohexanedimethanol; greater than 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-

cyclobutanediol and 45 to less than 55 mole % cyclohexanedimethanol; and 46 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 54 mole % cyclohexanedimethanol; and 46 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 54 mole % cyclohexanedimethanol.

[00305] In other aspects of the invention, the glycol component for the polyesters useful in the invention include but are not limited to at least one of the following combinations of ranges: 0.01 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 99.99 mole % cyclohexanedimethanol; 0.01 to less than 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 85 to 99.99 mole % cyclohexanedimethanol; 0.01 to 14 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 86 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 13 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 87 to 99.99 mole % cyclohexanedimethanol; 0.01 to 12 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 88 to 99.99 mole % 1,4-cyclohexanedimethano; 0.01 to 11 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 89 to 99.99 mole % cyclohexanedimethanol; 0.01 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 99.99 mole % cyclohexanedimethanol; 0.01 to less than 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 90 to 99.99 mole % cyclohexanedimethanol; 0.01 to 9 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 91 to 99.99 mole % cyclohexanedimethanol; 0.01 to 8 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 92 to 99.99 mole % cyclohexanedimethanol; 0.01 to 7 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 93 to 99.99 mole % cyclohexanedimethanol; 0.01 to 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95 to 99.99 mole % cyclohexanedimethanol; 0.01 to less than 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 95 to 99.99 mole % cyclohexanedimethanol; 0.01 to 4.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95.5 to 99.99 mole % cyclohexanedimethanol; 0.01 to 4 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 96 to 99.99 mole % cyclohexanedimethanol; 0.01 to 3.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 96.5 to 99.99 mole % cyclohexanedimethanol; 0.01 to 3 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 97 to 99.99 mole % cyclohexanedimethanol; 0.01 to 2.5 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 97.5 to 99.99 mole % cyclohexanedimethanol; 0.01 to 2 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 98 to 99.99 mole % cyclohexanedimethanol; 0.01 to 1.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 98.5 to 99.99 mole % cyclohexanedimethanol; 0.01 to 1 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 99 to 99.99 mole % cyclohexanedimethanol; and 0.01 to 0.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 99.5 to 99.99 mole % cyclohexanedimethanol.

[00306] In other aspects of the invention where the mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol is present at 0.01 to less than 5 mole % based on the mole percentages for the diol component equaling 100 mole % and where the presence of CHDM is optional, the glycol component for the polyesters useful in the invention include but are not limited to at least one or more of the following combinations of ranges: 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 95 mole %of ethylene glycol residues, and 0 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 99.98 mole %of ethylene glycol residues, and 0.01 to 99.97 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater 90 mole % of ethylene glycol residues, and 5 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 85 mole %of ethylene glycol residues, and 10 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 80 mole %of ethylene glycol residues, and 15 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 75 mole % of ethylene glycol residues, and 20 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 70 mole % of ethylene glycol residues, and 25 to 99.98 mole % of cyclohexanedimethanol; 0.01 to greater than 65 mole % of ethylene glycol residues, and 30 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5

mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 60 mole % of ethylene glycol residues, and 35 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 55 mole % of ethylene glycol residues, and 40 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 50 mole % of ethylene glycol residues, and 45 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 45 mole % of ethylene glycol residues, and 50 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 40 mole % of ethylene glycol residues, and 55 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 35 mole % of ethylene glycol residues, and 60 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 30 mole % of ethylene glycol residues, and 65 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 25 mole % of ethylene glycol residues, and 70 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 20 mole % of ethylene glycol residues, and 75 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 15 mole % of ethylene glycol residues, and 80 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 10 mole % of ethylene glycol residues, and 85 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 0.01 to greater than 5 mole % of ethylene glycol residues, and 90 to 99.98 mole % of cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and 0.01 to greater

than 5 mole % of ethylene glycol residues, and 90 to 99.98 mole % of cyclohexanedimethanol.

[00307] In embodiments where the mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, is 0.01 to 5 mole % based on the mole percentages for the diol component equaling 100 mole % and where the presence of CHDM is required, the glycol component for the polyesters useful the invention include but are not limited to at least of the following combinations of ranges: 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 89 to 94.99 mole % of ethylene glycol residues, and 5 to 10 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 89 to 94.99 mole % of ethylene glycol residues, and 5 to 10 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 84 to 89.99 mole % of ethylene glycol residues, and 10 to 15 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 79 to 84.99 mole % of ethylene glycol residues, and 15 to 20 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 74 to 79.99 mole % of ethylene glycol residues, and 20 to 25 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 69 to 74.99 mole % of ethylene glycol residues, and 25 to 30 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 64 to 69.99 mole % of ethylene glycol residues, and 30 to 35 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 59 to 64.99 mole % of ethylene glycol residues, and 35 to 40 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 54 to 59.99 mole % of ethylene glycol residues, and 40 to 45 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 49 to 54.99 mole % of ethylene glycol residues, and 45 to 50 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 44 to 49.99 mole % of ethylene glycol residues, and 50 to 55 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 39 to 44.99 mole % of ethylene glycol residues,

and 55 to 60 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 34 to 39.99 mole % of ethylene glycol residues, and 60 to 65 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 29 to 34.99 mole % of ethylene glycol residues, and 65 to 70 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 24 to 29.99 mole % of ethylene glycol residues, and 70 to 75 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 19 to 24.99 mole % of ethylene glycol residues, and 75 to 80 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 14 to 19.99 mole % of ethylene glycol residues, and 80 to 85 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 9 to 14.99 mole % of ethylene glycol residues, and 85 to 90 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 4 to 9.99 mole % of ethylene glycol residues, and 90 to 95 mole % of cyclohexanedimethanol; 0.01 to 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, 95 to 99.99 mole % of ethylene glycol residues, and 0 to 5 mole % of cyclohexanedimethanol;

[00308] In any embodiment In embodiments where the mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, is 0.01 to 5 mole % based on the mole percentages for the diol component equaling 100 mole % and where the presence of CHDM is required, the glycol component for the polyesters useful the invention can also include embodiments where 0.01 to less than 5 mole % TMCD is present and a corresponding reduction in either cyclohexanedimethanol and/or ethylene glycol residues would be contemplated within the scope of this invention.

[00309] The glycol component may also contain one of the following ranges of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues: 0.01 to 10 mole%; 0.01 to 9.5 mole % 0.01 to 9 mole %; 0.01 to 8.5 mole %; 0.01 to 8 mole %; 0.01 to 7.5 mole %; 0.01 to 7.0; 0.01 to 6.5 mole %; 0.01 to 6 mole %; 0.01 to 5.5 mole %; 0.01 to 5 mole %; 0.01 to less than 5 mole %; 0.01 to 4.5 mole %; 0.01 to 4 mole %; 0.01 to 3.5 mole %; 0.01 to 3 mole %; 0.01 to 2.5 mole %; 0.01 to 2.0 mole %; 0.01 to

2.5 mole %; 0.01 to 2 mole %; 0.01 to 1.5 mole %; 0.01 to 1.0 mole %; and 0.01 to 0.5 mole %.

[00310] In certain embodiments, the remainder of the glycol component can include, but is not limited, to any amount of cyclohexanedimethanol and/or ethylene glycol residues so long as the total amount of the glycol component equals 100 mole %.

[00311] In addition to the diols set forth above, the polyesters useful in the polyester compositions useful in the invention may be made from 1,3-propanediol, 1,4-butanediol, and mixtures thereof. It is contemplated that compositions of the invention made from 1,3-propanediol, 1,4-butanediol, and mixtures thereof can possess at least one of the Tg ranges described herein, at least one of the inherent viscosity ranges described herein, and/or at least one of the glycol or diacid ranges described herein. In addition or in the alternative, the polyesters made from 1,3-propanediol or 1,4-butanediol and mixtures thereof may also be made from 1,4-cyclohexanedmethanol in at least one of the following amounts: from 0.1 to 99 mole %; 0.1 to 90 mole %; from 0.1 to 80 mole %; from 0.1 to 70 mole %; from 0.1 to 60 mole %; from 0.1 to 50 mole %; from 0.1 to 40 mole %; from 0.1 to 35 mole %; from 0.1 to 30 mole %; from 0.1 to 25 mole %; from 0.1 to 20 mole %; from 0.1 to 15 mole %; from 0.1 to 10 mole %; from 0.1 to 5 mole %; from 1 to 99 mole %; from 1 to 90 mole %; from 1 to 80 mole %; from 1 to 70 mole %; from 1 to 60 mole %; from 1 to 50 mole %; from 1 to 40 mole %; from 1 to 35 mole %; from 1 to 30 mole %; from 1 to 25 mole %; from 1 to 20 mole %; from 1 to 15 mole %; from 1 to 10 mole %; from 1 to 5 mole %; from 5 to 80 mole %; 5 to 70 mole %; from 5 to 60 mole %; from 5 to 50 mole %; from 5 to 40 mole %; from 5 to 35 mole %; from 5 to 30 mole %; from 5 to 25 mole %; from 5 to 20 mole %; and from 5 to 15 mole %; from 5 to 10 mole %; from 10 to 99 mole %; from 10 to 90 mole %; from 10 to 80 mole %; from 10 to 70 mole %; from 10 to 60 mole %; from 10 to 50 mole %; from 10 to 40 mole %; from 10 to 35 mole %; from 10 to 30 mole %; from 10 to 25 mole %; from 10 to 20 mole %; from 10 to 15 mole %; from 20 to 99 mole %; 20 to 95 mole %; from 20 to 80 mole %; from 20 to 70 mole %; from 20 to 60 mole %; from 20 to 50 mole

%; from 20 to 40 mole %; from 20 to 35 mole %; from 20 to 30 mole %; and from 20 to 25 mole %.

[00312] For embodiments of the invention, the polyesters useful in the invention may exhibit at least one of the following inherent viscosities as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C: 0.10 to 1.2 dL/g; 0.10 to 1.1 dL/g; 0.10 to 1 dL/g; 0.10 to less than 1 dL/g; 0.10 to 0.98 dL/g; 0.10 to 0.95 dL/g; 0.10 to 0.90 dL/g; 0.10 to 0.85 dL/g; 0.10 to 0.80 dL/g; 0.10 to 0.75 dL/g; 0.10 to less than 0.75 dL/g; 0.10 to 0.72 dL/g; 0.10 to 0.70 dL/g; 0.10 to less than 0.70 dL/g; 0.10 to 0.68 dL/g; 0.10 to less than 0.68 dL/g; 0.10 to 0.65 dL/g; 0.10 to 0.6 dL/g; 0.10 to 0.55 dL/g; 0.10 to 0.5 dL/g; 0.10 to 0.4 dL/g; 0.10 to 0.35 dL/g; 0.20 to 1.2 dL/g; 0.20 to 1.1 dL/g; 0.20 to 1 dL/g; 0.20 to less than 1 dL/g; 0.20 to 0.98 dL/g; 0.20 to 0.95 dL/g; 0.20 to 0.90 dL/g; 0.20 to 0.85 dL/g; 0.20 to 0.80 dL/g; 0.20 to 0.75 dL/g; 0.20 to less than 0.75 dL/g; 0.20 to 0.72 dL/g; 0.20 to 0.70 dL/g; 0.20 to less than 0.70 dL/g; 0.20 to 0.68 dL/g; 0.20 to less than 0.68 dL/g; 0.20 to 0.65 dL/g; 0.20 to 0.6 dL/g; 0.20 to 0.55 dL/g; 0.20 to 0.5 dL/g; 0.20 to 0.4 dL/g; 0.20 to 0.35 dL/g; 0.35 to 1.2 dL/g; 0.35 to 1.1 dL/g; 0.35 to 1 dL/g; 0.35 to less than 1 dL/g; 0.35 to 0.98 dL/g; 0.35 to 0.95 dL/g; 0.35 to 0.90 dL/g; 0.35 to 0.85 dL/g; 0.35 to 0.80 dL/g; 0.35 to 0.75 dL/g; 0.35 to less than 0.75 dL/g; 0.35 to 0.72 dL/g; 0.35 to 0.70 dL/g; 0.35 to less than 0.70 dL/g; 0.35 to 0.68 dL/g; 0.35 to less than 0.68 dL/g; 0.35 to 0.65 dL/g; 0.40 to 1.2 dL/g; 0.40 to 1.1 dL/g; 0.40 to 1 dL/g; 0.40 to less than 1 dL/g; 0.40 to 0.98 dL/g; 0.40 to 0.95 dL/g; 0.40 to 0.90 dL/g; 0.40 to 0.85 dL/g; 0.40 to 0.80 dL/g; 0.40 to 0.75 dL/g; 0.40 to less than 0.75 dL/g; 0.40 to 0.72 dL/g; 0.40 to 0.70 dL/g; 0.40 to less than 0.70 dL/g; 0.40 to 0.68 dL/g; 0.40 to less than 0.68 dL/g; 0.40 to 0.65 dL/g; greater than 0.42 to 1.2 dL/g; greater than 0.42 to 1.1 dL/g; greater than 0.42 to 1 dL/g; greater than 0.42 to less than 1 dL/g; greater than 0.42 to 0.98 dL/g; greater than 0.42 to 0.95 dL/g; greater than 0.42 to 0.90 dL/g; greater than 0.42 to 0.85 dL/g; greater than 0.42 to 0.80 dL/g; greater than 0.42 to 0.75 dL/g; greater than 0.42 to less than 0.75 dL/g; greater than 0.42 to 0.72 dL/g; greater than 0.42 to 0.70 dL/g; greater than 0.42 to less than 0.70 dL/g; greater than 0.42 to 0.68 dL/g; greater than 0.42 to less than 0.68 dL/g; and greater than 0.42 to 0.65 dL/g.

[00313] For embodiments of the invention, the polyesters useful in the invention may exhibit at least one of the following inherent viscosities as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C: 0.45 to 1.2 dL/g; 0.45 to 1.1 dL/g; 0.45 to 1 dL/g; 0.45 to 0.98 dL/g; 0.45 to 0.95 dL/g; 0.45 to 0.90 dL/g; 0.45 to 0.85 dL/g; 0.45 to 0.80 dL/g; 0.45 to 0.75 dL/g; 0.45 to less than 0.75 dL/g; 0.45 to 0.72 dL/g; 0.45 to 0.70 dL/g; 0.45 to less than 0.70 dL/g; 0.45 to 0.68 dL/g; 0.45 to less than 0.68 dL/g; 0.45 to 0.65 dL/g; 0.50 to 1.2 dL/g; 0.50 to 1.1 dL/g; 0.50 to 1 dL/g; 0.50 to less than 1 dL/g; 0.50 to 0.98 dL/g; 0.50 to 0.95 dL/g; 0.50 to 0.90 dL/g; 0.50 to 0.85 dL/g; 0.50 to 0.80 dL/g; 0.50 to 0.75 dL/g; 0.50 to less than 0.75 dL/g; 0.50 to 0.72 dL/g; 0.50 to 0.70 dL/g; 0.50 to less than 0.70 dL/g; 0.50 to 0.68 dL/g; 0.50 to less than 0.68 dL/g; 0.50 to 0.65 dL/g; 0.55 to 1.2 dL/g; 0.55 to 1.1 dL/g; 0.55 to 1 dL/g; 0.55 to less than 1 dL/g; 0.55 to 0.98 dL/g; 0.55 to 0.95 dL/g; 0.55 to 0.90 dL/g; 0.55 to 0.85 dL/g; 0.55 to 0.80 dL/g; 0.55 to 0.75 dL/g; 0.55 to less than 0.75 dL/g; 0.55 to 0.72 dL/g; 0.55 to 0.70 dL/g; 0.55 to less than 0.70 dL/g; 0.55 to 0.68 dL/g; 0.55 to less than 0.68 dL/g; 0.55 to 0.65 dL/g; 0.58 to 1.2 dL/g; 0.58 to 1.1 dL/g; 0.58 to 1 dL/g; 0.58 to less than 1 dL/g; 0.58 to 0.98 dL/g; 0.58 to 0.95 dL/g; 0.58 to 0.90 dL/g; 0.58 to 0.85 dL/g; 0.58 to 0.80 dL/g; 0.58 to 0.75 dL/g; 0.58 to less than 0.75 dL/g; 0.58 to 0.72 dL/g; 0.58 to 0.70 dL/g; 0.58 to less than 0.70 dL/g; 0.58 to 0.68 dL/g; 0.58 to less than 0.68 dL/g; 0.58 to 0.65 dL/g; 0.60 to 1.2 dL/g; 0.60 to 1.1 dL/g; 0.60 to 1 dL/g; 0.60 to less than 1 dL/g; 0.60 to 0.98 dL/g; 0.60 to 0.95 dL/g; 0.60 to 0.90 dL/g; 0.60 to 0.85 dL/g; 0.60 to 0.80 dL/g; 0.60 to 0.75 dL/g; 0.60 to less than 0.75 dL/g; 0.60 to 0.72 dL/g; 0.60 to 0.70 dL/g; 0.60 to less than 0.70 dL/g; 0.60 to 0.68 dL/g; 0.60 to less than 0.68 dL/g; 0.60 to 0.65 dL/g; 0.65 to 1.2 dL/g; 0.65 to 1.1 dL/g; 0.65 to 1 dL/g; 0.65 to less than 1 dL/g; 0.65 to 0.98 dL/g; 0.65 to 0.95 dL/g; 0.65 to 0.90 dL/g; 0.65 to 0.85 dL/g; 0.65 to 0.80 dL/g; 0.65 to 0.75 dL/g; 0.65 to less than 0.75 dL/g; 0.65 to 0.72 dL/g; 0.65 to 0.70 dL/g; 0.65 to less than 0.70 dL/g; 0.68 to 1.2 dL/g; 0.68 to 1.1 dL/g; 0.68 to 1 dL/g; 0.68 to less than 1 dL/g; 0.68 to 0.98 dL/g; 0.68 to 0.95 dL/g; 0.68 to 0.90 dL/g; 0.68 to 0.85 dL/g; 0.68 to 0.80 dL/g; 0.68 to 0.75 dL/g; 0.68 to less than 0.75 dL/g; 0.68 to 0.72 dL/g; greater than 0.76 dL/g to 1.2 dL/g; greater than 0.76 dL/g to 1.1 dL/g; greater than 0.76 dL/g to 1 dL/g; greater than 0.76 dL/g to less

than 1 dL/g; greater than 0.76 dL/g to 0.98dL/g; greater than 0.76 dL/g to 0.95 dL/g; greater than 0.76 dL/g to 0.90 dL/g; greater than 0.80 dL/g to 1.2 dL/g; greater than 0.80 dL/g to 1.1 dL/g; greater than 0.80 dL/g to 1 dL/g; greater than 0.80 dL/g to less than 1 dL/g; greater than 0.80 dL/g to 1.2 dL/g; greater than 0.80 dL/g to 0.98dL/g; greater than 0.80 dL/g to 0.95 dL/g; greater than 0.80 dL/g to 0.90 dL/g.

[00314] It is contemplated that compositions useful in the invention can possess at least one of the inherent viscosity ranges described herein and at least one of the monomer ranges for the compositions described herein unless otherwise stated. It is also contemplated that compositions useful in the invention can possess at least one of the Tg ranges described herein and at least one of the monomer ranges for the compositions described herein unless otherwise stated. It is also contemplated that compositions useful in the invention can possess at least one of the inherent viscosity ranges described herein, at least one of the Tg ranges described herein, and at least one of the monomer ranges for the compositions described herein unless otherwise stated.

[00315] In one embodiment, terephthalic acid may be used as the starting material. In another embodiment, dimethyl terephthalate may be used as the starting material. In yet another embodiment, mixtures of terephthalic acid and dimethyl terephthalate may be used as the starting material and/or as an intermediate material.

[00316] In certain embodiments, terephthalic acid or an ester thereof, such as, for example, dimethyl terephthalate or a mixture of terephthalic acid residues and an ester thereof can make up a portion or all of the dicarboxylic acid component used to form the polyesters useful in the invention. In certain embodiments, terephthalic acid residues can make up a portion or all of the dicarboxylic acid component used to form the polyesters useful in the invention. In certain embodiments, higher amounts of terephthalic acid can be used in order to produce a higher impact strength polyester. For purposes of this disclosure, the terms "terephthalic acid" and "dimethyl terephthalate" are used interchangeably herein. In one embodiment, dimethyl terephthalate is part or all of the dicarboxylic acid component used to make the polyesters useful in the present

invention. In all embodiments, ranges of from 70 to 100 mole %; or 80 to 100 mole %; or 90 to 100 mole %; or 99 to 100 mole %; or 100 mole % terephthalic acid and/or dimethyl terephthalate and/or mixtures thereof may be used.

[00317] In addition to terephthalic acid, the dicarboxylic acid component of the polyesters useful in the invention can comprise up to 30 mole %, up to 20 mole %, up to 10 mole %, up to 5 mole%, or up to 1 mole % of one or more modifying aromatic dicarboxylic acids. Yet another embodiment contains 0 mole % modifying aromatic dicarboxylic acids. Thus, if present, it is contemplated that the amount of one or more modifying aromatic dicarboxylic acids can range from any of these preceding endpoint values including, for example, from 0.01 to 30 mole %, 0.01 to 20 mole %, from 0.01 to 10 mole %, from 0.01 to 5 mole % and from 0.01 to 1 mole %. In one embodiment, modifying aromatic dicarboxylic acids that may be used in the present invention include but are not limited to those having up to 20 carbon atoms, and which can be linear, para-oriented, or symmetrical. Examples of modifying aromatic dicarboxylic acids which may be used in this invention include, but are not limited to, isophthalic acid, 4,4'-biphenyldicarboxylic acid, 1,4-, 1,5-, 2,6-, 2,7-naphthalenedicarboxylic acid, and trans-4,4'-stilbenedicarboxylic acid, and esters thereof. In one embodiment, the modifying aromatic dicarboxylic acid is isophthalic acid.

[00318] The carboxylic acid component of the polyesters useful in the invention can be further modified with up to 10 mole %, such as up to 5 mole % or up to 1 mole % of one or more aliphatic dicarboxylic acids containing 2-16 carbon atoms, such as, for example, cyclohexanedicarboxylic, malonic, succinic, glutaric, adipic, pimelic, suberic, azelaic and dodecanedioic dicarboxylic acids. Certain embodiments can also comprise 0.01 to 10 mole %, such as 0.1 to 10 mole %, 1 or 10 mole %, 5 to 10 mole % of one or more modifying aliphatic dicarboxylic acids. Yet another embodiment contains 0 mole % modifying aliphatic dicarboxylic acids. The total mole % of the dicarboxylic acid component is 100 mole %. In one embodiment, adipic acid and/or glutaric acid are provided in the modifying aliphatic dicarboxylic acid component of the invention.

[00319] The modifying dicarboxylic acids of the invention can include indan dicarboxylic acids, for example, indan-1,3-dicarboxylic acids and/or phenylindan

dicarboxylic acids. In one embodiment, the dicarboxylic acid may be chosen from at least one of 1,2,3-trimethyl-3-phenylindan-4',5-dicarboxylic acid and 1,1,3-trimethyl-5-carboxy-3-(4-carboxyphenyl)indan dicarboxylic acid. For the purposes of this invention, any of the indan dicarboxylic acids described in United States Patent Application Publication No. 2006/0004151A1 entitled "Copolymers Containing Indan Moieties and Blends Thereof" by Shaikh et al., assigned to General Electric Company may be used as at least one modifying dicarboxylic acid within the scope of this invention; United States Patent Application Publication No. 2006/0004151A1 is incorporated herein by reference with respect to any of the indan dicarboxylic acids described therein.

[00320] Esters of terephthalic acid and the other modifying dicarboxylic acids or their corresponding esters and/or salts may be used instead of the dicarboxylic acids. Suitable examples of dicarboxylic acid esters include, but are not limited to, the dimethyl, diethyl, dipropyl, diisopropyl, dibutyl, and diphenyl esters. In one embodiment, the esters are chosen from at least one of the following: methyl, ethyl, propyl, isopropyl, and phenyl esters.

[00321] For the desired polyester, the molar ratio of cis/trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary from the pure form of each and mixtures thereof. In certain embodiments, the molar percentages for cis and/or trans 2,2,4,4,-tetramethyl-1,3-cyclobutanediol are greater than 50 mole % cis and less than 50 mole % trans; or greater than 55 mole % cis and less than 45 mole % trans; or 30 to 70 mole % cis and 70 to 30 mole % trans; or 40 to 60 mole % cis and 60 to 40 mole % trans; or 50 to 70 mole % trans and 50 to 30 mole % cis; or 50 to 70 mole % cis and 50 to 30 mole % trans; or 60 to 70 mole % cis and 30 to 40 mole % trans; or greater than 70 mole % cis and less than 30 mole % trans; wherein the total mole percentages for cis- and trans- 2,2,4,4-tetramethyl-1,3-cyclobutanediol is equal to 100 mole %. In an additional embodiment, the molar ratio of cis/trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary within the range of 50/50 to 0/100, for example, between 40/60 to 20/80.

[00322] The cyclohexanedimethanol may be cis, trans, or a mixture thereof, for example, a cis/trans ratio of 60:40 to 40:60 or a cis/trans ratio of 70:30 to 30:70. In another embodiment, the trans-cyclohexanedimethanol can be present in an

amount of 60 to 80 mole % and the cis-cyclohexanedimethanol can be present in an amount of 20 to 40 mole % wherein the total percentages of cis-cyclohexanedimethanol and trans-cyclohexanedimethanol is equal to 100 mole %. In particular embodiments, the trans-cyclohexanedimethanol can be present in an amount of 60 mole % and the cis-cyclohexanedimethanol can be present in an amount of 40 mole %. In particular embodiments, the trans-cyclohexanedimethanol can be present in an amount of 70 mole % and the cis-cyclohexanedimethanol can be present in an amount of 30 mole %. Any of 1,1-, 1,2-, 1,3-, 1,4- isomers of cyclohexanedimethanol or mixtures thereof may be present in the glycol component of this invention. In one embodiment, the polyesters useful in the invention comprise 1,4-cyclohexanedimethanol. In another embodiment, the polyesters useful in the invention comprise 1,4-cyclohexanedimethanol and 1,3-cyclohexanedimethanol. The molar ratio of cis/trans 1,4-cyclohexandimethanol can vary within the range of 50/50 to 0/100, for example, between 40/60 to 20/80.

[00323] In one embodiment, the glycol component of the polyester portion of the polyester compositions useful in the invention can contain 98 mole % or less of one or more modifying glycols which are not 2,2,4,4-tetramethyl-1,3-cyclobutanediol or cyclohexanedimethanol; in one embodiment, the glycol component of the polyester portion of the polyester compositions useful in the invention can contain 50 to 98 mole % of one or more modifying glycols which are not 2,2,4,4-tetramethyl-1,3-cyclobutanediol or cyclohexanedimethanol; in one embodiment, the glycol component of the polyester portion of the polyester compositions useful in the invention can contain 25 mole % or less of one or more modifying glycols which are not 2,2,4,4-tetramethyl-1,3-cyclobutanediol or cyclohexanedimethanol; in one embodiment, the glycol component of the polyester portion of the polyester compositions useful in the invention can contain 20 mole % or less of one or more modifying glycols which are not 2,2,4,4-tetramethyl-1,3-cyclobutanediol or cyclohexanedimethanol; in one embodiment, the polyesters useful in the invention may contain less than 15 mole % or of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 10 mole % or less of one or more modifying glycols. In

another embodiment, the polyesters useful in the invention can contain 5 mole % or less of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 3 mole % or less of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 0 mole % modifying glycols. Certain embodiments can also contain 0.01 to 98 mole %, such as 0.1 to 98 mole %, 1 to 98 mole %, 5 to 98 mole %, or 10 to 98 mole % of one or more modifying glycols.

[00324] Modifying glycols useful in the polyesters useful in the invention refer to diols other than 2,2,4,4-tetramethyl-1,3-cyclobutanediol and cyclohexanedimethanol and can contain 2 to 16 carbon atoms. Examples of suitable modifying glycols include, but are not limited to, ethylene glycol residues, 1,2-propanediol, 1,3-propanediol, neopentyl glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, p-xylene glycol, polytetramethylene glycol, and mixtures thereof. In one embodiment, the modifying glycol is ethylene glycol. In another embodiment, the modifying glycols include, but are not limited to, at least one of 1,3-propanediol and 1,4-butanediol. In another embodiment, ethylene glycol residues is excluded as a modifying diol. In another embodiment, 1,3-propanediol and 1,4-butanediol are excluded as modifying diols. In another embodiment, 2, 2-dimethyl-1,3-propanediol is excluded as a modifying diol.

[00325] The polyesters and/or the polycarbonates useful in the polyesters compositions of the invention can comprise from 0 to 10 mole percent, for example, from 0.01 to 5 mole percent, from 0.01 to 1 mole percent, from 0.05 to 5 mole percent, from 0.05 to 1 mole percent, or from 0.1 to 0.7 mole percent, based the total mole percentages of either the diol or diacid residues; respectively, of one or more residues of a branching monomer, also referred to herein as a branching agent, having 3 or more carboxyl substituents, hydroxyl substituents, or a combination thereof. In certain embodiments, the branching monomer or agent may be added prior to and/or during and/or after the polymerization of the polyester. The polyester(s) useful in the invention can thus be linear or branched. The polycarbonate can also be linear or branched. In certain embodiments, the branching monomer or agent may be added prior to and/or during and/or after the polymerization of the polycarbonate.

[00326] Examples of branching monomers include, but are not limited to, multifunctional acids or multifunctional alcohols such as trimellitic acid, trimellitic anhydride, pyromellitic dianhydride, trimethylolpropane, glycerol, pentaerythritol, citric acid, tartaric acid, 3-hydroxyglutaric acid and the like. In one embodiment, the branching monomer residues can comprise 0.1 to 0.7 mole percent of one or more residues chosen from at least one of the following: trimellitic anhydride, pyromellitic dianhydride, glycerol, sorbitol, 1,2,6-hexanetriol, pentaerythritol, trimethylolethane, and/or trimesic acid. The branching monomer may be added to the polyester reaction mixture or blended with the polyester in the form of a concentrate as described, for example, in U.S. Patent Nos. 5,654,347 and 5,696,176, whose disclosure regarding branching monomers is incorporated herein by reference.

[00327] The polyesters of the invention can comprise at least one chain extender. Suitable chain extenders include, but are not limited to, multifunctional (including, but not limited to, bifunctional) isocyanates, multifunctional epoxides, including for example ,epoxylated novolacs, and phenoxy resins. In certain embodiments, chain extenders may be added at the end of the polymerization process or after the polymerization process. If added after the polymerization process, chain extenders can be incorporated by compounding or by addition during conversion processes such as injection molding or extrusion. The amount of chain extender used can vary depending on the specific monomer composition used and the physical properties desired but is generally about 0.1 percent by weight to about 10 percent by weight, such as about 0.1 to about 5 percent by weight, based on the total weight of the polyester.

[00328] The glass transition temperature (Tg) of the polyesters useful in the invention was determined using a TA DSC 2920 from Thermal Analyst Instrument at a scan rate of 20°C/min.

[00329] Because of the long crystallization half-times (e.g., greater than 5 minutes) at 170°C exhibited by certain polyesters useful in the present invention, it can be possible to produce articles, including but not limited to, injection molded parts, injection blow molded articles, injection stretch blow molded articles,

extruded film, extruded sheet, extrusion blow molded articles, extrusion stretch blow molded articles, and fibers. A thermoformable sheet is an example of an article of manufacture provided by this invention. The polyesters of the invention can be amorphous or semicrystalline. In one aspect, certain polyesters useful in the invention can have relatively low crystallinity. Certain polyesters useful in the invention can thus have a substantially amorphous morphology, meaning that the polyesters comprise substantially unordered regions of polymer.

[00330] In one embodiment, an "amorphous" polyester can have a crystallization half-time of greater than 5 minutes at 170°C or greater than 10 minutes at 170°C or greater than 50 minutes at 170 °C or greater than 100 minutes at 170°C. In one embodiment, of the invention, the crystallization half-times can be greater than 1,000 minutes at 170°C. In another embodiment of the invention, the crystallization half-times of the polyesters useful in the invention can be greater than 10,000 minutes at 170°C. The crystallization half time of the polyester, as used herein, may be measured using methods well-known to persons of skill in the art. For example, the crystallization half time of the polyester, $t_{1/2}$, can be determined by measuring the light transmission of a sample via a laser and photo detector as a function of time on a temperature controlled hot stage. This measurement can be done by exposing the polymers to a temperature, T_{max}, and then cooling it to the desired temperature. The sample can then be held at the desired temperature by a hot stage while transmission measurements are made as a function of time. Initially, the sample can be visually clear with high light transmission and becomes opaque as the sample crystallizes. The crystallization half-time is the time at which the light transmission is halfway between the initial transmission and the final transmission. T_{max} is defined as the temperature required to melt the crystalline domains of the sample (if crystalline domains are present). The sample can be heated to Tmax to condition the sample prior to crystallization half time measurement. The absolute Tmax temperature is different for each composition. For example PCT can be heated to some temperature greater than 290°C to melt the crystalline domains.

[00331] As shown in Table 1 and Figure 1 of the Examples, 2,2,4,4-tetramethyl-1,3-cyclobutanediol is more effective than other comonomers such ethylene glycol and isophthalic acid at increasing the crystallization half-time, i.e., the time required for a polymer to reach half of its maximum crystallinity. By decreasing the crystallization rate of PCT, i.e. increasing the crystallization half-time, amorphous articles based on modified PCT may be fabricated by methods known in the art such as extrusion, injection molding, and the like. As shown in Table 1, these materials can exhibit higher glass transition temperatures and lower densities than other modified PCT copolyesters.

[00332] The polyester(s) useful in the invention can exhibit an improvement in toughness combined with processability for some of the embodiments of the invention. For example, lowering the inherent viscosity slightly of the polyesters useful in the invention can result in a more processable melt viscosity while retaining good physical properties of the polyesters such as toughness and heat resistance.

[00333] In one embodiment, the melt viscosity of the polyester(s) useful in the invention is less than 30,000 poise as measured a 1 radian/second on a rotary melt rheometer at 290°C. In another embodiment, the melt viscosity of the polyester(s) useful in the invention is less than 20,000 poise as measured a 1 radian/second on a rotary melt rheometer at 290°C.

[00334] In one embodiment, the melt viscosity of the polyester(s) useful in the invention is less than 10,000 poise as measured at 1 radian/second (rad/sec) on a rotary melt rheometer at 290°C. In one embodiment, the melt viscosity of the polyester(s) useful in the invention is less than 15,000 poise as measured at 1 radian/second (rad/sec) on a rotary melt rheometer at 290°C. In another embodiment, the melt viscosity of the polyester(s) useful in the invention is less than 6,000 poise as measured at 1 radian/second on a rotary melt rheometer at 290°C. Viscosity at rad/sec is related to processability.

[00335] In one embodiment, certain polyesters useful in this invention can be visually clear. The term "visually clear" is defined herein as an appreciable absence of cloudiness, haziness, and/or muddiness, when inspected visually. In another embodiment, when the polyesters are blended with polycarbonate,

including but not limited to, bisphenol A polycarbonates, the blends can be visually clear.

[00336] In other embodiments of the invention, the polyesters useful in the invention may have a yellowness index (ASTM D-1925) of less than 50 or less than 20.

[00337] In one embodiment, the polyesters useful in the invention and/or the polyester compositions of the invention, with or without toners, can have color values L*, a* and b* which can be determined using a Hunter Lab Ultrascan Spectra Colorimeter manufactured by Hunter Associates Lab Inc., Reston, Va. The color determinations are averages of values measured on either pellets of the polyesters or plaques or other items injection molded or extruded from them. They are determined by the L*a*b* color system of the CIE (International Commission on Illumination) (translated), wherein L* represents the lightness coordinate, a* represents the red/green coordinate, and b* represents the yellow/blue coordinate. In certain embodiments, the b* values for the polyesters useful in the invention can be from -10 to less than 10 and the L* values can be from 50 to 90. In other embodiments, the b* values for the polyesters useful in the invention can be present in one of the following ranges: from -10 to 9; -10 to 8; -10 to 7; -10 to 6; -10 to 5; -10 to 4; -10 to 3; -10 to 2; from -5 to 9; -5 to 8; -5 to 7; -5 to 6; -5 to 5; -5 to 4; -5 to 3; -5 to 2; 0 to 9; 0 to 8; 0 to 7; 0 to 6; 0 to 5; 0 to 4; 0 to 3; 0 to 2; 1 to 10; 1 to 9; 1 to 8; 1 to 7; 1 to 6; 1 to 5; 1 to 4; 1 to 3; and 1 to 2. In other embodiments, the L* value for the polyesters useful in the invention can be present in one of the following ranges: 50 to 60; 50 to 70; 50 to 80; 50 to 90; 60 to 70; 60 to 80; 60 to 90; 70 to 80; 79 to 90.

[00338] Increasing the content of 1,4-cyclohexanedimethanol in a copolyester based on terephthalic acid, ethylene glycol, and 1,4-cyclohexanedimethanol can improve toughness which can be determined by the brittle-to-ductile transition temperature in a notched Izod impact strength test as measured by ASTM D256. This toughness improvement, by lowering of the brittle-to-ductile transition temperature with 1,4-cyclohexanedimethanol, is believed to occur due to the flexibility and conformational behavior of 1,4-cyclohexanedimethanol in the copolyester. Incorporating 2,2,4,4-tetramethyl-1,3-cyclobutanediol into PCT is

believed to improve toughness, by lowering the brittle-to-ductile transition temperature, as shown in Table 2 and Figure 2 of the Examples. This is unexpected given the rigidity of 2,2,4,4-tetramethyl-1,3-cyclobutanediol.

[00339] In one embodiment, the polyesters useful in the invention can exhibit a ductile-to-brittle transition temperature of less than 0°C based on a 10-mil notch in a 1/8-inch thick bar as defined by ASTM D256.

[00340] Notched Izod impact strength, as described in ASTM D256, is a common method of measuring toughness. The polyesters useful in the invention can possess one or more of the following properties: In one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least 150 J/m (3 ft-lb/in) at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256; in one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least (400 J/m) 7.5 ft-lb/in at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256; in one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least 1000 J/m (18 ft-lb/in) at 23°C with a 10-mil notch in a 3.2mm (1/8-inch) thick bar determined according to ASTM D256. In one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least 150 J/m (3 ft-lb/in) at 23°C with a 10-mil notch in a 6.4mm (1/4-inch) thick bar determined according to ASTM D256; in one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least (400 J/m) 7.5 ft-lb/in at 23°C with a 10-mil notch in a 6.4mm (1/4-inch) thick bar determined according to ASTM D256; in one embodiment, the polyesters useful in the invention exhibit a notched Izod impact strength of at least 1000 J/m (18 ft-lb/in) at 23°C with a 10-mil notch in a 6.4mm (1/4-inch) thick bar determined according to ASTM D256.

[00341] In another embodiment, certain polyesters useful in the invention can exhibit an increase in notched Izod impact strength when measured at 0°C of at least 3% or at least 5% or at least 10% or at least 15% as compared to the notched Izod impact strength when measured at -5°C with a 10-mil notch in a 1/8-inch thick bar determined according to ASTM D256. In addition, certain other polyesters can also exhibit a retention of notched Izod impact strength

within plus or minus 5% when measured at 0°C through 30°C with a 10-mil notch in a 1/8-inch thick bar determined according to ASTM D256.

[00342] In yet another embodiment, certain polyesters useful in the invention can exhibit a retention in notched Izod impact strength with a loss of no more than 70% when measured at 23°C with a 10-mil notch in a 1/4-inch thick bar determined according to ASTM D256 as compared to notched Izod impact strength for the same polyester when measured at the same temperature with a 10-mil notch in a 1/8-inch thick bar determined according to ASTM D256.

[00343] In one embodiment, polyesters of this invention exhibit superior notched toughness in thick sections. When tested by the Notched Izod impact strength test method of ASTM D256, polymers can exhibit either a complete break failure mode, where the test specimen breaks into two distinct parts, or a partial or no break failure mode, where the test specimen remains as one part. The complete break failure mode is associated with low energy failure. The partial and no break failure modes are associated with high energy failure. A typical thickness used to measure Notched Izod impact strength is 1/8". At this thickness, very few polymers are believed to exhibit a partial or no break failure mode, polycarbonate being one notable example. When the thickness of the test specimen is increased to ¼", however, no commercial amorphous materials exhibit a partial or no break failure mode. In one embodiment, compositions of the present example exhibit a no break failure mode when tested in the Notched Izod impact strength test method using a ¼" thick specimen.

[00344] In one embodiment, the polyesters useful in the invention can exhibit at least one of the following densities: a density of less than 1.3 g/ml at 23°C; a density of less than 1.2 g/ml at 23°C; a density of less than 1.18 g/ml at 23°C; a density of 0.70 to 1.2 g/ml at 23°C; a density of 0.70 to 1.3 g/ml at 23°C; a density of 0.70 to less than 1.2 g/ml at 23°C; a density of 0.75 to 1.2 at 23°C; a density of 0.75 g/ml to less than 1.2 at 23°C; a density of 0.80 g/ml to 1.2 at 23°C; a density of 0.80 to less than 1.2 g/ml at 23°C; a density of 0.90 to 1.2 g/ml at 23°C; a density of 1.0 to 1.2 g/ml at 23°C; a density of 1.0 to 1.3 g/ml at 23°C a density of 1.1 to 1.2 g/ml at 23°C; a density of 1.13 to 1.3 g/ml at 23°C a density of 1.13 to 1.2 g/ml at 23°C; a density of 0.80 to 1.18 at 23°C; a density of 0.80 to less than

1.18 g/ml at 23°C; a density of 1.0 to less than 1.18 g/ml at 23°C; a density of 1.1 to less than 1.18 g/ml at 23°C.

[00345] In some embodiments, use of the polyester compositions useful in the invention minimizes and/or eliminates the drying step prior to melt processing and/or thermoforming.

[00346] In one embodiment, the thermal stabilizer(s) useful in the invention can be an organic compound such as, for example, a phosphorus acid ester containing halogenated or non-halogenated organic substituents. The thermal stabilizer can comprise a wide range of phosphorus compounds well-known in the art such as, for example, phosphines, phosphites, phosphinites, phosphonites, phosphinates, phosphonates, phosphine oxides, and phosphates. Examples of thermal stabilizers include tributyl phosphate, triethyl phosphate, tri-butoxyethyl phosphate, t-butylphenyl diphenyl phosphate, 2-ethylhexyl diphenyl phosphate, ethyl dimethyl phosphate, isodecyl diphenyl phosphate, trilauryl phosphate, triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, t-butylphenyl diphenylphosphate, resorcinol bis(diphenyl phosphate), tribenzyl phosphate, phenyl ethyl phosphate, trimethyl thionophosphate, phenyl ethyl thionophosphate, dimethyl methylphosphonate, diethyl methylphosphonate, diethyl pentylphosphonate, dilauryl methylphosphonate, diphenyl methylphosphonate, dibenzyl methylphosphonate, diphenyl cresylphosphonate, dimethyl cresylphosphonate, dimethyl methylthionophosphonate, phenyl diphenylphosphinate, benzyl diphenylphosphinate, methyl diphenylphosphinate, trimethyl phosphine oxide, triphenyl phosphine oxide, tribenzyl phosphine oxide, 4-methyl diphenyl phosphine oxide, triethyl phosphite, tributyl phosphite, trilauryl phosphite, triphenyl phosphite, tribenzyl phosphite, phenyl diethyl phosphite, phenyl dimethyl phosphite, benzyl dimethyl phosphite, dimethyl methylphosphonite, diethyl pentylphosphonite, diphenyl methylphosphonite, dibenzyl methylphosphonite, dimethyl cresylphosphonite, methyl dimethylphosphinite, methyl diethylphosphinite, phenyl diphenylphosphinite, methyl diphenylphosphinite, benzyl diphenylphosphinite, triphenyl phosphine, tribenzyl phosphine, and methyl diphenyl phosphine. In one embodiment, triphenyl phosphine oxide is excluded as a thermal stabilizer in the process(es) of

making the polyesters useful in the invention and/or in the polyester composition(s) of the invention.

[00347] In one embodiment, thermal stabilizers useful in the invention can be any of the previously described phosphorus-based acids wherein one or more of the hydrogen atoms of the acid compound (bonded to either oxygen or phosphorus atoms) are replaced with alkyl, branched alkyl, substituted alkyl, alkyl ethers, substituted alkyl ethers, alkyl-aryl, alkyl-substituted aryl, aryl, substituted aryl, and mixtures thereof. In another embodiment, thermal stabilizers useful in the invention, include but are not limited to, the above described compounds wherein at least one of the hydrogen atoms bonded to an oxygen atom of the compound is replaced with a metallic ion or an ammonium ion.

[00348] The esters can contain alkyl, branched alkyl, substituted alkyl, alkyl ethers, aryl, and/or substituted aryl groups. The esters can also have at least one alkyl group and at least one aryl group. The number of ester groups present in the particular phosphorus compound can vary from zero up to the maximum allowable based on the number of hydroxyl groups present on the phosphorus compound used. For example, an alkyl phosphate ester can include one or more of the mono-, di-, and tri alkyl phosphate esters; an aryl phosphate ester includes one or more of the mono-, di-, and tri aryl phosphate esters; and an alkyl phosphate ester and/or an aryl phosphate ester also include, but are not limited to, mixed alkyl aryl phosphate esters having at least one alkyl and one aryl group.

[00349] In one embodiment, the thermal stabilizers useful in the invention include but are not limited to alkyl, aryl or mixed alkyl aryl esters or partial esters of phosphoric acid, phosphorus acid, phosphinic acid, phosphonic acid, or phosphonous acid. The alkyl or aryl groups can contain one or more substituents.

[00350] In one aspect, the phosphorus compounds useful in the invention comprise at least one thermal stabilizer chosen from at least one of substituted or unsubstituted alkyl phosphate esters, substituted or unsubstituted aryl phosphate esters, substituted or unsubstituted mixed alkyl aryl phosphate esters, diphosphites, salts of phosphoric acid, phosphine oxides, and mixed aryl alkyl phosphites, reaction products thereof, and mixtures thereof. The phosphate

esters include esters in which the phosphoric acid is fully esterified or only partially esterified.

[00351] In one embodiment, for example, the thermal stabilizers useful in the invention can include at least one phosphate ester.

[00352] In one aspect, the phosphorus compounds useful in the invention comprise at least one thermal stabilizer chosen from at least one of substituted or unsubstituted alkyl phosphate esters, substituted or unsubstituted aryl phosphate esters, mixed substituted or unsubstituted alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof. The phosphate esters include esters in which the phosphoric acid is fully esterified or only partially esterified.

[00353] In one embodiment, for example, the thermal stabilizers useful in the invention can include at least one phosphate ester.

[00354] In another embodiment, the phosphate esters useful in the invention can include but are not limited to alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, and/or mixtures thereof.

[00355] In certain embodiments, the phosphate esters useful in the invention are those where the groups on the phosphate ester include are alkyl, alkoxy-alkyl, phenyl, or substituted phenyl groups. These phosphate esters are generally referred to herein as alkyl and/or aryl phosphate esters. Certain preferred embodiments include trialkyl phosphates, triaryl phosphates, alkyl diaryl phosphates, dialkyl aryl phosphates, and mixtures of such phosphates, wherein the alkyl groups are preferably those containing from 2 to 12 carbon atoms, and the aryl groups are preferably phenyl.

[00356] Representative alkyl and branched alkyl groups are preferably those containing from 1-12 carbon atoms, including, but not limited to, ethyl, propyl, isopropyl, butyl, hexyl, cyclohexyl, 2-ethylhexyl, octyl, decyl and dodecyl. Substituted alkyl groups include, but are not limited to, those containing at least one of carboxylic acid groups and esters thereof, hydroxyl groups, amino groups, keto groups, and the like.

[00357] Representative of alkyl-aryl and substituted alkyl-aryl groups are those wherein the alkyl portion contains from 1-12 carbon atoms, and the aryl group is

phenyl or substituted phenyl wherein groups such as alkyl, branched alkyl, aryl, hydroxyl, and the like are substituted for hydrogen at any carbon position on the phenyl ring. Preferred aryl groups include phenyl or substituted phenyl wherein groups such as alkyl, branched alkyl, aryl, hydroxyl and the like are substituted for hydrogen at any position on the phenyl ring.

[00358] In one embodiment, the phosphate esters useful as thermal stabilizers in the invention include but are not limited to dibutylphenyl phosphate, triphenyl phosphate, tricresyl phosphate, tributyl phosphate, tri-2-ethylhexyl phosphate, trioctyl phosphate, and/or mixtures thereof, including particularly mixtures of tributyl phosphate and tricresyl phosphate, and mixtures of isocetyl diphenyl phosphate and 2-ethylhexyl diphenyl phosphate.

[00359] In one embodiment, the phosphate esters useful as thermal stabilizers in the invention include but are not limited to, at least one of the following: trialkyl phosphates, triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

[00360] In one embodiment, the phosphate esters useful as thermal stabilizers in the invention include but are not limited to, at least one of the following: triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

[00361] In one embodiment, the phosphate esters useful as thermal stabilizers in the invention include but are not limited to, at least one of the following: triaryl phosphates and mixed alkyl aryl phosphates.

[00362] In one embodiment, at least one thermal stabilizer useful in the invention comprises, but is not limited to, triaryl phosphates, such as, for example, triphenyl phosphate. In one embodiment, at least one one thermal stabilizer comprises, but is not limited to Merpol A. In one embodiment, at least one thermal stabilizer useful in the invention comprises, but is not limited to, at least one of triphenyl phosphate and Merpol A. Merpol A is a phosphate ester commercially available from Stepan Chemical Co and/or E.I. duPont de Nemours & Co. The CAS Registry number for Merpol A is believed to be CAS Registry # 37208-27-8.

[00363] In one embodiment, the polyester compositions and/or processes of the invention may comprise 2-ethylhexyl diphenyl phosphate.

[00364] The term "thermal stabilizer" is intended to include the reaction product(s) thereof. The term "reaction product" as used in connection with the thermal stabilizers of the invention refers to any product of a polycondensation or esterification reaction between the thermal stabilizer and any of the monomers used in making the polyester as well as the product of a polycondensation or esterification reaction between the catalyst and any other type of additive.

[00365] When phosphorus is added to the polyesters and/or polyester compositions and/or process of making the polyesters of the invention, it is added in the form of a phosphorus compound, for example, at least one phosphate ester(s). The amount of phosphorus compound(s), (for example, at least one phosphate ester), is added to the polyesters of the invention and/or polyester compositions of the invention and/or processes of the invention can be measured in the form of phosphorus atoms present in the final polyester, for example, by weight measured in ppm.

[00366] • Amounts of thermal stabilizer added during polymerization or post manufacturing can include but are not limited to: 1 to 5000 ppm; 1 to 1000 ppm, 1 to 900 ppm, 1 to 800 ppm, 1 to 700 ppm. 1 to 600 ppm, 1 to 500 ppm, 1 to 400 ppm, 1 to 350 ppm, 1 to 300 ppm, 1 to 250 ppm, 1 to 200 ppm, 1 to 150 ppm, 1 to 100 ppm;10 to 5000 ppm; 10 to 1000 ppm, 10 to 900 ppm, 10 to 800 ppm, 10 to 700 ppm. 10 to 600 ppm, 10 to 500 ppm, 10 to 400 ppm, 10 to 350 ppm, 10 to 300 ppm, 10 to 250 ppm, 10 to 200 ppm, 10 to 150 ppm, 10 to 100 ppm; based on the total weight of the polyester composition.

[00367] In one embodiment, amounts of the phosphate ester of the invention added during polymerization are chosen from the following: 1 to 5000 ppm; 1 to 1000 ppm, 1 to 900 ppm, 1 to 800 ppm, 1 to 700 ppm. 1 to 600 ppm, 1 to 500 ppm, 1 to 400 ppm, 1 to 350 ppm, 1 to 300 ppm, 1 to 250 ppm, 1 to 200 ppm, 1 to 150 ppm, 1 to 100 ppm; 1 to 60 ppm; 2 to 5000 ppm; 2 to 1000 ppm, 2 to 900 ppm, 2 to 800 ppm, 2 to 700 ppm. 2 to 600 ppm, 2 to 500 ppm, 2 to 400 ppm, 2 to 350 ppm, 2 to 300 ppm, 2 to 250 ppm, 2 to 200 ppm, 2 to 150 ppm, 2 to 100 ppm; 2 to 60 ppm; 2 to 20 ppm, 3 to 5000 ppm; 3 to 1000 ppm, 3 to 900 ppm, 3 to 800 ppm, 3 to 700 ppm. 3 to 600 ppm, 3 to 500 ppm, 3 to 400 ppm, 3 to 350 ppm, 3 to 300 ppm, 3 to 250 ppm, 3 to 200 ppm, 3 to 150 ppm, 3 to 100 ppm; 3

to 60 ppm; 3 to 20 ppm, 4 to 5000 ppm; 4 to 1000 ppm, 4 to 900 ppm, 4 to 800 ppm, 4 to 700 ppm, 4 to 600 ppm, 4 to 500 ppm, 4 to 400 ppm, 4 to 350 ppm, 4 to 300 ppm, 4 to 250 ppm, 4 to 200 ppm, 4 to 150 ppm, 4 to 100 ppm; 4 to 60 ppm; 4 to 20 ppm, 5 to 5000 ppm; 5 to 1000 ppm, 5 to 900 ppm, 5 to 800 ppm, 5 to 700 ppm, 5 to 600 ppm, 5 to 500 ppm, 5 to 400 ppm, 5 to 350 ppm, 5 to 300 ppm, 5 to 250 ppm, 5 to 200 ppm, 5 to 150 ppm, 5 to 100 ppm; 5 to 60 ppm; 5 to 20 ppm, 6 to 5000 ppm; 6 to 1000 ppm, 6 to 900 ppm, 6 to 800 ppm, 6 to 700 ppm, 6 to 600 ppm, 6 to 500 ppm, 6 to 400 ppm, 6 to 350 ppm, 6 to 300 ppm, 6 to 250 ppm, 6 to 200 ppm, 6 to 150 ppm, 6 to 100 ppm; 6 to 60 ppm; 6 to 20 ppm, 7 to 5000 ppm; 7 to 1000 ppm, 7 to 900 ppm, 7 to 800 ppm, 7 to 700 ppm, 7 to 600 ppm, 7 to 500 ppm, 7 to 400 ppm, 7 to 350 ppm, 7 to 300 ppm, 7 to 250 ppm, 7 to 200 ppm, 7 to 150 ppm, 7 to 100 ppm; 7 to 60 ppm; 7 to 20 ppm, 8 to 5000 ppm; 8 to 1000 ppm, 8 to 900 ppm, 8 to 800 ppm, 8 to 700 ppm, 8 to 600 ppm, 8 to 500 ppm, 8 to 400 ppm, 8 to 350 ppm, 8 to 300 ppm, 8 to 250 ppm, 8 to 200 ppm, 8 to 150 ppm, 8 to 100 ppm; 8 to 60 ppm; 8 to 20 ppm, 9 to 5000 ppm; 9 to 1000 ppm, 9 to 900 ppm, 9 to 800 ppm, 9 to 700 ppm, 9 to 600 ppm, 9 to 500 ppm, 9 to 400 ppm, 9 to 350 ppm, 9 to 300 ppm, 9 to 250 ppm, 9 to 200 ppm, 9 to 150 ppm, 9 to 100 ppm; 9 to 60 ppm; 9 to 20 ppm, 10 to 5000 ppm; 10 to 1000 ppm, 10 to 900 ppm, 10 to 800 ppm, 10 to 700 ppm. 10 to 600 ppm, 10 to 500 ppm, 10 to 400 ppm, 10 to 350 ppm, 10 to 300 ppm, 10 to 250 ppm, 10 to 200 ppm, 10 to 150 ppm, 10 to 100 ppm, 10 to 60 ppm, 10 to 20 ppm, 50 to 5000 ppm, 50 to 1000 ppm, 50 to 900 ppm, 50 to 800 ppm, 50 to 700 ppm, 50 to 600 ppm, 50 to 500 ppm, 50 to 400 ppm, 50 to 350 ppm, 50 to 300 ppm, 50 to 250 ppm, 50 to 200 ppm, 50 to 150 ppm, 50 to 100 ppm; 50 to 80 ppm, 100 to 5000 ppm, 100 to 1000 ppm, 100 to 900 ppm, 100 to 800 ppm, 100 to 700 ppm, 100 to 600 ppm, 100 to 500 ppm, 100 to 400 ppm, 100 to 350 ppm, 100 to 300 ppm, 100 to 250 ppm, 100 to 200 ppm, 100 to 150 ppm; 150 to 5000 ppm, 150 to 1000 ppm, 150 to 900 ppm, 150 to 800 ppm, 150 to 700 ppm, 150 to 600 ppm, 150 to 500 ppm, 150 to 400 ppm, 150 to 350 ppm, 150 to 300 ppm, 150 to 250 ppm, 150 to 200 ppm, 200 to 5000 ppm, 200 to 1000 ppm, 200 to 900 ppm, 200 to 800 ppm, 200 to 700 ppm, 200 to 600 ppm, 200 to 500 ppm, 200 to 400 ppm, 200 to 350 ppm, 200 to 300 ppm, 200 to 250 ppm, 250 to 5000 ppm, 250 to

1000 ppm, 250 to 900 ppm, 250 to 800 ppm, 250 to 700 ppm, 250 to 600 ppm, 250 to 500 ppm, 250 to 400 ppm, 250 to 350 ppm, 250 to 300 ppm, 500 to 5000 ppm, 300 to 1000 ppm, 300 to 900 ppm, 300 to 800 ppm, 300 to 700 ppm, 300 to 600 ppm, 300 to 500 ppm, 300 to 400 ppm, 300 to 350 ppm, 350 to 5000 ppm, 350 to 1000 ppm, 350 to 900 ppm, 350 to 800 ppm, 350 to 700 ppm, 350 to 600 ppm, 350 to 500 ppm, 350 to 400 ppm; based on the total weight of the polyester composition and as measured in the form of phosphorus atoms in the final polyester.

[00368] The invention further relates to a polymer blend. The blend comprises:

(a) from 5 to 95 weight % of at least one of the polyesters described above; and

(b) from 5 to 95 weight % of at least one of the polymeric components.

[00369] Suitable examples of the polymeric components include, but are not limited to, nylon; polyesters different than those described herein; polyamides such as ZYTEL® from DuPont; polystyrene; polystyrene copolymers; styrene acrylonitrile copolymers; acrylonitrile butadiene styrene copolymers; poly(methylmethacrylate); acrylic copolymers; poly(ether-imides) such as ULTEM® (a poly(ether-imide) from General Electric); polyphenylene oxides such as poly(2,6-dimethylphenylene oxide) or poly(phenylene oxide)/polystyrene blends such as NORYL 1000® (a blend of poly(2,6-dimethylphenylene oxide) and polystyrene resins from General Electric); polyphenylene sulfides; polyphenylene sulfide/sulfones; poly(ester-carbonates); polycarbonates such as LEXAN® (a polycarbonate from General Electric); polysulfones; polysulfone ethers; and poly(ether-ketones) of aromatic dihydroxy compounds; or mixtures of any of the foregoing polymers. The blends can be prepared by conventional processing techniques known in the art, such as melt blending or solution blending. In one embodiment, polycarbonate is not present in the polyester composition. If polycarbonate is used in a blend in the polyester compositions of the invention, the blends can be visually clear. However, polyester compositions useful in the invention also contemplate the exclusion of polycarbonate as well as the inclusion of polycarbonate.

[00370] Polycarbonates useful in the invention may be prepared according to known procedures, for example, by reacting the dihydroxyaromatic compound with a carbonate precursor such as phosgene, a haloformate or a carbonate ester, a molecular weight regulator, an acid acceptor and a catalyst. Methods for preparing polycarbonates are known in the art and are described, for example, in U.S. Patent 4,452,933, where the disclosure regarding the preparation of polycarbonates is hereby incorporated by reference herein.

[00371] Examples of suitable carbonate precursors include, but are not limited to, carbonyl bromide, carbonyl chloride, and mixtures thereof; diphenyl carbonate; a di(halophenyl)carbonate, e.g., di(trichlorophenyl) carbonate, di(tribromophenyl) carbonate, and the like; di(alkylphenyl)carbonate, e.g., di(tolyl)carbonate; di(naphthyl)carbonate; di(chloronaphthyl)carbonate, and mixtures thereof; and bis-haloformates of dihydric phenols.

[00372] Examples of suitable molecular weight regulators include, but are not limited to, phenol, cyclohexanol, methanol, alkylated phenols, such as octylphenol, para-tertiary-butyl-phenol, and the like. In one embodiment, the molecular weight regulator is phenol or an alkylated phenol.

[00373] The acid acceptor may be either an organic or an inorganic acid acceptor. A suitable organic acid acceptor can be a tertiary amine and includes, but is not limited to, such materials as pyridine, triethylamine, dimethylaniline, tributylamine, and the like. The inorganic acid acceptor can be either a hydroxide, a carbonate, a bicarbonate, or a phosphate of an alkali or alkaline earth metal.

[00374] The catalysts used in making the polycarbonates useful in the invention that can be used include, but are not limited to, those that typically aid the polymerization of the monomer with phosgene. Suitable catalysts include, but are not limited to, tertiary amines such as triethylamine, tripropylamine, N,N-dimethylaniline, quaternary ammonium compounds such as, for example, tetraethylammonium bromide, cetyl triethyl ammonium bromide, tetra-n-heptylammonium iodide, tetra-n-propyl ammonium bromide, tetramethyl ammonium chloride, tetra-methyl ammonium hydroxide, tetra-n-butyl ammonium iodide, benzyltrimethyl ammonium chloride and quaternary phosphonium

compounds such as, for example, n-butyltriphenyl phosphonium bromide and methyltriphenyl phosphonium bromide.

[00375] The polycarbonates useful in the polyester compositions of the invention also may be copolyestercarbonates such as those described in U.S. Patents 3,169,121; 3,207,814; 4,194,038; 4,156,069; 4,430,484, 4,465,820, and 4,981,898, where the disclosure regarding copolyestercarbonates from each of the U.S. Patents is incorporated by reference herein.

[00376] Copolyestercarbonates useful in this invention can be available commercially and/or may be prepared by known methods in the art. For example, they can be typically obtained by the reaction of at least one dihydroxyaromatic compound with a mixture of phosgene and at least one dicarboxylic acid chloride, especially isophthaloyl chloride, terephthaloyl chloride, or both.

[00377] In addition, the polyester compositions and the polymer blend compositions useful in the invention may also contain from 0.01 to 25% by weight of the overall composition common additives such as colorants, dyes, mold release agents, flame retardants, plasticizers, nucleating agents, stabilizers, including but not limited to, UV stabilizers, thermal stabilizers and/or reaction products thereof, fillers, and impact modifiers. Examples of typical commercially available impact modifiers well known in the art and useful in this invention include, but are not limited to, ethylene/propylene terpolymers, functionalized polyolefins such as those containing methyl acrylate and/or glycidyl methacrylate, styrene-based block copolymeric impact modifiers, and various acrylic core/shell type impact modifiers. Residues of such additives are also contemplated as part of the polyester composition

[00378] Reinforcing materials may be useful in the compositions of this invention. The reinforcing materials may include, but are not limited to, carbon filaments, silicates, mica, clay, talc, titanium dioxide, Wollastonite, glass flakes, glass beads and fibers, and polymeric fibers and combinations thereof. In one embodiment, the reinforcing materials include glass, such as, fibrous glass filaments, mixtures of glass and talc, glass and mica, and glass and polymeric fibers.

[00379] Suitable catalysts for use in the processes of the invention to make the polyesters useful in the invention include at least one tin compound. The polyester compositions of the invention may also comprise at least one of the tin compounds useful in the processes of the invention. Other catalysts could possibly be used in the invention in combination with the at least one tin compound Other catalysts may include, but are not limited to, those based on titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds, and an aluminum compound with lithium hydroxide or sodium hydroxide. In one embodiment, the catalyst can be a combination of at least one tin compound and at least one titanium compound.

[00380] Catalyst amounts can range from 10 ppm to 20,000 ppm or 10 to10,000 ppm, or 10 to 5000 ppm or 10 to 1000 ppm or 10 to 500 ppm, or 10 to 300 ppm or 10 to 250 ppm based on the catalyst metal and based on the weight of the final polymer. The process can be carried out in either a batch or continuous process. In one embodiment, the catalyst is a tin compound. In one embodiment, the catalyst is solely a tin compound. In one embodiment, the tin compound can be used in either the esterification reaction or the polycondensation reaction or both reactions. In another embodiment, the catalyst is solely a tin compound useful in the polyesters useful in the invention and/or the processes of making the polyesters of the invention. In one embodiment, the catalyst comprises a tin compound used in the esterification reaction. Generally, in one embodiment, the tin compound catalyst is used in amounts of from about 0.005% to about 0.2% based on the weight of the dicarboxylic acid or dicarboxylic acid ester. Generally, in one embodiment, less than about 700 ppm elemental tin based on polyester weight should be present as residue in the polyester based on the total weight of the polyester.

[00381] When tin is added to to the polyesters and/or polyester compositions and/or process of making the polyesters of the invention, it is added to the process of making the polyester in the form of a tin compound. The amount of the tin compound added to the polyesters of the invention and/or polyester compositions of the invention and/or processes of the invention can be measured

in the form of tin atoms present in the final polyester, for example, by weight measured in ppm.

[00382] In another embodiment, the catalyst is solely a tin compound used in the esterification reaction in the amount of 10 ppm to 20,000 ppm or 10 to10,000 ppm, or 10 to 5000 ppm or 10 to 4500 ppm or 10 to 4000 ppm or 10 to 3500 ppm or 10 to 3000 ppm or 10 to 2500 ppm or 10 to 2000 ppm or or 10 to 1500 ppm or 10 to 1000 ppm or 10 to 500 ppm, or 10 to 300 ppm or 10 to 250 ppm or 15 ppm to 20,000 ppm or 15 to10,000 ppm, or 15 to 5000 ppm or or 15 to 4500 ppm or 15 to 4000 ppm or 15 to 3500 ppm or 15 to 3000 ppm or 15 to 2500 ppm or 15 to 2000 ppm or or 15 to 1500 ppm or 15 to 1000 ppm or 15 to 500 ppm, or 15 to 400 ppm or 15 to 300 ppm or 15 to 250 ppm or 20 ppm to 20,000 ppm or 20 to10,000 ppm, or 20 to 5000 ppm or or 20 to 4500 ppm or 20 to 4000 ppm or 20 to 3500 ppm or 20 to 3000 ppm or 20 to 2500 ppm or 20 to 2000 ppm or or 20 to 1500 ppm or 20 to 1000 ppm or 20 to 500 ppm, or 20 to 300 ppm or 20 to 250 ppm 25 ppm to 20,000 ppm or 25 to10,000 ppm, or 25 to 5000 ppm or or 25 to 4500 ppm or 25 to 4000 ppm or 25 to 3500 ppm or 25 to 3000 ppm or 25 to 2500 ppm or 25 to 2000 ppm or or 25 to 1500 ppm or 25 to 1000 ppm or 25 to 500 ppm, or 25 to 400 ppm, or 25 to 300 ppm or 25 to 250 ppm or 30 ppm to 20,000 ppm or 30 to10,000 ppm, or 30 to 5000 ppm or 30 to 4500 ppm or 30 to 4000 ppm or 30 to 3500 ppm or 30 to 3000 ppm or 30 to 2500 ppm or 30 to 2000 ppm or or 30 to 1500 ppm pr 30 to 1000 ppm or 30 to 500 ppm, or 30 to 300 ppm or 30 to 250 ppm or 35 ppm to 20,000 ppm or 35 to10,000 ppm, or 35 to 5000 ppm or 35 to 4500 ppm or 35 to 4000 ppm or 35 to 3500 ppm or 35 to 3000 ppm or 35 to 2500 ppm or 35 to 2000 ppm or or 35 to 1500 ppm or 35 to 1000 ppm or 35 to 500 ppm, or 35 to 300 ppm or 35 to 250 ppm or 40 ppm to 20,000 ppm or 40 to10,000 ppm, or 40 to 5000 ppm or or 40 to 4500 ppm or 40 to 4000 ppm or 40 to 3500 ppm or 40 to 3000 ppm or 40 to 2500 ppm or 40 to 2000 ppm or or 40 to 1500 ppm or 40 to 1000 ppm or 40 to 500 ppm, or 40 to 300 ppm or 40 to 250 ppm or 40 to 200 ppm or 45 ppm to 20,000 ppm or 45 to10,000 ppm, or 45 to 5000 ppm or 45 to 4500 ppm or 45 to 4000 ppm or 45 to 3500 ppm or 45 to 3000 ppm or 45 to 2500 ppm or 45 to 2000 ppm or 45 to 1500 ppm or 45 to 1000 ppm or 45 to 500 ppm, or 45 to 300 ppm or 45 to 250 ppm or 50 ppm to 20,000 ppm

or 50 to10,000 ppm, or 50 to 5000 ppm or 50 to 4500 ppm or 50 to 4000 ppm or 50 to 3500 ppm or 50 to 3000 ppm or 50 to 2500 ppm or 50 to 2000 ppm or or 50 to 1500 ppm or 50 to 1000 ppm or 50 to 500 ppm, or 50 to 300 ppm or 50 to 250 ppm or 50 to 200 ppm or 50 to 150 ppm 50 to 125 ppm, based on the weight of the final polyester, as measured in the form of tin atoms in the final polyester.

[00383] In another embodiment, the polyesters of the invention can be prepared using at least one tin compound as catalyst. For example, see U.S. Pat. No. 2,720,507, where the portion concerning tin catalysts is incorporated herein by reference. These catalysts are tin compounds containing at least one organic radical. These catalysts include compounds of both divalent or tetravalent tin which have the general formulas set forth below:

A. $M_2(Sn(OR)_4)$

B. $MH(Sn(OR)_4)$

C. $M'(Sn(OR)_4)$

D. $M'(HSn(OR)_4)_2$

E. $M_2(Sn(OR)_6)$

F. $MH(Sn(OR)_6)$

G. $M'(Sn(OR)_6)$

H. $M'(HSn(OR)_6)_2$

I. $Sn(OR)_2$

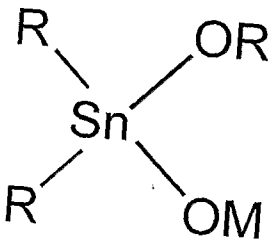
J. $Sn(OR)_4$

K. SnR'_2

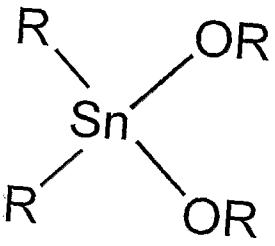
L. SnR'_4

M. R'_2SnO

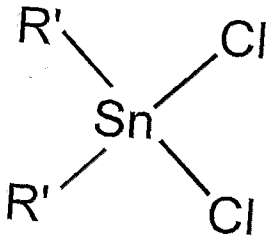
N.



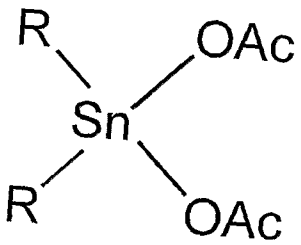
O.



P.



Q.



wherein M is an alkali metal, e.g. lithium, sodium, or potassium, M' is an alkaline earth metal such as Mg, Ca or Sr, each R represents an alkyl radical containing from 1 to 8 carbon atoms, each R' radical represents a substituent selected from those consisting of alkyl radicals containing from 1 to 8 carbon atoms (i. e. R radicals) and aryl radicals of the benzene series containing from 6 to 9 carbon atoms (e.g. phenyl, tolyl, benzyl, phenylethyl, etc., radicals), and Ac represents an acyl radical derived from an organic acid containing from 2 to 18 carbon atoms (e.g. acetyl, butyryl, lauroyl, benzoyl, stearoyl, etc.).

[00384] The novel bimetallic alkoxide catalysts can be made as described by Meerwein, Ann. 476, 113 (1929). As shown by Meerwein, these catalysts are not merely mixtures of the two metallic alkoxides. They are definite compounds having a salt-like structure. These are the compounds depicted above by the Formulas A through H. Those not specifically described by Meerwein can be prepared by procedures analogous to the working examples and methods set forth by Meerwein.

[00385] The other tin compounds can also be made by various methods such as those described in the following literature: For the preparation of diaryl tin dihalides (Formula P) see Ber. 62, 996 (1929); J. Am. Chem. Soc. 49, 1369 (1927). For the preparation of dialkyl tin dihalides (Formula P) see J. Am. Chem. Soc. 47, 2568 (1925) ; C.A. 41, 90 (1947). For the preparation of diaryl tin oxides (Formula M) see J. Am. Chem. Soc. 48, 1054 (1926). For the preparation of tetraaryl tin compounds (Formula K) see C.A. 32, 5387 (1938). For the preparation of tin alkoxides (Formula J) see C.A. 24, 586 (1930). For the preparation of alkyl tin salts (Formula Q) see C.A. 31, 4290. For the preparation of alkyl tin compounds (Formula K and L) see C.A. 35, 2470 (1941): C.A. 33, 5357 (1939). For the preparation of mixed alkyl aryl tin (Formulas K and L) see C.A. 31, 4290 (1937): C.A. 38, 331 (1944). For the preparation of other tin compounds not covered by these citations see "Die Chemie der Metal-Organischen Verbindungen." by Krause and V. Grosse, published in Berlin, 1937, by Gebroder-Borntrager.

[00386] The tin alkoxides (Formulas I and J) and the bimetallic alkoxides (Formulas A through H) contain R substituents which can represent both straight

chain and branched chain alkyl radicals, e.g. diethoxide, tetramethoxide, tetrabutoxide, tetra-tert-butoxide, tetrahexoxide, etc.

[00387] The alkyl derivatives (Formulas K and L) contain one or more alkyl radicals attached to a tin atom through a direct C-Sn linkage, e.g. dibutyl tin, dihexyl tin, tetra-butyl tin, tetraethyl tin, tetramethyl tin, dioctyl tin, etc. Two of the tetraalkyl radicals can be replaced with an oxygen atom to form compounds having Formula M, e.g. dimethyl tin oxide, diethyl tin oxide, dibutyl tin oxide, diheptyl tin oxide, etc. In one embodiment, the tin catalyst comprises dimethyl tin oxide.

[00388] Complexes can be formed by reacting dialkyl tin oxides with alkali metal alkoxides in an alcohol solution to form compounds having Formula N, which compounds are especially useful catalysts, e.g. react dibutyl tin oxide with sodium ethoxide, etc. This formula is intended to represent the reaction products described. Tin compounds containing alkyl and alkoxy radicals are also useful catalysts (see Formula O), e.g. diethyl tin diethoxide, dibutyl tin dibutoxide, dihexyl tin dimethoxide, etc.

[00389] Salts derived from dialkyl tin oxides reacted with carboxylic acids or hydrochloric acid are also of particular value as catalysts; see Formulas P and Q. Examples of these catalytic condensing agents include dibutyl tin diacetate, diethyl tin dibutyrate, dibutyl tin dilauroate, dimethyl tin dibenzoate, dibutyl tin dichloride, diethyl tin dichloride, dioctyl tin dichloride, dihexyl tin distearate, etc.

[00390] The tin compounds having Formulas K, L and M can be prepared wherein one or more of the R' radicals represents an aryl radical of the benzene series, e.g. phenyl, tolyl, benzyl, etc. Examples include diphenyl tin, tetraphenyl tin, diphenyl dibutyl tin, ditolyl diethyl tin, diphenyl tin oxide, dibenzyl tin, tetrabenzyl tin, di([B-phenylethyl) tin oxide, dibenzyl tin oxide, etc.

[00391] Examples of catalysts useful in the present invention include, but are not limited to, one of more of the following: butyltin tris-2-ethylhexanoate, dibutyltin diacetate, dibutyltin oxide, and dimethyl tin oxide.

[00392] In one embodiment, catalysts useful in the present invention include, but are not limited to, one or more of the following: butyltin tris-2-ethylhexanoate, dibutyltin diacetate, dibutyltin oxide, and dimethyl tin oxide.

[00393] Processes for preparing polyesters using tin-based catalysts are well known and described in the aforementioned U.S. Pat. No. 2,720, 507.

[00394] The polyester portion of the polyester compositions useful in the invention can be made by processes known from the literature such as, for example, by processes in homogenous solution, by transesterification processes in the melt, and by two phase interfacial processes. Suitable methods include, but are not limited to, the steps of reacting one or more dicarboxylic acids with one or more glycols at a temperature of 100°C to 315°C at a pressure of 0.1 to 760 mm Hg for a time sufficient to form a polyester. See U.S. Patent No. 3,772,405 for methods of producing polyesters, the disclosure regarding such methods is hereby incorporated herein by reference.

[00395] The polyester in general may be prepared by condensing the dicarboxylic acid or dicarboxylic acid ester with the glycol in the presence of the tin catalyst described herein at elevated temperatures increased gradually during the course of the condensation up to a temperature of about 225°-310° C., in an inert atmosphere, and conducting the condensation at low pressure during the latter part of the condensation, as described in further detail in U.S. Pat. No. 2, 720, 507 incorporated herein by reference.

[00396] In another aspect, this invention relates to a process for preparing copolyesters of the invention. In one embodiment, the process relates to preparing copolyesters comprising terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. This process comprises the steps of:

(A) heating a mixture comprising the monomers useful in the polyesters of the invention in the presence of at least one tin catalyst and at least one phosphate ester at a temperature of 150 to 250°C for a time sufficient to produce an initial polyester;

(B) polycondensing the product of Step (A) by heating it at a temperature of 240 to 320°C for 1 to 6 hours; and

(C) removing any unreacted glycols.

[00397] Reaction times for the esterification Step (A) are dependent upon the selected temperatures, pressures, and feed mole ratios of glycol to dicarboxylic acid.

[00398] In one embodiment, step (A) can be carried out until 50% by weight or more of the 2,2,4,4-tetramethyl-1,3-cyclobutanediol has been reacted. Step (A) may be carried out under pressure, ranging from 0 psig to 100 psig. The term "reaction product" as used in connection with any of the catalysts useful in the invention refers to any product of a polycondensation or esterification reaction with the catalyst and any of the monomers used in making the polyester as well as the product of a polycondensation or esterification reaction between the catalyst and any other type of additive.

[00399] Typically, Step (B) and Step (C) can be conducted at the same time. These steps can be carried out by methods known in the art such as by placing the reaction mixture under a pressure ranging, from 0.002 psig to below atmospheric pressure, or by blowing hot nitrogen gas over the mixture.

[00400] In one embodiment, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; and wherein the total mole % of the glycol component of the final polyester is 100 mole %.

[00401] In one embodiment, the invention comprises a process for making any of the polyesters useful in the invention comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %;

wherein the total mole % of the glycol component of the final polyester is 100 mole %;

wherein at least one phosphorus compound, for example, at least one phosphate ester, is added to Step (I), Step (II) and/or Steps (I) and (II); and

wherein the addition of the phosphorus compound(s), for example, at least one phosphate ester, results in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester useful in the invention of 2-10:1.

[00402] For example, in the previous two paragraphs, at least one phosphorus compound can be added in Step (I), (II) and/or in both Steps (I) and (II) of the process. In one embodiment, the phosphorus compound(s) are added in Step (I). The phosphorus compounds can comprise at least one phosphate ester, for example.

[00403] In any of the processes of the invention useful in making the polyesters useful in the invention, at least one thermal stabilizer, reaction products thereof, and mixtures thereof can be added either during esterification, polycondensation, or both and/or it can be added post-polymerization. In one embodiment, the thermal stabilizer useful in any of the processes of the invention can be added during esterificaton. In one embodiment, if the thermal stabilizer added after both

esterification and polycondensation, it is added in the amount of 1 to 2 weight % based on the total weight of the final polyester. In one embodiment, the thermal stabilizer can comprise at least one phosphorus compound useful in the invention. In one embodiment, the thermal stabilizer can comprise at least one phosphate ester. In one embodiment, the thermal stabilizer can comprise at least one phosphorus compound which is added during the esterificaton step. In one embodiment, the thermal stabilizer can comprise at least one phosphate ester, for example, which is added during the esterificaton step.

[00404] It is believed that any of the processes of making the polyesters useful in the invention may be used to make any of the polyesters useful in the invention.

[00405] Reaction times for the esterification Step (I) are dependent upon the selected temperatures, pressures, and feed mole ratios of glycol to dicarboxylic acid.

[00406] In one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 20 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 10 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 5 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 3 torr absolute to 0.02 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 20 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 10 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 5 torr absolute to 0.1 torr absolute; in one embodiment, the pressure used in Step (II) of any of the processes of the invention consists of at least one pressure chosen from 3 torr absolute to 0.1 torr absolute.

[00407] In one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.0-1.5/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.5/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.3/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.2/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.15/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.01-1.01-1.10/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.5/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.3/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.2/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.15/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.03-1.10/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.5/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.3/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.2/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.15/1.0; and. in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the

processes of the invention is 1.05-1.15/1.0; in one embodiment, the molar ratio of glycol component/dicarboxylic acid component added in Step (I) of any of the processes of the invention is 1.05-1.10/1.0.

[00408] In any of the process embodiments for making the polyesters useful in the invention, the heating time of Step (II) may be from 1 to 5 hours or 1 to 4 hours or 1 to 3 hours or 1.5 to 3 hours or 1 to 2 hours. In one embodiment, the heating time of Step (II) can be from 1.5 to 3 hours.

[00409] In one embodiment, the addition of the phosphate ester(s) in the process(es) of the invention can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyesters useful in the invention of 2-10:1. In one embodiment, the addition of the phosphate ester(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 5-9:1. In one embodiment, the addition of the phosphate ester(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 6-8:1. In one embodiment, the addition of the phosphate ester(s) in the process(es) can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of 7:1. For example, the weight of tin atoms and phosphorus atoms present in the final polyester can be measured in ppm and can result in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester of any of the aforesaid weight ratios.

[00410] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 15 to 400 ppm tin atoms based on the weight of the final polyester.

[00411] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

[00412] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

[00413] In one embodiment, the amount of tin atoms in the final polyesters useful in the invention can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

[00414] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester.

[00415] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester.

[00416] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester.

[00417] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 15 to 400 ppm tin atoms based on the weight of the final polyester.

[00418] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 1 to 100 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

[00419] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

[00420] In one embodiment, the amount of phosphorus atoms in the final polyesters useful in the invention can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester and the amount of tin atoms in the final polyester can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

[00421] The invention further relates to the polyester compositions made by the process(es) described above.

[00422] The invention further relates to the film(s) and/or sheet(s) comprising the polyester compositions of the invention. The methods of forming the polyesters into film(s) and/or sheet(s) are well known in the art. Examples of film(s) and/or sheet(s) of the invention including but not limited to extruded film(s) and/or sheet(s), calendered film(s) and/or sheet(s), compression molded film(s) and/or sheet(s), solution casted film(s) and/or sheet(s). Methods of making film and/or sheet include but are not limited to extrusion, calendering, compression molding, and solution casting.

[00423] Examples of potential articles made from film and/or sheet useful in the invention include, but are not limited, to uniaxially stretched film, biaxially stretched film, shrink film (whether or not uniaxially or biaxially stretched), liquid crystal display film (including, but not limited to, diffuser sheets, compensation films and protective films), thermoformed sheet, graphic arts film, outdoor signs, skylights, coating(s), coated articles, painted articles, laminates, laminated articles, and/or multiwall films or sheets.

[00424] "Graphic art film," as used herein, is a film having a thermally-curable ink (e.g., heat-curable ink or air-curable ink) or radiation-curable ink (e.g., ultra-violet-curable ink) printed thereon or therein. "Curable" refers to capable of undergoing polymerization and/or crosslinking. In addition to the ink, the graphic art film may optionally also include varnishes, coatings, laminates, and adhesives.

[00425] Exemplary thermally or air-cured inks involve pigment(s) dispersed in one or more standard carrier resins. The pigment can be 4B Toner (PR57), 2B Toner (PR48), Lake Red C (PR53), lithol red (PR49), iron oxide (PR101), Permanent Red R (PR4), Permanent Red 2G (PO5), pyrazolone orange (PO13), diaryl yellows (PY12, 13, 14), monoazo yellows (PY3,5,98), phthalocyanine green (PG7), phthalocyanine Blue, β form (PB15), ultramarine (PB62), permanent violet (PV23), titanium dioxide (PW6), carbon black (furnace/channel) (PB7), PMTA pink, green, blue, violet (PR81, PG1, PB1, PV3,), copper ferrocyanide dye complexes (PR169, PG45, PB62, PV27), or the like. (Parenthetical identifications in the foregoing refer to the generic color index prepared by the Society of Dyers and Colourists.) Such pigments and combinations thereof can be used to obtain

various colors including, but not limited to, white, black, blue, violet, red, green, yellow, cyan, magenta, or orange.

[00426] Other exemplary inks, including radiation-cured inks are disclosed in U.S. Patent No. 5,382,292, where the disclosure of such inks are incorporated herein by reference.

[00427] Examples of typical carrier resins used in standard inks include those which have nitrocellulose, amide, urethane, epoxide, acrylate, and/or ester functionalities. Standard carrier resins include one or more of nitrocellulose, polyamide, polyurethane, ethyl cellulose, cellulose acetate propionate, (meth)acrylates, poly(vinyl butyral), poly(vinyl acetate), poly(vinyl chloride), and the like. Such resins can be blended, with widely used blends including nitrocellulose/polyamide and nitrocellulose/polyurethane.

[00428] Ink resin(s) normally can be solvated or dispersed in one or more solvents. Typical solvents employed include, but are not limited to, water, alcohols (e.g., ethanol, 1-propanol, isopropanol, etc.), acetates (e.g., n-propyl acetate), aliphatic hydrocarbons, aromatic hydrocarbons (e.g., toluene), and ketones. Such solvents typically can be incorporated in amounts sufficient to provide inks having viscosities, as measured on a #2 Zahn cup as known in the art, of at least 15 seconds, such as at least 20 seconds, at least 25 seconds, or from 25 to 35 seconds.

[00429] In one embodiment, the polyester have sufficient Tg values to allow thermoformability, and to allow ease of printing.

[00430] In one embodiment, the graphic art film has at least one property chosen from thermoformability, toughness, clarity, chemical resistance, Tg, and flexibility.

[00431] Graphic art films can be used in a variety of applications, such as, for example, in-mold decorated articles, embossed articles, hard-coated articles. The graphic art film can be smooth or textured.

[00432] Exemplary graphic art films include, but are not limited to, nameplates; membrane switch overlays (e.g., for an appliance); point of purchase displays; flat or in-mold decorative panels on washing machines; flat touch panels on refrigerators (e.g., capacitive touch pad arrays); flat panel on ovens; decorative

interior trim for automobiles (e.g., a polyester laminate) ; instrument clusters for automobiles; cell phone covers; heating and ventilation control displays; automotive console panels; automotive gear shift panels; control displays or warning signals for automotive instrument panels; facings, dials or displays on household appliances; facings, dials or displays on washing machines; facings, dials or displays on dishwashers; keypads for electronic devices; keypads for mobile phones, personal digital assistants (PDAs, or hand-held computers) or remote controls; displays for electronic devices; displays for hand-held electronic devices such as phones and PDAs; panels and housings for mobile or standard phones; logos on electronic devices; and logos for hand-held phones.

[00433] Multiwall film or sheet refers to sheet extruded as a profile consisting of multiple layers that are connected to each other by means of vertical ribs. Examples of multiwall film or sheet include but are not limited to outdoor shelters (for example, greenhouses and commercial canopies).

[00434] Examples of extruded articles comprising the polyester compositions useful in this invention include, but are not limited to, thermoformed sheet, film for graphic arts applications, outdoor signs, skylights, multiwall film, plastic film for plastic glass laminates, and liquid crystal display (LCD) films, including but not limited to, diffuser sheets, compensation films, and protective films for LCDs.

[00435] Other articles within the scope of the invention comprising the polyester compositions of the invention include but are not limited to safety/sport (examples including but not limited to: safety shields, face shields, sports goggles [racquetball, ski, etc...], police riot shields); corrugated sheet articles; recreation/outdoor vehicles and devices (examples including but not limited to: lawn tractors, snow mobiles, motorcycle windshield, camper windows, golf cart windshield, jet ski); residential and commercial lighting (examples including but not limited to: diffusers, office, home and commercial fixtures; High Intensity Discharge (HID) Lighting); telecommunications/business equipment/electronics (examples including but not limited to cell phone housing, TV housing, computer housing, stereo housing, PDAs, etc); optical media; tanning beds; multiwall sheet, extruded articles; rigid medical packaging; intravenous components; dialysis filter housing; blood therapy containers; sterilization containers (for example, infant

care sterilization containers); pacifiers, tool handles (examples including but not limited to screw drivers, hammer, etc.); thermoplastic articles; sound barriers; automotive exterior (headlight covers, taillight covers, side windows, sunroof); rigid consumer/industrial packaging; tubs;showers; hot tubs; machine guards; vending machine display panels; meters; sports and recreation (examples: swimming pool enclosures, stadium seats, hockey rink, open air structures, ski gondola); fish aquarium; ophthalmic products, decorative block windows; and interior automotive (instrument clusters).

[00436] The invention further relates to bottles described herein. The methods of forming the polyesters into bottles are well known in the art. Examples of bottles include but are not limited to bottles such as pharmaceutical bottles, baby bottles; water bottles; juice bottles; large commercial water bottles having a weight from 200 to 800 grams; beverage bottles which include but are not limited to two liter bottles, 20 ounce bottles, 16.9 ounce bottles; medical bottles; personal care bottles, carbonated soft drink bottles; hot fill bottles; water bottles; alcoholic beverage bottles such as beer bottles and wine bottles; and bottles comprising at least one handle. These bottles include but are not limited to injection blow molded bottles, injection stretch blow molded bottles, extrusion blow molded bottles, and extrusion stretch blow molded bottles. Methods of making bottles include but are not limited to extrusion blow molding, extrusion stretch blow molding, injection blow molding, and injection stretch blow molding. In each case, the invention further relates to the preforms (or parisons) used to make each of said bottles.

[00437] These bottles include, but are not limited to, injection blow molded bottles, injection stretch blow molded bottles, extrusion blow molded bottles, and extrusion stretch blow molded bottles. Methods of making bottles include but are not limited to extrusion blow molding, extrusion stretch blow molding, thermoforming, injection blow molding, and injection stretch blow molding.

[00438] Other examples of containers include, but are not limited to, containers for cosmetics and personal care applications including bottles, jars, vials and tubes; sterilization containers; buffet steam pans; food pans or trays; frozen food trays; microwaveable food trays; hot fill containers, amorphous lids or sheets to

seal or cover food trays; food storage containers; for example, boxes; tumblers, pitchers, cups, bowls, including but not limited to those used in restaurant smallware; beverage containers; retort food containers; centrifuge bowls; vacuum cleaner canisters, and collection and treatment canisters.

[00439] "Restaurant smallware," as used herein, refers to any container used for eating or serving food. Examples of restaurant smallware include pitchers, cups, mugs optionally including handles (including decorative mugs, single-or double walled mugs, pressurized mugs, vacuum mugs), bowls (e.g., serving bowls, soup bowls, salad bowls), and plates (e.g., eating and serving plates, such as buffet plates, saucers, dinner plates).

[00440] In one embodiment, the containers used as restaurant smallware are capable of withstanding refrigerator temperatures ranging from greater than 0°C (e.g., 2°C) to 5°C. In another embodiment, the restaurant smallware containers can withstand steam treatments and/or commercial dishwasher conditions. In another embodiment, the restaurant smallware containers are capable of withstanding microwave conditions. In one embodiment, restaurant smallware containers have at least one property chosen from toughness, clarity, chemical resistance, Tg, hydrolytic stability, and dishwasher stability.

[00441] In one embodiment, the medical devices comprising the polyester compositions of the invention include but are not limited to medical devices comprising an ultraviolet light (UV)-curable, silicone-based coating, on at least a portion of a surface of a medical device comprising a polyester comprising a cyclobutanediol, which improves protein resistance and biocompatibility, may be coated on various substrates, and overcomes several difficulties identified in previously disclosed methods.

[00442] In one embodiment, the present invention comprises a thermoplastic article, typically in the form of sheet material, having a decorative material embedded therein which comprise any of the compositions described herein.

[00443] "Food storage container," as used herein, are capable of storing and/or serving hot and/or cold food and/or beverages at temperatures customarily used for storing and serving foods and beverages, e.g., ranging from deep freezer temperatures to hot temperatures such as those in a low temperature oven or

those used in hot beverage dispensers. In one embodiment, the food storage container can be sealed to reduce the rate of food oxidation. In another embodiment, the food storage container can be used to display and serve the food to dining customers. In one embodiment, the food storage containers are capable of being stored in a freezer, e.g., at temperatures less than 0°C, such as temperatures ranging from -20 to 0°C (e.g., -18°C). In another embodiment, the food storage containers are capable of storing food in the refrigerator at temperatures ranging from greater than 0°C (e.g., 2°C) to 5°C. In another embodiment, the food storage containers can withstand steam treatments and/or commercial dishwasher conditions. In another embodiment, the food storage containers are capable of withstanding microwave conditions.

[00444] Examples of food storage containers include buffet steam pans, buffet steam trays, food pans, hot and cold beverage dispensers (e.g. refrigerator beverage dispensers, automated hot or cold beverage dispensers), and food storage boxes.

[00445] In one embodiment, food storage containers have at least one additional property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00446] . In one embodiment of the invention, there is provided a thermoplastic article which is obtained by applying heating and pressure to one or more laminates or "sandwiches", wherein at least one of said laminates comprises, in order, (1) at least one upper sheet material, (2) at least one decorative material, and (3) at least one lower sheet material. Optionally, an adhesive layer may be used between (1) and (2) and/or between (2) and (3). Any of layers (1), (2) and/or (3) of the "sandwich" may comprise any of the compositions of the invention.

[00447] "Ophthalmic product" as used herein, refers to prescription eyeglass lenses, nonprescription eyeglass lenses, sunglass lenses, and eyeglass and sunglass frames.

[00448] In one embodiment, the ophthalmic product is chosen from tinted eyeglass lenses and hardcoated eyeglass lenses. In one embodiment, the

eyeglass lenses, such as the tinted eyeglass lenses or hardcoated eyeglass lenses, comprise at least one polarizing film or polarizing additive.

[00449] In one embodiment, when the product is a lens, the ophthalmic product has a refractive index ranging from 1.54 to 1.56.

[00450] In one embodiment, the ophthalmic product can have at least one property chosen from toughness, clarity, chemical resistance (e.g., for withstanding lens cleaners, oils, hair products, etc.), Tg, and hydrolytic stability.

[00451] "Outdoor sign," as used herein, refers to a surface formed from the polyester described herein, or containing symbols (e.g., numbers, letters, words, pictures, etc.), patterns, or designs coated with the polyester or polyester film described herein. In one embodiment, the outdoor sign comprises a polyester containing printed symbols, patterns, or designs. In one embodiment, the sign is capable of withstanding typical weather conditions, such as rain, snow, ice, sleet, high humidity, heat, wind, sunlight, or combinations thereof, for a sufficient period of time, e.g., ranging from one day to several years or more.

[00452] Exemplary outdoor signs include, but are not limited to, billboards, neon signs, electroluminescent signs, electric signs, fluorescent signs, and light emitting diode (LED) displays. Other exemplary signs include, but are not limited to, painted signs, vinyl decorated signs, thermoformed signs, and hardcoated signs.

[00453] In one embodiment, the outdoor sign has at least one property chosen from thermoformability, toughness, clarity, chemical resistance, and Tg.

[00454] A "vending machine display panel," as used herein, refers to a front or side panel on a vending machine that allows a customer to view the items for sale, or advertisement regarding such items. In one embodiment, the vending machine display panel can be a visually clear panel of a vending machine through which a consumer can view the items on sale. In other embodiments, the vending machine display panel can have sufficient rigidity to contain the contents within the machine and/or to discourage vandalism and/or theft.

[00455] In one embodiment, the vending machine display panel can have dimensions well known in the art, such as planar display panels in snack,

beverage, popcorn, or sticker/ticket vending machines, and capsule display panels as in, e.g., gumball machines or bulk candy machines.

[00456] In one embodiment, the vending machine display panel can optionally contain advertising media or product identification indicia. Such information can be applied by methods well known in the art, e.g., silk screening.

[00457] In one embodiment, the vending machine display panel can be resistant to temperatures ranging from -100 to 120°C. In another embodiment, the vending machine display panel can be UV resistant by the addition of, e.g., at least one UV additive, as disclosed herein.

[00458] In one embodiment, the vending machine display panel has at least one property chosen from thermoformability, toughness, clarity, chemical resistance, and Tg.

[00459] "Point of purchase display," as used herein, refers to a wholly or partially enclosed casing having at least one visually clear panel for displaying an item. Point of purchase displays are often used in retail stores to for the purpose of catching the eye of the customer. Exemplary point of purchase displays include enclosed wall mounts, countertops, enclosed poster stands, display cases (e.g., trophy display cases), sign frames, and cases for computer disks such as CDs and DVDs. The point of purchase display can include shelves, and additional containers, such as holders for magazines or pamphlets. One of ordinary skill in the art can readily envision the shape and dimensions for the point of purchase display depending on the item to be displayed. For example, the display can be as small as a case for jewelry, or a larger enclosed cabinet for displaying multiple trophies.

[00460] In one embodiment, the point of purchase display has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00461] "Intravenous component," as used herein, refers to components made from a polymeric material used for administering fluids (e.g., medicaments, nutrients) to the bloodstream of a patient. In one embodiment, the intravenous component is a rigid component.

[00462] Exemplary intravenous components include y-site connector assemblies, luer components, filters, stopcocks, manifolds, and valves. A y-site connector has a "Y" shape including a first arm having a first passage, a second arm having a second passage, and a third arm connected with said first and second arms and having a third passage communicating with said first and second passages. Luer components can include luer locks, connections, and valves.

[00463] In one embodiment, the intravenous component can withstand sterilization treatments, such as high pressure steam sterilization, ethylene oxide gas sterilization, radiation sterilization, and dry-heating sterilization. In one embodiment, the intravenous component has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00464] A "dialysis filter housing," as used herein, refers to a protective casing having a plurality of openings for holding a plurality of hollow fibers or tubing, which can be used for introducing and discharging a dialyzate to a patient. In one embodiment, a cross-sectional area of one opening in the protective casing ranges from 0.001 cm^2 to less than 50 cm^2.

[00465] In one embodiment, the dialysis filter housing has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00466] "Blood therapy containers," as used herein, refers to those containers used in administering and withdrawing blood to and from a patient. Exemplary blood therapy containers include oxygenators, cassettes, centrifuge bowls, collection and treatment canisters, pump cartridges, venal port housings, and dialyzer housings. Oxygenators can remove carbon dioxide from the venous blood of the patient, introduce oxygen to the withdrawn blood to convert it into arterial blood, and introduce the oxygenated blood to the patient. Other containers can be used to temporarily house the withdrawn or stored blood prior to its administration to the patient.

[00467] In one embodiment, the blood therapy container can withstand sterilization treatments, such as high pressure steam sterilization, ethylene oxide gas sterilization, radiation sterilization, and dry-heating sterilization. In one

embodiment, the blood therapy container has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00468] "Appliance parts," as used herein, refers to a rigid piece used in conjunction with an appliance. In one embodiment, the appliance part is partly or wholly separable from the appliance. In another embodiment, the appliance part is one that is typically made from a polymer. In one embodiment, the appliance part is visually clear.

[00469] Exemplary appliance parts include those requiring toughness and durabilty, such as cups and bowls used with food processers, mixers, blenders, and choppers; parts that can withstand refrigerator and freezer temperatures (e.g., refrigerator temperatures ranging from greater than 0°C (e.g., 2°C) to 5°C, or freezer temperatures, e.g., at temperatures less than 0°C, such as temperatures ranging from -20 to 0°C, e.g., -18°C), such as refrigerator and freezer trays, bins, and shelves; parts having sufficient hydrolytic stability at temperatures up to 90°C, such as washing machine doors, steam cleaner canisters, tea kettles, and coffee pots; and vacuum cleaner canisters and dirt cups.

[00470] In one embodiment, these appliance parts have at least one property chosen from toughness, clarity, chemical resistance, Tg, hydrolytic stability, and dishwasher stability. The appliance part can also be chosen from steam cleaner canisters, which, in one embodiment, can have at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00471] In one embodiment, the polyesters useful in the appliance part has a Tg of 105 to 140°C and the appliance part is chosen from vacuum cleaner canisters and dirt cups. In another embodiment, the polyesters useful in the appliance part has a Tg of 120 to 150°C and the appliance part is chosen from steam cleaner canisters, tea kettles and coffee pots.

[00472] "Skylight," as used herein, refers to a light permeable panel secured to a roof surface such that the panel forms a portion of the ceiling. In one embodiment, the panel is rigid, e.g., has dimensions sufficient to achieve stability and durability, and such dimensions can readiliy be determined by one skilled in

the art. In one embodiment, the skylight panel has a thickness greater than 3/16 inches, such as a thickness of at least 1/2 inches.

[00473] In one embodiment, the skylight panel is visually clear. In one embodiment, the skylight panel can transmit at least 35% visible light, at least 50%, at least 75%, at least 80%, at least 90%, or even at least 95% visible light. In another embodiment, the skylight panel comprises at least one UV additive that allows the skylight panel to block up to 80%, 90%, or up to 95% UV light.

[00474] In one embodiment, the skylight has at least one property chosen from thermoformability, toughness, clarity, chemical resistance, and Tg.

[00475] "Outdoor shelters," as used herein, refer to a roofed and/or walled structure capable of affording at least some protection from the elements, e.g., sunlight, rain, snow, wind, cold, etc., having at least one rigid panel. In one embodiment, the outdoor shelter has at least a roof and/or one or more walls. In one embodiment, the outdoor shelter has dimensions sufficient to achieve stability and durability, and such dimensions can readiliy be determined by one skilled in the art. In one embodiment, the outdoor shelter panel has a thickness greater than 3/16 inches.

[00476] In one embodiment, the outdoor shelter panel is visually clear. In one embodiment, the outdoor shelter panel can transmit at least 35% visible light, at least 50%, at least 75%, at least 80%, at least 90%, or even at least 95% visible light. In another embodiment, the outdoor shelter panel comprises at least one UV additive that allows the outdoor shelter to block up to 80%, 90%, or up to 95% UV light.

[00477] Exemplary outdoor shelters include security glazings, transportation shelters (e.g., bus shelters), telephone kiosks, and smoking shelters. In one embodiment, where the shelter is a transportation shelter, telephone kiosk, or smoking shelter, the shelter has at least one property chosen from thermoformability, toughness, clarity, chemical resistance, and Tg. In one embodiment, where the shelter is a security glazing, the shelter has at least one property chosen from toughness, clarity, chemical resistance, and Tg.

[00478] A "canopy," as used herein, refers to a roofed structure capable of affording at least some protection from the elements, e.g., sunlight, rain, snow,

wind, cold, etc. In one embodiment, the roofed structure comprises, either in whole or in part, at least one rigid panel, e.g., has dimensions sufficient to achieve stability and durability, and such dimensions can readiliy be determined by one skilled in the art. In one embodiment, the canopy panel has a thickness greater than 3/16 inches, such as a thickness of at least 1/2 inches.

[00479] In one embodiment, the canopy panel is visually clear. In one embodiment, the canopy panel can transmit at least 35% visible light, at least 50%, at least 75%, at least 80%, at least 90%, or even at least 95% visible light. In another embodiment, the canopy panel comprises at least one UV additive that allows the canopy to block up to 80%, 90%, or up to 95% UV light.

[00480] Exemplary canopies include covered walkways, roof lights, sun rooms, airplane canopies, and awnings. In one embodiment, the canopy has at least one property chosen from toughness, clarity, chemical resistance, Tg, and flexibility.

[00481] A "sound barrier," as used herein, refers to a rigid structure capable of reducing the amount of sound transmission from one point on a side of the structure to another point on the other side when compared to sound transmission between two points of the same distance without the sound barrier. The effectiveness in reducing sound transmission can be assessed by methods known in the art. In one embodiment, the amount of sound transmission that is reduced ranges from 25 % to 90 %.

[00482] In another embodiment, the sound barrier can be rated as a sound transmission class value, as described in, for example, ASTM E90, "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements," and ASTM E413, "Classification of Rating Sound Insulation." An STC 55 barrier can reduce the sound of a jet engine, ~130 dBA, to 60 dBA, which is the sound level within a typical office. A sound proof room can have a sound level ranging from 0-20 dBA. One of ordinary skill in the art can construct and arrange the sound barrier to achieve a desired STC rating. In one embodiment, the sound barrier has an STC rating of at least 20, such as a rating ranging from 20 to 60.

[00483] In one embodiment, the sound barrier comprises a plurality of panels connected and arranged to achieve the desired barrier outline. The sound barriers can be used along streets and highways to dampen automotive noises. Alternatively, the sound barriers can be used in the home or office, either as a discrete panel or panels, or inserted within the architecture of the walls, floors, ceilings, doors, and/or windows.

[00484] In one embodiment, the sound barrier is visually clear. In one embodiment, the sound barrier can transmit at least 35% visible light, at least 50%, at least 75%, at least 80%, at least 90%, or even at least 95% visible light. In another embodiment, the sound barrier comprises at least one UV additive that allows the sound barrier to block up to 80%, 90%, or up to 95% UV light.

[00485] In one embodiment, the sound barrier has at least one property chosen from toughness, clarity, chemical resistance, and Tg.

[00486] A "greenhouse," as used herein, refers to an enclosed structure used for the cultivation and/or protection of plants. In one embodiment, the greenhouse is capable of maintaining a humidity and/or gas (oxygen, carbon dioxide, nitrogen, etc.) content desirable for cultivating plants while being capable of affording at least some protection from the elements, e.g., sunlight, rain, snow, wind, cold, etc. In one embodiment, the roof of the greenhouse comprises, either in whole or in part, at least one rigid panel, e.g., has dimensions sufficient to achieve stability and durability, and such dimensions can readiliy be determined by one skilled in the art. In one embodiment, the greenhouse panel has a thickness greater than 3/16 inches, such as a thickness of at least 1/2 inches.

[00487] In one embodiment, the greenhouse panel is visually clear. In another embodiment, substantially all of the roof and walls of the greenhouse are visually clear. In one embodiment, the greenhouse panel can transmit at least 35% visible light, at least 50%, at least 75%, at least 80%, at least 90%, or even at least 95% visible light. In another embodiment, the greenhouse panel comprises at least one UV additive that allows the greenhouse panel to block up to 80%, 90%, or up to 95% UV light.

[00488] In one embodiment, the greenhouse panel has at least one property chosen from toughness, clarity, chemical resistance, and Tg.

[00489] An "optical medium," as used herein, refers to an information storage medium in which information is recorded by irradiation with a laser beam, e.g., light in the visible wavelength region, such as light having a wavelength ranging from 600 to 700 nm. By the irradiation of the laser beam, the irradiated area of the recording layer is locally heated to change its physical or chemical characteristics, and pits are formed in the irradiated area of the recording layer. Since the optical characteristics of the formed pits are different from those of the area having been not irradiated, the digital information is optically recorded. The recorded information can be read by reproducing procedure generally comprising the steps of irradiating the recording layer with the laser beam having the same wavelength as that employed in the recording procedure, and detecting the light-reflection difference between the pits and their periphery.

[00490] In one embodiment, the optical medium comprises a transparent disc having a spiral pregroove, a recording dye layer placed in the pregroove on which information is recorded by irradiation with a laser beam, and a light-reflecting layer. The optical medium is optionally recordable by the consumer. In one embodiment, the optical medium is chosen from compact discs (CDs) and digital video discs (DVDs). The optical medium can be sold with prerecorded information, or as a recordable disc.

[00491] In one embodiment, at least one of the following comprises the polyester of the invention: the substrate, at least one protective layer of the optical medium, and the recording layer of the optical medium.

[00492] In one embodiment, the optical medium has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00493] "Infant-care sterilization container," as used herein, refers to a container configured to hold infant-care products for use in in-home sterilization of the infant-care products. In one embodiment, the infant-care sterilization container is a baby bottle sterilization container.

[00494] In one embodiment, infant-care sterilization containers have at least one additional property chosen from toughness, clarity, chemical resistance, Tg, hydrolytic stability, and dishwasher stability.

[00495] "Pacifiers" as used herein, comprise a flexible nipple (e.g., for an infant to suck and/or bite) surrounded by a rigid mouth shield, where the rigid mouth shield is optionally connected to a handle, allowing the infant or supervising adult a convenient structure for gripping and/or holding the pacifier. The handle may be rigid or flexible.

[00496] In one embodiment, the pacifier can be made of multiple components. For example, the nipple can pass through an aperture in the center of the mouth shield. The handle may or may not be integrally connected to the mouth shield. The handle can be rigid or flexible.

[00497] In another embodiment, the nipple and mouth shield of the pacifier is formed as an integral unit. Generally, the selection of plastic is governed by the need to provide a relatively rigid mount shield and handle. In this embodiment, the nipple of the pacifier may be more rigid yet still be desirable for an infant to suck or bite.

[00498] In one embodiment, pacifiers have at least one property chosen from toughness, clarity, chemical resistance, Tg, hydrolytic stability, and dishwasher stability.

[00499] A "retort food container," as used herein, refers to flexible container or pouch for storing food and/or beverages, in which the food and/or beverage is hermetically sealed for long-term unrefrigerated storage. The food can be sealed under vacuum or an inert gas. The retort food container can comprise at least one polyester layer, e.g., a single layer or multi-layer container. In one embodiment, a multi-layer container includes a light reflecting inner layer, e.g., a metallized film.

[00500] In one embodiment, at least one foodstuff chosen from vegetables, fruit, grain, soups, meat, meat products, dairy products, sauces, dressings, and baking supplies is contained in the retort food container.

[00501] In one embodiment, the retort food container has at least one property chosen from toughness, clarity, chemical resistance, Tg, and hydrolytic stability.

[00502] A "glass laminate," as used herein, refers to at least one coating on a glass, where at least one of the coatings comprises the polyester. The coating can be a film or a sheet. The glass can be clear, tinted, or reflective. In one

embodiment, the laminate is permanently bonded to the glass, e.g., applying the laminate under heating and pressure to form a single, solid laminated glass product. One or both faces of the glass can be laminated. In certain embodiments, the glass laminate contains more than one coating comprising the polyester compositions of the present invention. In other embodiments, the glass laminate comprises multiple glass substrates, and more than one coating comprising the polyester compositions of the present invention.

[00503] Exemplary glass laminates include windows (e.g., windows for high rise buildings, building entrances), safety glass, windshields for transportation applications (e.g., automotive, buses, jets, armored vehicles), bullet proof or resistant glass, security glass (e.g., for banks), hurricane proof or resistant glass, airplane canopies, mirrors, solar glass panels, flat panel displays, and blast resistant windows. The glass laminate can be visually clear, be frosted, etched, or patterned.

[00504] In one embodiment the glass laminate can be resistant to temperatures ranging from -100 to 120°C. In another embodiment, the glass laminate can be UV resistant by the addition of, e.g., at least one UV additive, as disclosed herein.

[00505] Methods for laminating the films and/or sheets of the present invention to the glass are well known to one of ordinary skill in the art. Lamination without the use of an adhesive layer may be performed by vacuum lamination. To obtain an effective bond between the glass layer and the laminate, in one embodiment, the glass has a low surface roughness.

[00506] Alternatively, a double-sided adhesive tape, an adhesive layer, or a gelatin layer, obtained by applying, for example, a hotmelt, a pressure- or thermo-sensitive adhesive, or a UV or electron-beam curable adhesive, can be used to bond the laminate of the present invention to the glass. The adhesive layer may be applied to the glass sheet, to the laminate, or to both, and may be protected by a stripping layer, which can be removed just before lamination.

[00507] In one embodiment, the glass laminate has at least one property chosen from toughness, clarity, chemical resistance, hydrolytic stability, and Tg.

[00508] For the purposes of this invention, the term "wt" means "weight".

[00509] The following examples further illustrate how the polyesters of the invention can be made and evaluated, and are intended to be purely exemplary of the invention and are not intended to limit the scope thereof. Unless indicated otherwise, parts are parts by weight, temperature is in degrees C or is at room temperature, and pressure is at or near atmospheric.

EXAMPLES

[00510] The following examples illustrate in general how a polyester is prepared and the effect of using 2,2,4,4-tetramethyl-1,3-cyclobutanediol (and various cis/trans mixtures) on various polyester properties such as toughness, glass transition temperature, inherent viscosity, etc., compared to polyesters comprising 1,4-cyclohexanedimethanol and/or ethylene glycol residues, but lacking 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Additionally, based on the following examples, the skilled artisan will understand how the thermal stabilizers of the invention can be used in the preparation of polyesters containing them.

Measurement Methods

[00511] The inherent viscosity of the polyesters was determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C, and is reported in dL/g.

[00512] Unless stated otherwise, the glass transition temperature (T_g) was determined using a TA DSC 2920 instrument from Thermal Analyst Instruments at a scan rate of 20°C/min according to ASTM D3418.

[00513] The glycol content and the cis/trans ratio of the compositions were determined by proton nuclear magnetic resonance (NMR) spectroscopy. All NMR spectra were recorded on a JEOL Eclipse Plus 600MHz nuclear magnetic resonance spectrometer using either chloroform-trifluoroacetic acid (70-30 volume/volume) for polymers or, for oligomeric samples, 60/40(wt/wt) phenol/ tetrachloroethane with deuterated chloroform added for lock. Peak assignments for 2,2,4,4-tetramethyl-1,3-cyclobutanediol resonances were made by comparison to model mono- and dibenzoate esters of 2,2,4,4-tetramethyl-1,3-cyclobutanediol. These model compounds closely approximate the resonance positions found in the polymers and oligomers.

[00514] The crystallization half-time, $t_{1/2}$, was determined by measuring the light transmission of a sample via a laser and photo detector as a function of time on a temperature controlled hot stage. This measurement was done by exposing the polymers to a temperature, T_{max}, and then cooling it to the desired temperature.

The sample was then held at the desired temperature by a hot stage while transmission measurements were made as a function of time. Initially, the sample was visually clear with high light transmission and became opaque as the sample crystallized. The crystallization half-time was recorded as the time at which the light transmission was halfway between the initial transmission and the final transmission. T_{max} is defined as the temperature required to melt the crystalline domains of the sample (if crystalline domains are present). The T_{max} reported in the examples below represents the temperature at which each sample was heated to condition the sample prior to crystallization half time measurement. The T_{max} temperature is dependant on composition and is typically different for each polyester. For example, PCT may need to be heated to some temperature greater than 290°C to melt the crystalline domains.

[00515] Density was determined using a gradient density column at 23°C.

[00516] The melt viscosity reported herein was measured by using a Rheometrics Dynamic Analyzer (RDA II). The melt viscosity was measured as a function of shear rate, at frequencies ranging from 1 to 400 rad/sec, at the temperatures reported. The zero shear melt viscosity (η_o) is the melt viscosity at zero shear rate estimated by extrapolating the data by known models in the art. This step is automatically performed by the Rheometrics Dynamic Analyzer (RDA II) software.

[00517] The polymers were dried at a temperature ranging from 80 to 100°C in a vacuum oven for 24 hours and injection molded on a Boy 22S molding machine to give 1/8x1/2x5-inch and 1/4x1/2x5-inch flexure bars. These bars were cut to a length of 2.5 inch and notched down the ½ inch width with a 10-mil notch in accordance with ASTM D256. The average Izod impact strength at 23°C was determined from measurements on 5 specimens.

[00518] In addition, 5 specimens were tested at various temperatures using 5°C increments in order to determine the brittle-to-ductile transition temperature. The brittle-to-ductile transition temperature is defined as the temperature at which 50% of the specimens fail in a brittle manner as denoted by ASTM D256.

[00519] Color values reported herein are CIELAB L*, a*, and b* values measured following ASTM D 6290-98 and ASTM E308-99, using measurements

from a Hunter Lab Ultrascan XE Spectrophotometer (Hunter Associates Laboratory Inc., Reston, VA) with the following parameters: (1) D65 illuminant, (2) 10 degree observer, (3) reflectance mode with specular angle included, (4) large area view, (5) 1" port size. The measurements were performed on polymer granules ground to pass a 6 mm sieve.

[00520] The percent foam in the polyesters of the invention was measured as follows. A 20 mL Headspace Vial supplied by MicroLiter Analytical Supplies, Suwanee, Ga. was placed on laboratory scale, 5 grams of dried polymer was added and the weight was recorded. Water was then carefully added until the vial was full and this weight was then recorded. The difference in weight (wt1) was recorded and used to estimate the vial volume with polymer containing no foam. This value was used for all subsequent runs. For each test, 5 grams of dried polymer sample was added to a clean Headspace Vial. A septum cap was attached to the top of the vial and the vial purged with dry nitrogen gas for approximately one minute. The purge line was removed and a dry nitrogen line equipped with a bubbler was inserted into the septum cap to ensure inert gas at atmospheric (ambient) pressure was maintained in the vial during the heating time. The vial was then placed into a pre-heated 300°C heating block (drilled out for a loose but close fit for vial) and held in the block for 15 minutes. The vial was then removed and air-cooled on a laboratory bench. After the vial was cooled, the vial top was removed and the vial was placed on a laboratory scale and weighed. Once the weight was recorded, water was carefully added to completely fill the vial. In this context, to completely fill the vial means to add water to the top of vial as judged to be the same height as when determining wt1) and the weight recorded. The difference in these weights (wt2) was calculated. By subtracting wt2 from wt1, the amount of "displaced water" by the foaming of the polymer is determined (wt3 = wt1 - wt2). It was assumed that for this test the density of water is one, which allows these weights to be converted into volumes, V1=wt1, V2=wt2, and V3=wt3. The "% foam in the polyester" is calculated by the following formula: "% foam in the polymer"= V3/[(5g polymer/Density of dry polyester in g/mL)+ V3]. In this formula, the density of the dry polyesters of the invention comprising about 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol

was 1.17 g/mL. This 1.17 g/mL value did not change significantly for the polyesters tested with a composition in the range from 40% to 50% mol TMCD. The density value for dry polyesters of about 20 mole % TCMD was 1.18 g/mL. The % Foam is a volume % of void volume in the after-test polymer. A visual grade of the final polymer sample after heating and cooling can also be determined.

[00521] The amount of tin (Sn) in the examples below is reported in part per million (ppm) of metal and was measured by x-ray fluorescence (xrf) using a PANanalytical Axios Advanced wavelength dispersive x-ray fluorescence spectrometer. The amount of phosphorous is similarly reported as ppm of elemental phosphorus and was also measured by xrf using the same instrument.

[00522] 10-mil films of selected polyester samples were compression molded using a Carver press at 240°C. Inherent viscosity was measured on these films as described above.

[00523] Unless otherwise specified, the cis/trans ratio of the 1,4 cyclohexanedimethanol used in the following examples was approximately 30/70, and could range from 35/65 to 25/75. Unless otherwise specified, the cis/trans ratio of the 2,2,4,4-tetramethyl-1,3-cyclobutanediol used in the following examples was approximately 50/50.

[00524] The following abbreviations apply throughout the working examples and figures:

TPA	Terephthalic acid
DMT	Dimethyl therephthalate
TMCD	2,2,4,4-tetramethyl-1,3-cyclobutanediol
CHDM	1,4-cyclohexanedimethanol
IV	Inherent viscosity
TPP	Triphenyl phosphate
DBTO	Dibutyl tin oxide
DMTO	Dimethyl tin oxide
η_o	Zero shear melt viscosity
T_g	Glass transition temperature
T_{bd}	Brittle-to-ductile transition temperature
T_{max}	Conditioning temperature for crystallization half time measurements

Example 1

[00525] This example illustrates that 2,2,4,4-tetramethyl-1,3-cyclobutanediol is more effective at reducing the crystallization rate of PCT than ethylene glycol or isophthalic acid. In addition, this example illustrates the benefits of 2,2,4,4-tetramethyl-1,3-cyclobutanediol on the glass transition temperature and density.

[00526] A variety of copolyesters were prepared as described below. These copolyesters were all made with 200 ppm dibutyl tin oxide as the catalyst in order to minimize the effect of catalyst type and concentration on nucleation during crystallization studies. The cis/trans ratio of the 1,4-cyclohexanedimethanol was 31/69 while the cis/trans ratio of the 2,2,4,4-tetramethyl-1,3-cyclobutanediol is reported in Table 1.

[00527] For purposes of this example, the samples had sufficiently similar inherent viscosities thereby effectively eliminating this as a variable in the crystallization rate measurements.

[00528] Crystallization half-time measurements from the melt were made at temperatures from 140 to 200°C at 10°C increments and are reported in Table 1. The fastest crystallization half-time for each sample was taken as the minimum value of crystallization half-time as a function of temperature, typically occurring around 170 to 180°C. The fastest crystallization half-times for the samples are plotted in Figure 1 as a function of mole% comonomer modification to PCT.

[00529] The data shows that 2,2,4,4-tetramethyl-1,3-cyclobutanediol is more effective than ethylene glycol and isophthalic acid at decreasing the crystallization rate (i.e., increasing the crystallization half-time). In addition, 2,2,4,4-tetramethyl-1,3-cyclobutanediol increases T_g and lowers density.

Table 1

Crystallization Half-times (min)

Example	Comonomer (mol %)[1]	IV (dl/g)	Density (g/ml)	T_g (°C)	T_{max} (°C)	at 140 °C (min)	at 150 °C (min)	at 160 °C (min)	at 170 °C (min)	at 180 °C (min)	at 190 °C (min)	at 200 °C (min)
1A	20.2 % A[2]	0.630	1.198	87.5	290	2.7	2.1	1.3	1.2	0.9	1.1	1.5
1B	19.8 % B	0.713	1.219	87.7	290	2.3	2.5	1.7	1.4	1.3	1.4	1.7
1C	20.0 % C	0.731	1.188	100.5	290	>180	>60	35.0	23.3	21.7	23.3	25.2
1D	40.2 % A[2]	0.674	1.198	81.2	260	18.7	20.0	21.3	25.0	34.0	59.9	96.1
1E	34.5 % B	0.644	1.234	82.1	260	8.5	8.2	7.3	7.3	8.3	10.0	11.4
1F	40.1 % C	0.653	1.172	122.0	260	>10 days	>5 days	>5 days	19204	> 5 days	>5 days	>5 days
1G	14.3 % D	0.646[3]	1.188	103.0	290	55.0	28.8	11.6	6.8	4.8	5.0	5.5
1H	15.0 % E	0.728[4]	1.189	99.0	290	25.4	17.1	8.1	5.9	4.3	2.7	5.1

1 The balance of the diol component of the polyesters in Table 1 is 1, 4-cyclohexanedimethanol; and the balance of the dicarboxylic acid component of the polyesters in Table 1 is dimethyl terephthalate; if the dicarboxylic acid is not described, it is 100 mole % dimethyl terephthalate.

2 100 mole % 1,4-cyclohexanedimethanol.

3 A film was pressed from the ground polyester of Example 1G at 240°C. The resulting film had an inherent viscosity value of 0.575 dL/g.

4 A film was pressed from the ground polyester of Example 1H at 240°C. The resulting film had an inherent viscosity value of 0.0.652 dL/g.

where: A is Isophthalic Acid

B is Ethylene Glycol

C is 2,2,4,4-Tetramethyl-1,3-cyclobutanediol (approx. 50/50 cis/trans)

D is 2,2,4,4-Tetramethyl-1,3-cyclobutanediol (98/2 cis/trans)

E is 2,2,4,4-Tetramethyl-1,3-cyclobutanediol (5/95 cis/trans)

[00530]

[00531] As shown in Table 1 and Figure 1, 2,2,4,4-tetramethyl-1,3-cyclobutanediol is more effective than other comonomers, such ethylene glycol and isophthalic acid, at increasing the crystallization half-time, i.e., the time required for a polymer to reach half of its maximum crystallinity. By decreasing the crystallization rate of PCT (increasing the crystallization half-time),

amorphous articles based on 2,2,4,4-tetramethyl-1,3-cyclobutanediol-modified PCT as described herein may be fabricated by methods known in the art. As shown in Table 1, these materials can exhibit higher glass transition temperatures and lower densities than other modified PCT copolyesters.

[00532] Preparation of the polyesters shown on Table 1 is described below.

Example 1A

[00533] This example illustrates the preparation of a copolyester with a target composition of 80 mol% dimethyl terephthalate residues, 20 mol % dimethyl isophthalate residues, and 100 mol% 1,4-cyclohexanedimethanol residues (28/72 cis/trans).

[00534] A mixture of 56.63 g of dimethyl terephthalate, 55.2 g of 1,4-cyclohexanedimethanol, 14.16 g of dimethyl isophthalate, and 0.0419 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 210°C. The stirring speed was set to 200 RPM throughout the experiment. The contents of the flask were heated at 210°C for 5 minutes and then the temperature was gradually increased to 290°C over 30 minutes. The reaction mixture was held at 290°C for 60 minutes and then vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 5 minutes. A pressure of 0.3 mm of Hg was maintained for a total time of 90 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 87.5°C and an inherent viscosity of 0.63 dl/g. NMR analysis showed that the polymer was composed of 100 mol% 1,4-cyclohexanedimethanol residues and 20.2 mol% dimethyl isophthalate residues.

Example 1B

[00535] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 20 mol % ethylene glycol residues, and 80 mol% 1,4-cyclohexanedimethanol residues (32/68 cis/trans).

[00536] A mixture of 77.68 g of dimethyl terephthalate, 50.77 g of 1,4-cyclohexanedimethanol, 27.81 g of ethylene glycol, and 0.0433 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 200°C. The stirring speed was set to 200 RPM throughout the experiment. The contents of the flask were heated at 200°C for 60 minutes and then the temperature was gradually increased to 210°C over 5 minutes. The reaction mixture was held at 210°C for 120 minutes and then heated up to 280°C in 30 minutes. Once at 280°C, vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 10 minutes. A pressure of 0.3 mm of Hg was maintained for a total time of 90 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 87.7°C and an inherent viscosity of 0.71 dl/g. NMR analysis showed that the polymer was composed of 19.8 mol% ethylene glycol residues.

Example 1C

[00537] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 20 mol % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and 80 mol% 1,4-cyclohexanedimethanol residues (31/69 cis/trans).

[00538] A mixture of 77.68 g of dimethyl terephthalate, 48.46 g of 1,4-cyclohexanedimethanol, 17.86 g of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 0.046 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. This polyester was prepared in a manner similar to that described in Example 1A. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 100.5°C and an inherent viscosity of 0.73 dl/g. NMR analysis showed that the polymer was composed of 80.5 mol% 1,4-cyclohexanedimethanol residues and 19.5 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 1D

[00539] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 40 mol % dimethyl isophthalate residues, and 100 mol% 1,4-cyclohexanedimethanol residues (28/72 cis/trans).

[00540] A mixture of 42.83 g of dimethyl terephthalate, 55.26 g of 1,4-cyclohexanedimethanol, 28.45 g of dimethyl isophthalate, and 0.0419 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 210°C. The stirring speed was set to 200 RPM throughout the experiment. The contents of the flask were heated at 210°C for 5 minutes and then the temperature was gradually increased to 290°C over 30 minutes. The reaction mixture was held at 290°C for 60 minutes and then vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 5 minutes. A pressure of 0.3 mm of Hg was maintained for a total time of 90 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 81.2°C and an inherent viscosity of 0.67 dl/g. NMR analysis showed that the polymer was composed of 100 mol% 1,4-cyclohexanedimethanol residues and 40.2 mol% dimethyl isophthalate residues.

Example 1E

[00541] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 40 mol % ethylene glycol residues, and 60 mol% 1,4-cyclohexanedimethanol residues (31/69 cis/trans).

[00542] A mixture of 81.3 g of dimethyl terephthalate, 42.85 g of 1,4-cyclohexanedimethanol, 34.44 g of ethylene glycol, and 0.0419 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 200°C. The stirring speed was set to 200 RPM

throughout the experiment. The contents of the flask were heated at 200°C for 60 minutes and then the temperature was gradually increased to 210°C over 5 minutes. The reaction mixture was held at 210°C for 120 minutes and then heated up to 280°C in 30 minutes. Once at 280°C, vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 10 minutes. A pressure of 0.3 mm of Hg was maintained for a total time of 90 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 82.1°C and an inherent viscosity of 0.64 dl/g. NMR analysis showed that the polymer was composed of 34.5 mol% ethylene glycol residues.

Example 1F

[00543] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 40 mol % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and 60 mol% 1,4-cyclohexanedimethanol residues (31/69 cis/trans).

[00544] A mixture of 77.4 g of dimethyl terephthalate, 36.9 g of 1,4-cyclohexanedimethanol, 32.5 g of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 0.046 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 210°C. The stirring speed was set to 200 RPM throughout the experiment. The contents of the flask were heated at 210°C for 3 minutes and then the temperature was gradually increased to 260°C over 30 minutes. The reaction mixture was held at 260°C for 120 minutes and then heated up to 290°C in 30 minutes. Once at 290°C, vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 5 minutes. A pressure of 0.3 mm of Hg was maintained for a total time of 90 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 122°C and an inherent viscosity of 0.65 dl/g. NMR analysis showed that the polymer was composed of 59.9 mol%

1,4-cyclohexanedimethanol residues and 40.1 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 1G

[00545] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 20 mol % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues (98/2 cis/trans), and 80 mol% 1,4-cyclohexanedimethanol residues (31/69 cis/trans).

[00546] A mixture of 77.68 g of dimethyl terephthalate, 48.46 g of 1,4-cyclohexanedimethanol, 20.77 g of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 0.046 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 210°C. The stirring speed was set to 200 RPM throughout the experiment. The contents of the flask were heated at 210°C for 3 minutes and then the temperature was gradually increased to 260°C over 30 minutes. The reaction mixture was held at 260°C for 120 minutes and then heated up to 290°C in 30 minutes. Once at 290°C, vacuum was gradually applied over the next 5 minutes until the pressure inside the flask reached 100 mm of Hg and the stirring speed was also reduced to 100 RPM. The pressure inside the flask was further reduced to 0.3 mm of Hg over the next 5 minutes and the stirring speed was reduced to 50 RPM. A pressure of 0.3 mm of Hg was maintained for a total time of 60 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 103°C and an inherent viscosity of 0.65 dl/g. NMR analysis showed that the polymer was composed of 85.7 mol% 1,4-cyclohexanedimethanol residues and 14.3 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 1H

[00547] This example illustrates the preparation of a copolyester with a target composition of 100 mol% dimethyl terephthalate residues, 20 mol % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues (5/95 cis/trans), and 80 mol% 1,4-cyclohexanedimethanol residues (31/69 cis/trans).

[00548] A mixture of 77.68 g of dimethyl terephthalate, 48.46 g of 1,4-cyclohexanedimethanol, 20.77 g of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 0.046 g of dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 210°C. The stirring speed was set to 200 RPM at the beginning of the experiment. The contents of the flask were heated at 210°C for 3 minutes and then the temperature was gradually increased to 260°C over 30 minutes. The reaction mixture was held at 260°C for 120 minutes and then heated up to 290°C in 30 minutes. Once at 290°C, vacuum was gradually applied over the next 5 minutes with a set point of 100 mm of Hg and the stirring speed was also reduced to 100 RPM. The pressure inside the flask was further reduced to a set point of 0.3 mm of Hg over the next 5 minutes and the stirring speed was reduced to 50 RPM. This pressure was maintained for a total time of 60 minutes to remove excess unreacted diols. It was noted that the vacuum system failed to reach the set point mentioned above, but produced enough vacuum to produce a high melt viscosity, visually clear and colorless polymer with a glass transition temperature of 99°C and an inherent viscosity of 0.73 dl/g. NMR analysis showed that the polymer was composed of 85 mol% 1,4-cyclohexanedimethanol residues and 15 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 2

[00549] This example illustrates that 2,2,4,4-tetramethyl-1,3-cyclobutanediol improves the toughness of PCT-based copolyesters (polyesters containing terephthalic acid and 1,4-cyclohexanedimethanol).

[00550] Copolyesters based on 2,2,4,4-tetramethyl-1,3-cyclobutanediol were prepared as described below. The cis/trans ratio of the 1,4-cyclohexanedimethanol was approximately 31/69 for all samples. Copolyesters based on ethylene glycol and 1,4-cyclohexanedimethanol were commercial polyesters. The copolyester of Example 2A (Eastar PCTG 5445) was obtained from Eastman Chemical Co. The copolyester of Example 2B was obtained from Eastman Chemical Co. under the trade name Spectar. Example 2C and Example 2D were prepared on a pilot plant scale (each a 15-lb batch) following

an adaptation of the procedure described in Example 1A and having the inherent viscosities and glass transition temperatures described in Table 2 below. Example 2C was prepared with a target tin amount of 300ppm (Dibutyltin Oxide). The final product contained 295 ppm tin. The color values for the polyester of Example 2C were L*= 77.11; a*= -1.50; and b*= 5.79. Example 2D was prepared with a target tin amount of 300ppm (Dibutyltin Oxide). The final product contained 307 ppm tin. The color values for the polyester of Example 2D were L*= 66.72; a*= -1.22; and b*= 16.28.

[00551] Materials were injection molded into bars and subsequently notched for Izod testing. The notched Izod impact strengths were obtained as a function of temperature and are also reported in Table 2.

[00552] For a given sample, the Izod impact strength undergoes a major transition in a short temperature span. For instance, the Izod impact strength of a copolyester based on 38 mol% ethylene glycol undergoes this transition between 15 and 20°C. This transition temperature is associated with a change in failure mode; brittle/low energy failures at lower temperatures and ductile/high energy failures at higher temperatures. The transition temperature is denoted as the brittle-to-ductile transition temperature, Tbd, and is a measure of toughness. Tbd is reported in Table 2 and plotted against mol% comonomer in Figure 2.

[00553] The data shows that adding 2,2,4,4-tetramethyl-1,3-cyclobutanediol to PCT lowers Tbd and improves the toughness, as compared to ethylene glycol, which increases Tbd of PCT.

Table 2

Notched Izod Impact Energy (ft-lb/in)

Example	Comonomer (mol %)[1]	IV (dl/g)	T_g (°C)	T_{bd} (°C)	at -20 °C	at -15 °C	at -10 °C	at -5 °C	at 0 °C	at 5 °C	at 10 °C	at 15 °C	at 20 °C	at 25 °C	at 30 °C
2A	38.0 % B	0.68	86	18	NA	NA	NA	1.5	NA	NA	1.5	1.5	32	32	NA
2B	69.0 % B	0.69	82	26	NA	NA	NA	NA	NA	NA	2.1	NA	2.4	13.7	28.7
2C	22.0 % C	0.66	106	-5	1.5	NA	12	23	23	NA	23	NA	NA	NA	NA
2D	42.8 % C	0.60	133	-12	2.5	2.5	11	NA	14	NA	NA	NA	NA	NA	NA

1 The balance of the glycol component of the polyesters in the Table is 1,4-cyclohexanedimethanol. All polymers were prepared from 100 mole % dimethyl terephthalate.
NA = Not available.

where: B is Ethylene glycol
C is 2,2,4,4-Tetramethyl-1,3-cyclobutanediol (50/50 cis/trans)

Example 3

[00554] This example illustrates that 2,2,4,4-tetramethyl-1,3-cyclobutanediol can improve the toughness of PCT-based copolyesters(polyesters containing terephthalic acid and 1,4-cyclohexanedimethanol). Polyesters prepared in this example comprise from 15 to 25 mol% of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

[00555] Copolyesters based on dimethyl terephthalate, 2,2,4,4-tetramethyl-1,3-cyclobutanediol , and 1,4-cyclohexanedimethanol (31/69 cis/trans) were prepared as described below, having the composition and properties shown on Table 3. The balance up to 100 mol% of the diol component of the polyesters in Table 3 was 1,4-cyclohexanedimethanol (31/69 cis/trans).

[00556] Materials were injection molded into both 3.2mm and 6.4mm thick bars and subsequently notched for Izod impact testing. The notched Izod impact strengths were obtained at 23°C and are reported in Table 3. Density, Tg, and crystallization halftime were measured on the molded bars. Melt viscosity was measured on pellets at 290°C.

Table 3

Compilation of various properties for certain polyesters

Example	TMCD mole%	% cis TMCD	Pellet IV (dl/g)	Molded Bar IV (dl/g)	Notched Izod of 3.2mm thick bars at 23°C (J/m)	Notched Izod of 6.4mm thick bars at 23°C (J/m)	Specific Gravity (g/mL)	Tg (°C)	Crystallization Halftime from melt at 170°C (min)	Melt Viscosity at 1 rad/sec at 290°C (Poise)
A	15	48.8	0.736	0.707	1069	878	1.184	104	15	5649
B	18	NA	0.728	0.715	980	1039	1.183	108	22	6621
C	20	NA	0.706	0.696	1006	1130	1.182	106	52	6321
D	22	NA	0.732	0.703	959	988	1.178	108	63	7161
E	21	NA	0.715	0.692	932	482	1.179	110	56	6162
F	24	NA	0.708	0.677	976	812	1.180	109	58	6282
G	23	NA	0.650	0.610	647	270	1.182	107	46	3172
H	23	47.9	0.590	0.549	769	274	1.181	106	47	1736
I	23	48.1	0.531	0.516	696	352	1.182	105	19	1292
J	23	47.8	0.364	NA	NA	NA	NA	98	NA	167

NA = Not available.

Example 3A

[00557] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 14.34 lb (45.21 gram-mol) 1,4-cyclohexanedimethanol, and 4.58 lb (14.44 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and at a pressure of 20 psig. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to <1 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg until the power draw to the agitator no longer increased (70 minutes). The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer

had an inherent viscosity of 0.736 dL/g and a Tg of 104 °C. NMR analysis showed that the polymer was composed of 85.4 mol% 1,4-cyclohexane-dimethanol residues and 14.6 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 78.20, a*= -1.62, and b*= 6.23.

Example 3B to Example 3D

[00558] The polyesters described in Example 3B to Example 3D were prepared following a procedure similar to the one described for Example 3A. The composition and properties of these polyesters are shown in Table 3.

Example 3E

[00559] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 12.61 lb (39.77 gram-mol) 1,4-cyclohexanedimethanol, and 6.30 lb (19.88 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to <1 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg for 60 minutes. The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.715 dL/g and a Tg of 110°C. X-ray analysis showed that the polyester had 223 ppm tin. NMR analysis showed that the polymer was composed of 78.6 mol% 1,4-cyclohexane-dimethanol residues and 21.4 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 76.45, a*= -1.65, and b*= 6.47.

Example 3F

[00560] The polyester described in Example 3F was prepared following a procedure similar to the one described for Example 3A. The composition and properties of this polyester are shown in Table 3.

Example 3G

[00561] The polyester described in Example 3G was prepared following a procedure similar to the one described for Example 3A. The composition and properties of this polyester are shown in Table 3.

Example 3H

[00562] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 12.61 lb (39.77 gram-mol) 1,4-cyclohexanedimethanol, and 6.30 lb (19.88 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to <1 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg for 12 minutes. The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.590 dL/g and a Tg of 106°C. NMR analysis showed that the polymer was composed of 77.1 mol% 1,4-cyclohexane-dimethanol residues and 22.9 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 83.27, a*= -1.34, and b*= 5.08.

Example 3I

[00563] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 12.61 lb (39.77 gram-mol) 1,4-cyclohexanedimethanol, and 6.30 lb (19.88 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig.The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to 4 mm of Hg. The reaction mixture was held at 290°C and at a pressure of 4 mm of Hg for 30 minutes. The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.531 dL/g and a Tg of 105 °C. NMR analysis showed that the polymer was composed of 76.9 mol% 1,4-cyclohexane-dimethanol residues and 23.1 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 80.42, a*= -1.28, and b*= 5.13.

Example 3J

[00564] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 12.61 lb (39.77 gram-mol) 1,4-cyclohexanedimethanol, and 6.30 lb (19.88 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was

increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to 4 mm of Hg. When the reaction mixture temperature was 290°C and the pressure was 4 mm of Hg, the pressure of the pressure vessel was immediately increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.364 dL/g and a Tg of 98°C. NMR analysis showed that the polymer was composed of 77.5 mol% 1,4-cyclohexane-dimethanol residues and 22.5 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 77.20, a*= -1.47, and b*= 4.62.

Example 4

[00565] This example illustrates that 2,2,4,4-tetramethyl-1,3-cyclobutanediol can improve the toughness of PCT-based copolyesters(polyesters containing terephthalic acid and 1,4-cyclohexanedimethanol). Polyesters prepared in this example fall comprise more than 25 to less than 40 mol% of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

[00566] Copolyesters based on dimethyl terephthalate, 2,2,4,4-tetramethyl-1,3-cyclobutanediol , and 1,4-cyclohexanedimethanol (31/69 cis/trans) were prepared as described below, having the composition and properties shown on Table 4. The balance up to 100 mol% of the diol component of the polyesters in Table 4 was 1,4-cyclohexanedimethanol (31/69 cis/trans).

[00567] Materials were injection molded into both 3.2mm and 6.4mm thick bars and subsequently notched for Izod impact testing. The notched Izod impact strengths were obtained at 23°C and are reported in Table 4. Density, Tg, and crystallization halftime were measured on the molded bars. Melt viscosity was measured on pellets at 290°C.

Table 4

Compilation of various properties for certain polyesters

Example	TMCD mole%	% cis TMCD	Pellet IV (dl/g)	Molded Bar IV (dl/g)	Notched Izod of 3.2mm thick bars at 23°C (J/m)	Notched Izod of 6.4mm thick bars at 23°C (J/m)	Specific Gravity (g/mL)	Tg (°C)	Crystallization Halftime from melt at 170°C (min)	Melt Viscosity at 1 rad/sec at 290°C (Poise)
A	27	47.8	0.714	0.678	877	878	1.178	113	280	8312
B	31	NA	0.667	0.641	807	789	1.174	116	600	6592

NA = Not available.

Example 4A

[00568] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 11.82 lb (37.28 gram-mol) 1,4-cyclohexanedimethanol, and 6.90 lb (21.77 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig.The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to <1 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg until the power draw to the agitator no longer increased (50 minutes). The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.714 dL/g and a Tg of 113°C. NMR analysis showed that the polymer was composed of 73.3 mol% 1,4-cyclohexane-dimethanol residues and 26.7 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 4B

[00569] The polyester of Example 4B was prepared following a procedure similar to the one described for Example 4A. The composition and properties of this polyester are shown in Table 4.

Example 5

[00570] This example illustrates that 2,2,4,4-tetramethyl-1,3-cyclobutanediol can improve the toughness of PCT-based copolyesters(polyesters containing terephthalic acid and 1,4-cyclohexanedimethanol). Polyesters prepared in this example comprise 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues in an amount of 40 mol% or greater.

[00571] Copolyesters based on dimethyl terephthalate, 2,2,4,4-tetramethyl-1,3-cyclobutanediol , and 1,4-cyclohexanedimethanol (31/69 cis/trans) were prepared as described below, having the composition and properties shown on Table 5. The balance up to 100 mol% of the diol component of the polyesters in Table 5 was 1,4-cyclohexanedimethanol (31/69 cis/trans).

[00572] Materials were injection molded into both 3.2mm and 6.4mm thick bars and subsequently notched for Izod impact testing. The notched Izod impact strengths were obtained at 23°C and are reported in Table 5. Density, Tg, and crystallization halftime were measured on the molded bars. Melt viscosity was measured on pellets at 290°C.

Table 5

Compilation of various properties for certain polyesters

Example	TMCD mole%	% cis TMCD	Pellet IV (dl/g)	Molded Bar IV (dl/g)	Notched Izod of 3.2mm thick bars at 23°C (J/m)	Notched Izod of 6.4mm thick bars at 23°C (J/m)	Specific Gravity (g/mL)	Tg (°C)	Crystallization Halftime from melt at 170°C (min)	Melt Viscosity at 1 rad/sec at 290°C (Poise)
A	44	46.2	0.657	0.626	727	734	1.172	119	NA	9751
B	45	NA	0.626	0.580	748	237	1.167	123	NA	8051
C	45	NA	0.582	0.550	671	262	1.167	125	19782	5835
D	45	NA	0.541	0.493	424	175	1.167	123	NA	3275
E	59	46.6	0.604	0.576	456	311	1.156	139	NA	16537
F	45	47.2	0.475	0.450	128	30	1.169	121	NA	1614

NA = Not available.

Example 5A

[00573] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 8.84 lb (27.88 gram-mol) 1,4-cyclohexanedimethanol, and 10.08 lb (31.77 gram-mol) 2,2,4,4-

tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. Then the agitator speed was decreased to 15 RPM, the temperature of the reaction mixture was then increased to 290°C and the pressure was decreased to 2 mm of Hg. The reaction mixture was held at 290°C and at a pressure of 2 mm of Hg until the power draw to the agitator no longer increased (80 minutes). The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.657 dL/g and a Tg of 119°C. NMR analysis showed that the polymer was composed of 56.3 mol% 1,4-cyclohexane-dimethanol residues and 43.7 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 75.04, a*=-1.82, and b*= 6.72.

Example 5B to Example 5D

[00574] The polyesters described in Example 5B to Example 5D were prepared following a procedure similar to the one described for Example 5A. The composition and properties of these polyesters are shown in Table 5.

Example 5E

[00575] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 6.43 lb (20.28 gram-mol 1,4-cyclohexanedimethanol, and 12.49 lb (39.37 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig.The reaction

mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. Then the agitator speed was decreased to 15 RPM, the temperature of the reaction mixture was then increased to 290°C and the pressure was decreased to 2 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg until the power draw to the agitator no longer increased (50 minutes). The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.604 dL/g and a Tg of 139°C. NMR analysis showed that the polymer was composed of 40.8 mol% 1,4-cyclohexanedimethanol residues and 59.2 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 80.48, a*= -1.30, and b*= 6.82.

Example 5F

[00576] 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 8.84 lb (27.88 gram-mol) 1,4-cyclohexanedimethanol, and 10.08 lb (31.77 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig.The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM and the pressure was decreased to 4 mm of Hg. When the reaction mixture temperature was 270°C and the pressure was 4 mm of Hg, the pressure of the pressure vessel was immediately increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.475 dL/g and a Tg of 121°C.

NMR analysis showed that the polymer was composed of 55.5 mol% 1,4-cyclohexane-dimethanol residues and 44.5 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 85.63, a*= -0.88, and b*= 4.34.

Example 6—Comparative Example

[00577] This example shows data for comparative materials in Table 6. The PC was Makrolon 2608 from Bayer, with a nominal composition of 100 mole% bisphenol A residues and 100 mole% diphenyl carbonate residues. Makrolon 2608 has a nominal melt flow rate of 20 grams/10 minutes measured at 300C using a 1.2 kg weight. The PET was Eastar 9921 from Eastman Chemical Company, with a nominal composition of 100 mole% terephthalic acid, 3.5 mole% cyclohexanedimethanol (CHDM) and 96.5 mole% ethylene glycol. The PETG was Eastar 6763 from Eastman Chemical Company, with a nominal composition of 100 mole% terephthalic acid, 31 mole% cyclohexanedimethanol (CHDM) and 69 mole % ethylene glycol. The PCTG was Eastar DN001 from Eastman Chemical Company, with a nominal composition of 100 mole% terephthalic acid, 62 mole% cyclohexanedimethanol (CHDM) and 38 mole % ethylene glycol. The PCTA was Eastar AN001 from Eastman Chemical Company, with a nominal composition of 65 mole% terephthalic acid, 35 mole% isophthalic acid and 100 mole% cyclohexanedimethanol (CHDM). The Polysulfone was Udel 1700 from Solvay, with a nominal composition of 100 mole% bisphenol A residues and 100 mole% 4,4-dichlorosulfonyl sulfone residues. Udel 1700 has a nominal melt flow rate of 6.5 grams/10 minutes measured at 343C using a 2.16 kg weight. The SAN was Lustran 31 from Lanxess, with a nominal composition of 76 weight % styrene and 24 weight % acrylonitrile. Lustran 31 has a nominal melt flow rate of 7.5 grams/10 minutes measured at 230C using a 3.8 kg weight. The examples comprising 2,2,4,4-tetramethyl-1,3-cyclobutanediol show improved toughness in 6.4mm thickness bars compared to all of the other resins.

Table 6

Compilation of various properties for certain commercial polymers

Example	Polymer name	Pellet IV (dl/g)	Molded Bar IV (dl/g)	Notched Izod of 3.2mm thick bars at 23°C (J/m)	Notched Izod of 6.4mm thick bars at 23°C (J/m)	Specific Gravity (g/mL)	Tg (°C)	Crystallization Halftime from melt (min)
A	PC	12 MFR	NA	929	108	1.20	146	NA
B	PCTG	0.73	0.696	NB	70	1.23	87	30 at 170°C
C	PCTA	0.72	0.702	98	59	1.20	87	15 at 150°C
D	PETG	0.75	0.692	83	59	1.27	80	2500 at 130°C
E	PET	0.76	0.726	45	48	1.33	78	1.5 at 170°C
F	SAN	7.5 MFR	NA	21	NA	1.07	~110	NA
G	PSU	6.5 MFR	NA	69	NA	1.24	~190	NA

NA = Not available

Example 7

[00578] This example illustrates the effect of the amount of 2,2,4,4-tetramethyl-1,3-cyclobutanediol used for the preparation of various polyesters on the glass transition temperature of the polyesters. Polyesters prepared in this example comprise from 15 to 25 mol% of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

Example 7A to Example 7G

[00579] Dimethyl terephthalate, 1,4-cyclohexanedimethanol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol were weighed into a 500-ml single neck round bottom flask. NMR analysis on the 2,2,4,4-tetramethyl-1,3-cyclobutanediol starting material showed a cis/trans ratio of 53/47. The polyesters of this example were prepared with a 1.2/1 glycol/acid ratio with the entire excess coming from the 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Enough dibutyltin oxide catalyst was added to give 300 ppm tin in the final polymer. The flask was under a 0.2 SCFC nitrogen purge with vacuum reduction capability. The flask was immersed in a Belmont metal bath at 200°C and stirred at 200 RPM after the reactants had melted. After about 2.5 hours, the temperature was raised to 210°C and these conditions were held for an additional 2 hours. The temperature was raised to 285°C (in approximately 25 minutes) and the pressure was reduced to 0.3 mm of Hg over a period of 5 minutes. The stirring was reduced as the viscosity increased, with 15 RPM being the minimum stirring used. The total polymerization time was varied to attain the target inherent viscosities. After the

polymerization was complete, the Belmont metal bath was lowered and the polymer was allowed to cool to below its glass transition temperature. After about 30 minutes, the flask was reimmersed in the Belmont metal bath (the temperature had been increased to 295°C during this 30 minute wait) and the polymer mass was heated until it pulled away from the glass flask. The polymer mass was stirred at mid level in the flask until the polymer had cooled. The polymer was removed from the flask and ground to pass a 3 mm screen. Variations to this procedure were made to produce the copolyesters described below with targeted compositions of 20, 32, and 45 mol%.

[00580] Inherent viscosities were measured as described in the "Measurement Methods" section above. The compositions of the polyesters were determined by ^{1}H NMR as explained before in the Measurement Methods section. The glass transition temperatures were determined by DSC, using the second heat after quench at a rate of 20°C/min.

Example 7H to Example 7Q

[00581] These examples were prepared by carrying out the ester exchange and polycondensation reactions in separate stages. The ester exchange experiments were conducted in a continuous temperature rise (CTR) reactor. The CTR was a 3000 ml glass reactor equipped with a single shaft impeller blade agitator, covered with an electric heating mantle and fitted with a heated packed reflux condenser column. The reactor was charged with 777g (4 moles) of dimethyl terephthalate, 230g (1.6 moles) of 2,2,4,4-tetramethyl-1,3,-cyclobutanediol, 460.8g (3.2 moles) of cyclohexane dimethanol and 1.12g of butyltin tris-2-ethylhexanoate (such that there will be 200ppm tin metal in the final polymer). The heating mantle was set manually to 100 % output. The set points and data collection were facilitated by a Camile process control system. Once the reactants were melted, stirring was initiated and slowly increased to 250 rpm. The temperature of the reactor gradually increased with run time. The weight of methanol collected was recorded via balance. The reaction was stopped when methanol evolution stopped or at a pre-selected lower temperature of 260°C. The oligomer was discharged with a nitrogen purge and cooled to room

temperature. The oligomer was frozen with liquid nitrogen and broken into pieces small enough to be weighed into a 500 ml round bottom flask.

[00582] In the polycondensation reactions, a 500 ml round bottom flask was charged with approximately 150 g of the oligomer prepared above. The flask was equipped with a stainless steel stirrer and polymer head. The glassware was set up on a half mole polymer rig and the Camile sequence was initiated. The stirrer was positioned one full turn from the flask bottom once the oligomer melted. The temperature/pressure/stir rate sequence controlled by the Camile software for each example is reported in the following tables.

[00583] Camile Sequence for Example 7H and Example 7I

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	6	25
7	110	290	6	25

[00584] Camile Sequence for Example 7N to Example 7Q

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	3	25
7	110	290	3	25

[00585] Camile Sequence for Example 7K and Example 7L

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	2	25
7	110	290	2	25

[00586] Camile Sequence for Example 7J and Example 7M

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	1	25
7	110	290	1	25

[00587] The resulting polymers were recovered from the flask, chopped using a hydraulic chopper, and ground to a 6 mm screen size. Samples of each ground polymer were submitted for inherent viscosity in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.5 g/100 ml at 25°C, catalyst level (Sn) by x-ray fluorescence, and color (L*, a*, b*) by transmission spectroscopy. Polymer composition was obtained by ^{1}H NMR. Samples were submitted for thermal stability and melt viscosity testing using a Rheometrics Mechanical Spectrometer (RMS-800).

[00588] The table below shows the experimental data for the polyesters of this example. The data shows that an increase in the level of 2,2,4,4-tetramethyl-1,3-cyclobutanediol raises the glass transition temperature in an almost linear fashion, for a constant inherent viscosity. Figure 3 also shows the dependence of Tg on composition and inherent viscosity.

Table 7

Glass transition temperature as a function of inherent viscosity and composition

Example	mol% TMCD	% cis TMCD	IV (dL/g)	T_g (°C)	η_o at 260°C (Poise)	η_o at 275°C (Poise)	η_o at 290°C (Poise)
A	20	51.4	0.72	109	11356	19503	5527
B	19.1	51.4	0.60	106	6891	3937	2051
C	19	53.2	0.64	107	8072	4745	2686
D	18.8	54.4	0.70	108	14937	8774	4610
E	17.8	52.4	0.50	103	3563	1225	883
F	17.5	51.9	0.75	107	21160	10877	5256
G	17.5	52	0.42	98	NA	NA	NA
H	22.8	53.5	0.69	109	NA	NA	NA
I	22.7	52.2	0.68	108	NA	NA	NA
J	23.4	52.4	0.73	111	NA	NA	NA
K	23.3	52.9	0.71	111	NA	NA	NA
L	23.3	52.4	0.74	112	NA	NA	NA
M	23.2	52.5	0.74	112	NA	NA	NA
N	23.1	52.5	0.71	111	NA	NA	NA
O	22.8	52.4	0.73	112	NA	NA	NA
P	22.7	53	0.69	112	NA	NA	NA
Q	22.7	52	0.70	111	NA	NA	NA

NA = Not available

Example 8

[00589] This example illustrates the effect of the amount of 2,2,4,4-tetramethyl-1,3-cyclobutanediol used for the preparation of various polyesters on the glass transition temperature of the polyesters. Polyesters prepared in this example fall comprise more than 25 to less than 40 mol% of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

[00590] Dimethyl terephthalate, 1,4-cyclohexanedimethanol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol were weighed into a 500-ml single neck round bottom flask. NMR analysis on the 2,2,4,4-tetramethyl-1,3-cyclobutanediol starting material showed a cis/trans ratio of 53/47. The polyesters of this example were prepared with a 1.2/1 glycol/acid ratio with the entire excess coming from the 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Enough dibutyltin oxide catalyst was added to give 300 ppm tin in the final polymer. The flask was under a 0.2 SCFC nitrogen purge with vacuum reduction capability. The flask was

immersed in a Belmont metal bath at 200°C and stirred at 200 RPM after the reactants had melted. After about 2.5 hours, the temperature was raised to 210°C and these conditions were held for an additional 2 hours. The temperature was raised to 285°C (in approximately 25 minutes) and the pressure was reduced to 0.3 mm of Hg over a period of 5 minutes. The stirring was reduced as the viscosity increased, with 15 RPM being the minimum stirring used. The total polymerization time was varied to attain the target inherent viscosities. After the polymerization was complete, the Belmont metal bath was lowered and the polymer was allowed to cool to below its glass transition temperature. After about 30 minutes, the flask was reimmersed in the Belmont metal bath (the temperature had been increased to 295°C during this 30 minute wait) and the polymer mass was heated until it pulled away from the glass flask. The polymer mass was stirred at mid level in the flask until the polymer had cooled. The polymer was removed from the flask and ground to pass a 3 mm screen. Variations to this procedure were made to produce the copolyesters described below with targeted compositions of 20, 32, and 45 mol%.

[00591] Inherent viscosities were measured as described in the "Measurement Methods" section above. The compositions of the polyesters were determined by ^{1}H NMR as explained before in the Measurement Methods section. The glass transition temperatures were determined by DSC, using the second heat after quench at a rate of 20°C/min.

[00592] The table below shows the experimental data for the polyesters of this example. The data shows that an increase in the level of 2,2,4,4-tetramethyl-1,3-cyclobutanediol raises the glass transition temperature in an almost linear fashion, for a constant inherent viscosity. Figure 3 also shows the dependence of Tg on composition and inherent viscosity.

Table 8

Glass transition temperature as a function of inherent viscosity and composition

Example	mol% TMCD	% cis TMCD	IV (dL/g)	T_g (°C)	η_o at 260°C (Poise)	η_o at 275°C (Poise)	η_o at 290°C (Poise)
A	32.2	51.9	0.71	118	29685	16074	8522
B	31.6	51.5	0.55	112	5195	2899	2088
C	31.5	50.8	0.62	112	8192	4133	2258
D	30.7	50.7	0.54	111	4345	2434	1154
E	30.3	51.2	0.61	111	7929	4383	2261
F	30.0	51.4	0.74	117	31476	17864	8630
G	29.0	51.5	0.67	112	16322	8787	4355
H	31.1	51.4	0.35	102	NA	NA	NA

NA = Not available

Example 9

[00593] This example illustrates the effect of the amount of 2,2,4,4-tetramethyl-1,3-cyclobutanediol used for the preparation of various polyesters on the glass transition temperature of the polyesters. Polyesters prepared in this example comprise 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues in an amount of 40 mol% or greater.

Example 9A to Example 9AC

[00594] These examples were prepared by carrying out the ester exchange and polycondensation reactions in separate stages. The ester exchange experiments were conducted in a continuous temperature rise (CTR) reactor. The CTR was a 3000 ml glass reactor equipped with a single shaft impeller blade agitator, covered with an electric heating mantle and fitted with a heated packed reflux condenser column. The reactor was charged with 777g of dimethyl terephthalate, 375g of 2,2,4,4-tetramethyl-1,3,-cyclobutanediol, 317g of cyclohexane dimethanol and 1.12g of butyltin tris-2-ethylhexanoate (such that there will be 200ppm tin metal in the final polymer). The heating mantle was set manually to 100 % output. The set points and data collection were facilitated by a Camile process control system. Once the reactants were melted, stirring was initiated and slowly increased to 250 rpm. The temperature of the reactor gradually increased with run time. The weight of methanol collected was recorded via balance. The reaction was stopped when methanol evolution

stopped or at a pre-selected lower temperature of 260°C. The oligomer was discharged with a nitrogen purge and cooled to room temperature. The oligomer was frozen with liquid nitrogen and broken into pieces small enough to be weighed into a 500 ml round bottom flask.

[00595] In the polycondensation reactions, a 500 ml round bottom flask was charged with 150 g of the oligomer prepared above. The flask was equipped with a stainless steel stirrer and polymer head. The glassware was set up on a half mole polymer rig and the Camile sequence was initiated. The stirrer was positioned one full turn from the flask bottom once the oligomer melted. The temperature/pressure/stir rate sequence controlled by the Camile software for these examples is reported in the following table, unless otherwise specified below.

Camile Sequence for Polycondensation Reactions

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	6	25
7	110	290	6	25

[00596] Camile Sequence for Examples A, C, R, Y, AB, AC

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	6	25
7	110	290	6	25

[00597] For Examples B, D, F, the same sequence in the preceding table was used, except the time was 80 min in Stage 7. For Examples G and J, the same sequence in the preceding table was used, except the time was 50 min in Stage

7. For Example L, the same sequence in the preceding table was used, except the time was 140 min in Stage 7.

[00598] Camile Sequence for Example E

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	300	90	50
6	5	300	7	25
7	110	300	7	25

[00599] For Example I, the same sequence in the preceding table was used, except the vacuum was 8 torr in Stages 6 and 7. For Example O, the same sequence in the preceding table was used, except the vacuum was 6 torr in Stages 6 and 7. For Example P, the same sequence in the preceding table was used, except the vacuum was 4 torr in Stages 6 and 7. For Example Q, the same sequence in the preceding table was used, except the vacuum was 5 torr in Stages 6 and 7.

[00600] Camile Sequence for Example H

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	280	90	50
6	5	280	5	25
7	110	280	5	25

[00601] For Example U and AA, the same sequence in the preceding table was used, except the vacuum was 6 torr in Stages 6 and 7. For Example V and X, the same sequence in the preceding table was used, except the vacuum was 6 torr and stir rate was 15 rpm in Stages 6 and 7. For Example Z, the same sequence in the preceding table was used, except the stir rate was 15 rpm in Stages 6 and 7.

[00602] Camile Sequence for Example K

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	300	90	50
6	5	300	6	15
7	110	300	6	15

[00603] For Example M, the same sequence in the preceding table was used, except the vacuum was 8 torr in Stages 6 and 7. For Example N, the same sequence in the preceding table was used, except the vacuum was 7 torr in Stages 6 and 7.

[00604] Camile Sequence for Examples S and T

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	5	290	6	25
5	110	290	6	25

[00605] The resulting polymers were recovered from the flask, chopped using a hydraulic chopper, and ground to a 6 mm screen size. Samples of each ground polymer were submitted for inherent viscosity in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.5 g/100 ml at 25°C, catalyst level (Sn) by x-ray fluorescence, and color (L*, a*, b*) by transmission spectroscopy. Polymer composition was obtained by 1H NMR. Samples were submitted for thermal stability and melt viscosity testing using a Rheometrics Mechanical Spectrometer (RMS-800).

Example 9AD to Example 9AK, and Example 9AT

[00606] The polyesters of these examples were prepared as described above for Examples A to AC, except that the target tin amount in the final polymer was 150ppm for examples AD to AK and AT. The following tables describe the temperature/pressure/stir rate sequences controlled by the Camile software for these examples.

[00607] Camile Sequence for Examples AD, AF, and AH

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	400	50
5	110	290	400	50
6	5	290	8	50
7	110	295	8	50

[00608] For Example AD, the stirrer was turned to 25 rpm with 95 min left in Stage 7.

[00609] Camile Sequence for Example AE

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	10	245	760	0
2	5	245	760	50
3	30	283	760	50
4	3	283	175	50
5	5	283	5	50
6	5	283	1.2	50
7	71	285	1.2	50

[00610] For Example AK, the same sequence in the preceding table was used, except the time was 75 min in Stage 7.

[00611] Camile Sequence for Example AG

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	10	245	760	0
2	5	245	760	50
3	30	285	760	50
4	3	285	175	50
5	5	285	5	50
6	5	285	4	50
7	220	290	4	50

[00612] Camile Sequence for Example AI

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	285	90	50
6	5	285	6	50
7	70	290	6	50

[00613] Camile Sequence for Example AJ

Stage	Time (min)	Temp (°C)	Vacuum (torr)	Stir (rpm)
1	5	245	760	0
2	5	245	760	50
3	30	265	760	50
4	3	265	90	50
5	110	290	90	50
6	5	290	6	25
7	110	295	6	25

Example 9AL to Example 9AS

[00614] Dimethyl terephthalate, 1,4-cyclohexanedimethanol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol were weighed into a 500-ml single neck round bottom flask. The polyesters of this example were prepared with a 1.2/1 glycol/acid ratio with the entire excess coming from the 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Enough dibutyltin oxide catalyst was added to give 300 ppm tin in the final polymer. The flask was under a 0.2 SCFC nitrogen purge with vacuum reduction capability. The flask was immersed in a Belmont metal bath at 200°C and stirred at 200 RPM after the reactants had melted. After about 2.5 hours, the temperature was raised to 210°C and these conditions were held for an additional 2 hours. The temperature was raised to 285°C (in approximately 25 minutes) and the pressure was reduced to 0.3 mm of Hg over a period of 5 minutes. The stirring was reduced as the viscosity increased, with 15 RPM being the minimum stirring used. The total polymerization time was varied to attain the target inherent viscosities. After the polymerization was complete, the Belmont metal bath was lowered and the polymer was allowed to cool to below its glass transition temperature. After about 30 minutes, the flask was reimmersed in the Belmont metal bath (the temperature had been increased to 295°C during this 30

minute wait) and the polymer mass was heated until it pulled away from the glass flask. The polymer mass was stirred at mid level in the flask until the polymer had cooled. The polymer was removed from the flask and ground to pass a 3 mm screen. Variations to this procedure were made to produce the copolyesters described below with targeted compositions of 20, 32, and 45 mol%.

[00615] Inherent viscosities were measured as described in the "Measurement Methods" section above. The compositions of the polyesters were determined by ^{1}H NMR as explained before in the Measurement Methods section. The glass transition temperatures were determined by DSC, using the second heat after quench at a rate of 20°C/min.

[00616] The table below shows the experimental data for the polyesters of this example. The data shows that an increase in the level of 2,2,4,4-tetramethyl-1,3-cyclobutanediol raises the glass transition temperature in an almost linear fashion, for a constant inherent viscosity. Figure 3 also shows the dependence of Tg on composition and inherent viscosity.

Table 9

Glass transition temperature as a function of inherent viscosity and composition

Example	mol% TMCD	% cis TMCD	IV (dL/g)	T_g (°C)	η_o at 260°C (Poise)	η_o at 275°C (Poise)	η_o at 290°C (Poise)
A	43.9	72.1	0.46	131	NA	NA	NA
B	44.2	36.4	0.49	118	NA	NA	NA
C	44	71.7	0.49	128	NA	NA	NA
D	44.3	36.3	0.51	119	NA	NA	NA
E	46.1	46.8	0.51	125	NA	NA	NA
F	43.6	72.1	0.52	128	NA	NA	NA
G	43.6	72.3	0.54	127	NA	NA	NA
H	46.4	46.4	0.54	127	NA	NA	NA
I	45.7	47.1	0.55	125	NA	NA	NA
J	44.4	35.6	0.55	118	NA	NA	NA
K	45.2	46.8	0.56	124	NA	NA	NA
L	43.8	72.2	0.56	129	NA	NA	NA
M	45.8	46.4	0.56	124	NA	NA	NA
N	45.1	47.0	0.57	125	NA	NA	NA
O	45.2	46.8	0.57	124	NA	NA	NA
P	45	46.7	0.57	125	NA	NA	NA
Q	45.1	47.1	0.58	127	NA	NA	NA
R	44.7	35.4	0.59	123	NA	NA	NA
S	46.1	46.4	0.60	127	NA	NA	NA
T	45.7	46.8	0.60	129	NA	NA	NA
U	46	46.3	0.62	128	NA	NA	NA
V	45.9	46.3	0.62	128	NA	NA	NA
X	45.8	46.1	0.63	128	NA	NA	NA
Y	45.6	50.7	0.63	128	NA	NA	NA
Z	46.2	46.8	0.65	129	NA	NA	NA
AA	45.9	46.2	0.66	128	NA	NA	NA
AB	45.2	46.4	0.66	128	NA	NA	NA
AC	45.1	46.5	0.68	129	NA	NA	NA
AD	46.3	52.4	0.52	NA	NA	NA	NA
AE	45.7	50.9	0.54	NA	NA	NA	NA
AF	46.3	52.6	0.56	NA	NA	NA	NA
AG	46	50.6	0.56	NA	NA	NA	NA
AH	46.5	51.8	0.57	NA	NA	NA	NA
AI	45.6	51.2	0.58	NA	NA	NA	NA
AJ	46	51.9	0.58	NA	NA	NA	NA
AK	45.5	51.2	0.59	NA	NA	NA	NA
AL	45.8	50.1	0.624	125	NA	NA	7696
AM	45.7	49.4	0.619	128	NA	NA	7209
AN	46.2	49.3	0.548	124	NA	NA	2348
AP	45.9	49.5	0.72	128	76600	40260	19110
AQ	46.0	50	0.71	131	68310	32480	17817
AR	46.1	49.6	0.383	117	NA	NA	387
AS	45.6	50.5	0.325	108	NA	NA	NA
AT	47.2	NA	0.48	NA	NA	NA	NA

NA = Not available

Example 10

[00617] This example illustrates the effect of the predominance of the type of 2,2,4,4-tetramethyl-1,3-cyclobutanediol isomer (cis or trans) on the glass transition temperature of the polyester.

[00618] Dimethyl terephthalate, 1,4-cyclohexanedimethanol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol were weighed into a 500-ml single neck round bottom flask. The polyesters of this example were prepared with a 1.2/1 glycol/acid ratio with the entire excess coming from the 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Enough dibutyltin oxide catalyst was added to give 300 ppm tin in the final polymer. The flask was under a 0.2 SCFC nitrogen purge with vacuum reduction capability. The flask was immersed in a Belmont metal bath at 200°C and stirred at 200 RPM after the reactants had melted. After about 2.5 hours, the temperature was raised to 210°C and these conditions were held for an additional 2 hours. The temperature was raised to 285°C (in approximately 25 minutes) and the pressure was reduced to 0.3 mm of Hg over a period of 5 minutes. The stirring was reduced as the viscosity increased, with 15 RPM being the minimum stirring used. The total polymerization time was varied to attain the target inherent viscosities. After the polymerization was complete, the Belmont metal bath was lowered and the polymer was allowed to cool to below its glass transition temperature. After about 30 minutes, the flask was reimmersed in the Belmont metal bath (the temperature had been increased to 295°C during this 30 minute wait) and the polymer mass was heated until it pulled away from the glass flask. The polymer mass was stirred at mid level in the flask until the polymer had cooled. The polymer was removed from the flask and ground to pass a 3 mm screen. Variations to this procedure were made to produce the copolyesters described below with targeted compositions of 20, 32, and 45 mol%.

[00619] Inherent viscosities were measured as described in the "Measurement Methods" section above. The compositions of the polyesters were determined by ^{1}H NMR as explained before in the Measurement Methods section. The glass transition temperatures were determined by DSC, using the second heat after quench at a rate of 20°C/min.

[00620] The table below shows the experimental data for the polyesters of this Example. The data shows that cis 2,2,4,4-tetramethyl-1,3-cyclobutanediol is approximately twice as effective as trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol at increasing the glass transition temperature for a constant inherent viscosity.

Table 10

Effect of 2,2,4,4-tetramethyl-1,3-cyclobutanediol cis/trans composition on T_g

Example	mol% TMCD	IV (dL/g)	T_g (°C)	η_o at 260°C (Poise)	η_o at 275°C (Poise)	η_o at 290°C (Poise)	% cis TMCD
A	45.8	0.71	119	N.A.	N.A.	N.A.	4.1
B	43.2	0.72	122	N.A.	N.A.	N.A.	22.0
C	46.8	0.57	119	26306	16941	6601	22.8
D	43.0	0.67	125	55060	36747	14410	23.8
E	43.8	0.72	127	101000	62750	25330	24.5
F	45.9	0.533	119	11474	6864	2806	26.4
G	45.0	0.35	107	N.A.	N.A.	N.A.	27.2
H	41.2	0.38	106	1214	757	N.A.	29.0
I	44.7	0.59	123	N.A.	N.A.	N.A.	35.4
J	44.4	0.55	118	N.A.	N.A.	N.A.	35.6
K	44.3	0.51	119	N.A.	N.A.	N.A.	36.3
L	44.0	0.49	128	N.A.	N.A.	N.A.	71.7
M	43.6	0.52	128	N.A.	N.A.	N.A.	72.1
N	43.6	0.54	127	N.A.	N.A.	N.A.	72.3
O	41.5	0.58	133	15419	10253	4252	88.7
P	43.8	0.57	135	16219	10226	4235	89.6
Q	41.0	0.33	120	521	351	2261	90.4
R	43.0	0.56	134	N.A.	N.A.	N.A.	90.6
S	43.0	0.49	132	7055	4620	2120	90.6
T	43.1	0.55	134	12970	8443	3531	91.2
U	45.9	0.52	137	N.A.	N.A.	N.A.	98.1

NA = not available

Example 11

[00621] This example illustrates the preparation of a copolyester containing 100 mol% dimethyl terephthalate residues, 55 mol% 1,4-cyclohexanedimethanol residues, and 45 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

[00622] A mixture of 97.10 g (0.5 mol) dimethyl terephthalate, 52.46 g (0.36 mol) 1,4-cyclohexanedimethanol, 34.07 g (0.24 mol) 2,2,4,4-tetramethyl-1,3-

cyclobutanediol, and 0.0863 g (300 ppm) dibutyl tin oxide was placed in a 500-milliliter flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The flask was placed in a Wood's metal bath already heated to 200°C. The contents of the flask were heated at 200°C for 1 hour and then the temperature was increased to 210°C. The reaction mixture was held at 210°C for 2 hours and then heated up to 290°C in 30 minutes. Once at 290°C, a vacuum of 0.01 psig was gradually applied over the next 3 to 5 minutes. Full vacuum (0.01 psig) was maintained for a total time of about 45 minutes to remove excess unreacted diols. A high melt viscosity, visually clear and colorless polymer was obtained with a glass transition temperature of 125°C and an inherent viscosity of 0.64 dl/g.

Example 12

[00623] This example illustrates that a polyester based on 100% 2,2,4,4-tetramethyl-1,3-cyclobutanediol has a slow crystallization half-time.

[00624] A polyester based solely on terephthalic acid and 2,2,4,4-tetramethyl-1,3-cyclobutanediol was prepared in a method similar to the method described in Example 11 with the properties shown on Table 11. This polyester was made with 300 ppm dibutyl tin oxide. The trans/cis ratio of the 2,2,4,4-tetramethyl-1,3-cyclobutanediol was 65/35.

[00625] Films were pressed from the ground polymer at 320°C. Crystallization half-time measurements from the melt were made at temperatures from 220 to 250°C at 10°C increments and are reported in Table 11. The fastest crystallization half-time for the sample was taken as the minimum value of crystallization half-time as a function of temperature. The fastest crystallization half-time of this polyester is around 1300 minutes. This value contrasts with the fact that the polyester (PCT) based solely on terephthalic acid and 1,4-cyclohexanedimethanol (no comonomer modification) has an extremely short crystallization half-time (<1 min) as shown in Figure 1.

Table 11

Crystallization Half-times (min)

Comonomer (mol %)	IV (dl/g)	T_g (°C)	T_{max} (°C)	at 220°C (min)	at 230°C (min)	at 240°C (min)	at 250°C (min)
100 mol% F	0.63	170.0	330	3291	3066	1303	1888

where: F is 2,2,4,4-Tetramethyl-1,3-cyclobutanediol (65/35 Trans/Cis)

Example 13

[00626] Sheets comprising a polyester that had been prepared with a target composition of 100 mole % terephthalic acid residues, 80 mole % 1,4-cyclohexanedimethanol residues, and 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues were produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 177 mil and then various sheets were sheared to size. Inherent viscosity and glass transition temperature were measured on one sheet. The sheet inherent viscosity was measured to be 0.69 dl/g. The glass transition temperature of the sheet was measured to be 106°C. Sheets were then conditioned at 50% relative humidity and 60°C for 2 weeks. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example G). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 106°C can be thermoformed under the conditions shown below, as evidenced by these sheets having at least 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	86	145	501	64	N
B	100	150	500	63	N
C	118	156	672	85	N
D	135	163	736	94	N
E	143	166	760	97	N
F	150	168	740	94	L
G	159	172	787	100	L

Example 14

[00627] Sheets comprising a polyester that had been prepared with a target composition of 100 mole % terephthalic acid residues, 80 mole % 1,4-cyclohexanedimethanol residues, and 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues were produced using a 3.5 inch single screw. A sheet was extruded continuously, gauged to a thickness of 177 mil and then various sheets were sheared to size. Inherent viscosity and glass transition temperature were measured on one sheet. The sheet inherent viscosity was measured to be 0.69 dl/g. The glass transition temperature of the sheet was measured to be 106°C. Sheets were then conditioned at 100% relative humidity and 25°C for 2 weeks. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 60/40/40% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example G). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 106°C can be thermoformed under the

conditions shown below, as evidenced by the production of sheets having at least 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	141	154	394	53	N
B	163	157	606	82	N
C	185	160	702	95	N
D	195	161	698	95	N
E	215	163	699	95	L
F	230	168	705	96	L
G	274	174	737	100	H
H	275	181	726	99	H

Example 15—Comparative Example

[00628] Sheets consisting of Kelvx 201 were produced using a 3.5 inch single screw extruder. Kelvx is a blend consisting of 69.85% PCTG (Eastar from Eastman Chemical Co. having 100 mole % terephthalic acid residues, 62 mole % 1,4-cyclohexanedimethanol residues, and 38 mole % ethylene glycol residues); 30% PC (bisphenol A polycarbonate); and 0.15% Weston 619 (stabilizer sold by Crompton Corporation). A sheet was extruded continuously, gauged to a thickness of 177 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 100°C. Sheets were then conditioned at 50% relative humidity and 60°C for 2 weeks. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example E). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below

demonstrate that these thermoplastic sheets with a glass transition temperature of 100°C can be thermoformed under the conditions shown below, as evidenced by the production of sheets having at least 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	90	146	582	75	N
B	101	150	644	83	N
C	111	154	763	98	N
D	126	159	733	95	N
E	126	159	775	100	N
F	141	165	757	98	N
G	148	168	760	98	L

Example 16—Comparative Example

[00629] Sheets consisting of Kelvx 201 were produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 177 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 100°C. Sheets were then conditioned at 100% relative humidity and 25°C for 2 weeks. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 60/40/40% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example H). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 100°C can be thermoformed under the conditions shown below, as evidenced

by the production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	110	143	185	25	N
B	145	149	529	70	N
C	170	154	721	95	N
D	175	156	725	96	N
E	185	157	728	96	N
F	206	160	743	98	L
G	253	NR	742	98	H
H	261	166	756	100	H

NR = Not recorded

Example 17—Comparative Example

[00630] Sheets consisting of PCTG 25976 (100 mole % terephthalic acid residues, 62 mole % 1,4-cyclohexanedimethanol residues, and 38 mole % ethylene glycol residues) were produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 87°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.17 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 87°C can be thermoformed under the conditions shown below, as

evidenced by the production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	102	183	816	100	N
B	92	171	811	99	N
C	77	160	805	99	N
D	68	149	804	99	N
E	55	143	790	97	N
F	57	138	697	85	N

Example 18—Comparative Example

[00631] A miscible blend consisting of 20 wt% Teijin L-1250 polycarbonate (a bisphenol-A polycarbonate), 79.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 94°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.25 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 94°C can be thermoformed under the conditions shown below, as evidenced

by the production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	92	184	844	100	H
B	86	171	838	99	N
C	73	160	834	99	N
D	58	143	787	93	N
E	55	143	665	79	N

Example 19—Comparative Example

[00632] A miscible blend consisting of 30 wt% Teijin L-1250 polycarbonate, 69.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 99°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.25 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 99°C can be thermoformed under the conditions shown below, as evidenced by the

production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	128	194	854	100	H
B	98	182	831	97	L
C	79	160	821	96	N
D	71	149	819	96	N
E	55	145	785	92	N
F	46	143	0	0	NA
G	36	132	0	0	NA

NA = not applicable. A value of zero indicates that the sheet was not formed because it did not pull into the mold (likely because it was too cold).

Example 20—Comparative Example

[00633] A miscible blend consisting of 40 wt% Teijin L-1250 polycarbonate, 59.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 105°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.265 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Examples 8A to 8E). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 105°C can

be thermoformed under the conditions shown below, as evidenced by the production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	111	191	828	100	H
B	104	182	828	100	H
C	99	179	827	100	N
D	97	177	827	100	N
E	78	160	826	100	N
F	68	149	759	92	N
G	65	143	606	73	N

Example 21—Comparative Example

[00634] A miscible blend consisting of 50 wt% Teijin L-1250 polycarbonate, 49.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 111°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.225 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Examples A to D). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 111°C can be thermoformed under the conditions shown below, as evidenced by the

production of sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	118	192	815	100	H
B	99	182	815	100	H
C	97	177	814	100	L
D	87	171	813	100	N
E	80	160	802	98	N
F	64	154	739	91	N
G	60	149	0	0	NA

NA = not applicable. A value of zero indicates that the sheet was not formed because it did not pull into the mold (likely because it was too cold).

Example 22—Comparative Example

[00635] A miscible blend consisting of 60 wt% Teijin L-1250 polycarbonate, 39.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 117°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.215 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 117°C

cannot be thermoformed under the conditions shown below, as evidenced by the inability to produce sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	114	196	813	100	H
B	100	182	804	99	H
C	99	177	801	98	L
D	92	171	784	96	L
E	82	168	727	89	L
F	87	166	597	73	N

Example 23—Comparative Example

[00636] A miscible blend consisting of 65 wt% Teijin L-1250 polycarbonate, 34.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 120°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.23 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 120°C cannot be thermoformed under the conditions shown below, as evidenced by the

inability to produce sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	120	197	825	100	H
B	101	177	820	99	H
C	95	174	781	95	L
D	85	171	727	88	L
E	83	166	558	68	L

Example 24—Comparative Example

[00637] A miscible blend consisting of 70 wt% Teijin L-1250 polycarbonate, 29.85 wt% PCTG 25976, and 0.15 wt% Weston 619 was produced using a 1.25 inch single screw extruder. Sheets consisting of the blend were then produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 123°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.205 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw, and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Examples A and B). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 123°C cannot be thermoformed under the conditions shown below, as evidenced by the

inability to produce sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	126	198	826	100	H
B	111	188	822	100	H
C	97	177	787	95	L
D	74	166	161	19	L
E	58	154	0	0	NA
F	48	149	0	0	NA

NA = not applicable. A value of zero indicates that the sheet was not formed because it did not pull into the mold (likely because it was too cold).

Example 25—Comparative Example

[00638] Sheets consisting of Teijin L-1250 polycarbonate were produced using a 3.5 inch single screw extruder. A sheet was extruded continuously, gauged to a thickness of 118 mil and then various sheets were sheared to size. The glass transition temperature was measured on one sheet and was 149°C. Sheets were then conditioned at 50% relative humidity and 60°C for 4 weeks. The moisture level was measured to be 0.16 wt%. Sheets were subsequently thermoformed into a female mold having a draw ratio of 2.5:1 using a Brown thermoforming machine. The thermoforming oven heaters were set to 70/60/60% output using top heat only. Sheets were left in the oven for various amounts of time in order to determine the effect of sheet temperature on the part quality as shown in the table below. Part quality was determined by measuring the volume of the thermoformed part, calculating the draw and visually inspecting the thermoformed part. The draw was calculated as the part volume divided by the maximum part volume achieved in this set of experiments (Example A). The thermoformed part was visually inspected for any blisters and the degree of blistering rated as none (N), low (L), or high (H). The results below demonstrate that these thermoplastic sheets with a glass transition temperature of 149°C cannot be thermoformed under the conditions shown below, as evidenced by the inability to produce sheets having greater than 95% draw and no blistering, without predrying the sheets prior to thermoforming.

Example	Thermoforming Conditions		Part Quality		
	Heat Time (s)	Sheet Temperature (°C)	Part Volume (mL)	Draw (%)	Blisters (N, L, H)
A	152	216	820	100	H
B	123	193	805	98	H
C	113	191	179	22	H
D	106	188	0	0	H
E	95	182	0	0	NA
F	90	171	0	0	NA

NA = not applicable. A value of zero indicates that the sheet was not formed because it did not pull into the mold (likely because it was too cold).

Example 26

[00639] This example illustrates the preparation of polyesters comprising at least one thermal stabilizer, reaction products thereof, and mixtures thereof, resulting in improved stability of the polyester melts during processing.

[00640] A variety of polyesters were prepared as described below from 100 mole% dimethyl terephthalate (DMT), 1,4-cyclohexanedimethanol (CHDM), and 2,2,4,4-tetramethyl-1,3-cyclobutanediol (TMCD). The mole% of TMCD for the experiments of this example is reported in Table 12 below, with the glycol balance being CHDM. The DMT was purchased from Cape Industries, the CHDM (min. 98 %) and the TMCD (min. 98 %) were from Eastman Chemical Company. The tin compound was either dimethyltin oxide (from Strem Chemical Co. or Gelest, Inc.) or butyltin-tris-2-ethylhexonate (from Aldrich or Arkema). The phosphorus compound was triphenyl phosphate (TPP, from Aldrich (98 %) or FERRO, Corp.). Unless otherwise indicated below, the source of phosphorous was added upfront, with the rest of the polyester reagents. The cis/trans ratio of the CHDM was as described above while the cis/trans ratio of the TMCD is reported in Table 12.

Table 12

Composition and inherent viscosity for the polyesters of Example 26

Example	Melt IV (dL/g)	TMCD (mole%)	TMCD %cis	Sn (ppm)	P (ppm) theo/meas	Sn/P actual wt ratio	Final Pz Temp (°C)
A	0.605	44.8	50.0	205[1]	none	*	290
B	0.583	44.4	51.9	201[1]	none	*	290
C	0.578	43.9	50.7	199[1]	none	*	290
D	0.607	44.9	50.5	199[2]	none	*	290
E	0.437	44.5	52.0	200[2]	none	*	290
F	0.292	44.8	51.9	190[2]	34/34	5.6	290
G	0.240	43.6	52.8	206[1]	34/37	5.6	290
H	0.213	43.2	53.7	192[2]	34/49	3.9	290
I	0.585	45.1	50.2	191[2]	10/11	17.4	290
J	0.580	45.1	50.5	192[1]	10/11	17.5	290
K	0.541	44.0	52.3	202[2]	19/20	10.1	290
L	0.595	45.3	50.6	198[2]	20/20	9.9	290
M	0.632	45.6	49.0	203[2]	20/22	9.2	265
N	0.577	46.2	50.1	196[2]	30/26	7.5	265
O	0.608	46.0	49.6	190[1]	20/19	10.0	265
P	0.517	45.2	49.4	100[2]	10/10	10.0	265
Q	0.602	46.1	49.2	102[2]	10/10	10.2	265
R	0.740	19.0	51.7	190[2]	20/18	10.6	275

1 butyltin tris-2-ethylhexanoate was used as the source of tin
2 dimethyl tin oxide was used as the source of tin

[00641] The data in Table 13 shows that the stability of polymer melts for Comparative Examples A to D was not deemed acceptable if the same conditions were to be used at a pilot-pant or commercial scale. In contrast, experiments having appropriate ratios of tin/phosphorous produced stable melts, suitable for scale up processes.

Table 13

Properties of the polyesters of Example 26

Example	L*	a*	b*	Melt level stability	Polymer color observations	% foam in polyester	Visual grading of polyester
A	82.50	-0.89	4.66	4	Yellow tint	34%	4
B	79.74	-0.75	4.89	4	Yellow tint	21%	4
C	78.64	-0.39	6.83	4	Brownish-yellow tint	37%	4
D	85.44	-1.45	4.07	3	Slight yellow tint	27%	4
E	86.19	-1.04	3.94	3	Good color: No yellow tint	35%	4
F	89.17	-0.78	2.07	1	Good color: No yellow tint	12%	1
G	88.96	-1.00	3.76	1	Slight yellow tint	9%	1
H	88.92	-0.64	2.12	1	Good color: No yellow tint	9%	1
I	80.92	-1.02	3.22	2	Good color: No yellow tint	20%	3
J	82.10	-1.67	3.69	2	Good color: No yellow tint	22%	3
K	85.74	-0.81	2.46	1	NM	NM	NM
L	82.51	-1.03	2.56	1	Good color: No yellow tint	15%	2
M	85.54	-1.07	2.06	1	Good color: No yellow tint	22%	3
N	84.54	-0.71	1.07	1	Good color: No yellow tint	14%	2
O	85.03	-0.82	1.17	1	Slight yellow tint	14%	3
P	85.02	-0.87	1.59	1	Slight yellow tint	17%	2
Q	82.49	-0.86	1.09	1	Good color: No yellow tint	17%	2
R	85.27	-1.74	4.40	1	Slight yellow tint	24%	4
S	NA	NA	NA	NA	NA	35%	NA
T	NA	NA	NA	NA	NA	9%	NA

NM = not measured

[00642] The melt level stability reported in Table 13 is based on the following scale:

1	Stable melt levels, limited off-gassing, similar to conventional polyesters where excess glycols slowly boil off
2	Relatively stable melt levels but some additional void/bubbles compared to 1 above.
3	Unstable melt levels during vacuum levels, heavy foaming and frothing leading to high void volumes (bubbles that increase melt overall volume), unstable off-gassing, melt level surges that were kept from overflowing flask only with adjustment of stirring rate or by having stirrer above level of melt to push down and break up the foam. Too unstable to scale up dependably.
4	Very unstable melt levels during vacuum levels, excessive foaming and frothing leading to high void volumes (bubbles that increase melt overall volume), unstable off-gassing, melt level surges that overflowed out of flask and frequently pushed melt/foam into the gas space in vacuum system. Frequently, it was not possible to complete run (greater than 50% of duplicate runs could not be completed for this level of stability).

[00643] The visual grading reported in Table 13 is based on the following scale:

Grading	Explanation
1	Few bubbles: can see through molten polymer
2	Sparse bubbles: enough bubbles to obstruct view through polymer but not enough to drastically increase the polymer volume
3	Numerous bubbles: volume of polymer is affected by the bubbles
4	Very dense foam: volume of polymer is drastically affected by the numerous bubbles

[00644] Example 26S and Example 26T are comparative examples. Example 26S represents a polyester prepared in a similar manner to Example 29A below with no phosphorus thermal stabilizer, having an IV of 0.54 dL/g and containing 100 mole % terephthalic acid residues, 43.8 mole % TMCD residues and 56.2 mole %CHDM acid residues. This polyester was prepared using butyltin tris-2-ethylhexanoate was used as the source of tin catalyst (Sn=216 ppm)at 290°C final finisher temperature and having color values L*=60.97, b*=9.02, and a*=-0.89. Example 26T represents a commercial Kelvx polymer containing 65 mole % terephthalic acid residues, 35 mole % isophthalic acid residues, and 100 mole % 1,4-cyclohexanedimethanol residues.

[00645] The polyesters of this example were prepared in a 500 ml round bottom flask fitted with a stirrer and a polymer head that allowed both a nitrogen purge and vacuum when necessary. Raw materials were weighed into the flask for a 0.4 mole run (polymer repeat unit = 274 grams/mole): 0.400 moles of DMT (77.6 grams), 0.224 moles of CHDM (32.3 grams) and 0.256 moles of TMCD (36.8 grams) and 0.112 g butyltin tris-2-ethylhexanoate or 0.0314 g dimethyl tin oxide (as reported in Table 12), such that there was approximately 200 ppm tin metal in the final polymer, but were modified accordingly for other target concentrations, such as 100 ppm Sn. The amounts of TMCD and CHDM were

modified accordingly to produce the polyester of Example 26, in which the target TMCD concentration was 20 mol percent.

[00646] The glycol/acid ratio was 1.2/1 with the excess being 2% CHDM and the rest of the 20% excess being TMCD. The catalyst was weighed into the flask, either as a solid or liquid. Triphenyl phosphate was weighed into the flask as a solid in the amount recited in Table 12 for each experiment. 100 ppm (0.0109g as a liquid) of tetramethyl ammonium hydroxide (TMAH) was used in the preparation of Example 26N.

[00647] The set points and data collection were facilitated by a Camile process control system. Once the reactants were melted, stirring was initiated and slowly increased as indicated below in the corresponding Camile sequences. The temperature of the reactor also gradually increased with run time.

[00648] The ester exchange and polycondensation reactions were carried out in the same 500 ml flask. The blade of the stirrer was moved up to the top of the melt during the processing of the polyesters of Example 26A and Example 26B to beat down the foam layer. The temperature/pressure/stir rate sequence controlled by the Camile software for each example is reported in the following tables. The final polymerization temperature (Pz Temp.) for the experiments of this Example ranged from 265°C to 290°C and is reported in Table 12.

[00649] Camile Sequence for Example 26A to Example 26L

Stage	Time (minutes)	Temperature (°C)	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	5	245	760	50
12	30	265	760	50
13	3	265	90	50
14	110	290	90	50
15	5	290	6	25
16	110	290	6	25
17	2	290	400	0
18	1	300	760	0

[00650] Camile Sequence for Example 26M to Example 26O

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	5	25
16	110	255	5	25
17	3	265	1	25
18	110	265	1	25
19	2	265	400	0
20	1	265	760	0

[00651] Camile Sequence for Example 26P

Viscosity constrained sequence, low vacuum

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	5	25
16	110	255	5	25
17	3	265	0.2	25
18	110	265	0.2	25
19	2	265	400	0
20	1	265	760	0

[00652] Camile Sequence for Example 26Q

Viscosity constrained sequence, low vacuum

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	3	25
16	110	255	3	25
17	3	265	0.2	25
18	110	265	0.2	25
19	2	265	400	0
20	1	265	760	0

[00653] Camile Sequence for Example 26R

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	245	760	100
10	5	260	760	50
11	3	260	375	50
12	30	260	375	50
13	3	260	20	50
14	30	260	20	50
15	3	265	5	25
16	110	265	5	25
17	3	275	1	25
18	110	275	1	25
19	2	275	400	0
20	1	275	760	0

Example 27

[00654] This example illustrates the preparation of polyesters comprising at least one thermal stabilizer, reaction products thereof, and mixtures thereof, employing different process conditions from Example 26, resulting in improved stability of the polyester melts during processing.

[00655] A variety of polyesters were prepared as described below from 100 mole% DMT, CHDM, and TMCD. The mole% of TMCD for the experiments of this example is reported in Table 14 below, with the glycol balance being CHDM. The DMT, CHDM, and TMCD were of the same origin as in Example 26. The catalyst was dimethyltin oxide (Strem Chemical Co., Batch B4058112), butyltin-tris-2-ethylhexonate (Aldrich, Batch 06423CD, or Arkema), or dibutyl tin oxide (Arkema). The thermal stabilizer was triphenyl phosphate, also with the same origin as in Example 26. Unless otherwise indicated below, the source of phosphorous was added upfront, with the rest of the polyester reagents. The cis/trans ratio of the CHDM was as described above while the cis/trans ratio of the TMCD is reported in Table 14. The polyesters of Example 27A and Example 27E were not prepared with TPP.

Table 14

Composition and inherent viscosity for the polyesters of Example 27

Example	Melt IV (dL/g)	TMCD (mole%)	TMCD %cis	Sn (ppm)	P (ppm) theo/meas	Sn/P actual wt ratio	Final Pz Temp (°C)
A	0.548	46.3	50.1	190[3]	none	*	290
B	0.696	45.3	49.3	193[2]	10/9	21.4	275
C	0.597	45.1	50.4	199[2]	20/18	11.1	275
D	0.547	45.6	50.4	195[2]	30/27	7.2	275
E	0.714	45.4	49.9	198[2]	none	*	265
F	0.731	44.5	48.0	188[2]	30/25	7.5	265
G	0.727	44.7	48.5	203[2]	30/26	7.8	265
H	0.645	44.0	51.0	55[2]	7.5/8	6.9	265
I	0.605	43.3	48.6	55[2]	7.5/8	6.9	265
J	0.711	46.1	48.6	196[2]	20/17	11.5	275
K	0.721	45.8	48.8	193[2]	20/17	11.4	275

1 butyltin tris-2-ethylhexanoate was used as the source of tin
2 dimethyl tin oxide was used as the source of tin
3 dibutyl tin oxide was used as the source of tin

[00656] The data in Table 15 shows that the stability of polymer melts can be enhanced by modifying process conditions such as final polymerization temperature, rate of vacuum being created in the reaction vessel, the time under vacuum, among other, as reported below. The melt level stability and the visual grading reported in Table 15 are based on the scales disclosed in Example 26.

Table 15

Properties of the polyesters of Example 27

Example	L*	a*	b*	Melt level stability	Polymer color observations	% foam in polyester	Visual grading of polyester
A	83.55	-0.93	2.44	2	Slight yellow tint	30%	4
B	84.39	-1.48	3.89	1	Good color: No yellow tint	29%	4
C	84.46	-0.98	1.82	1	Slight yellow tint	21%	2
D	86.30	-0.75	1.27	1	Good color: No yellow tint	17%	2
E	85.60	-1.20	2.68	3	Yellow tint	38%	4
F	83.88	-0.97	1.64	1	Slight yellow tint	12%	1
G	85.76	-0.92	2.03	1	Slight yellow tint	12%	2
H	84.40	-0.98	1.61	1	Good color: No yellow tint	NM	1
I	84.88	-0.63	0.99	1	Slight yellow tint	11%	1
J	85.01	-1.02	1.77	1	Slight yellow tint	18%	3
K	84.13	-0.93	1.56	1	Slight yellow tint	25%	4

NM = not measured

Example 27A

[00657] A 500 ml round bottom flask was charged with 0.4 moles of DMT (77.6 grams), 0.224 moles of CHDM (32.3 grams), 0.256 moles of TMCD (36.8 grams), and 0.0460 grams of dibutyl tin oxide. The flask was equipped with a stainless

steel stirrer and polymer head that allowed both nitrogen purge and vacuum capabilities. The flask was immersed in a Belmont metal bath at 200°C and stirred at 25 RPM until the contents melted. The stirring was increased to 200 RPM and these conditions were held for 3 hours and 15 minutes. The temperature was increased to 220°C and these conditions held for an additional 30 minutes. The temperature was increased to 290°C over 20 minutes. After 290°C was obtained, the pressure was reduced from atmosphere to a set point (SP) of 0.3 over 15 minutes. Stirring was decreased as the viscosity increased to a minimum of 15 RPM. The lowest vacuum reading measured was 0.70 (even though the SP was 0.3) and the total time under vacuum was 30 minutes.

[00658] The rest of the polyesters of this example were prepared in a 500 ml round bottom flask fitted with a stirrer and a polymer head that allowed both a nitrogen purge and vacuum when necessary. Raw materials were weighed into the flask for a 0.4 mole run (polymer repeat unit = 274 grams/mole): 0.400 moles of DMT (77.6 grams), 0.224 moles of CHDM (32.3 grams) and 0.256 moles of TMCD (36.8 grams) and 0.112 g butyltin tris-2-ethylhexanoate, 0.0314 g dimethyl tin oxide, or 0.0460 g dibutyl tin oxide (as reported in Table 14). These values assume a target concentration of 200 ppm Sn in the final polymer and were adjusted accordingly for other target concentrations. The actual tin concentration for each polyester in this example is reported in Table 14

[00659] The glycol/acid ratio for all but two runs in this example was 1.2/1 with the excess being 2% CHDM and the rest of the 20% excess being TMCD. The glycol/acid ratio for Example 27H was 1.1/1, with the excess being TMCD. The glycol/acid ratio for Example 27I was 1.05/1, with the excess being TMCD. The catalyst was weighed into the flask, either as a solid or liquid. Triphenyl phosphate was weighed into the flask as a solid in the amounts recited in Table 14. The TPP in Example 27K was added late from a methanol solution.

[00660] The set points and data collection were facilitated by a Camile process control system. Once the reactants were melted, stirring was initiated and slowly increased as indicated below in the corresponding Camile sequences. The temperature of the reactor also gradually increased with run time.

[00661] The ester exchange and polycondensation reactions were carried out in the same 500 ml flask. The temperature/pressure/stir rate sequence controlled by the Camile software for each example is reported in the following tables. The final polymerization temperature (Pz Temp.) for the experiments of this Example ranged from 265°C to 290°C and is reported in Table 14.

[00662] Camile Sequence for Example 27B to Example 27D

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	32	250	375	50
12	30	255	375	50
13	3	255	50	50
14	30	260	50	50
15	3	265	15	25
16	110	265	15	25
17	3	270	2	25
18	110	275	2	25
19	2	275	400	0
20	1	275	760	0

[00663] Camile Sequence for Example 27E

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	5	25
16	110	255	5	25
17	3	265	1	25
18	110	265	1	25
19	2	265	400	0
20	1	265	760	0

[00664] Camile Sequence for Example 27F and Example 27G

Viscosity constrained sequence, low vacuum

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	5	25
16	110	255	5	25
17	3	265	0.2	25
18	110	265	0.2	25
19	2	265	400	0
20	1	265	760	0

[00665] Camile Sequence for Example 27H and Example 27I

Viscosity constrained sequence, low vacuum

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	3	25
16	110	255	3	25
17	3	265	1	25
18	110	265	1	25
19	2	265	400	0
20	1	265	760	0

[00666] Camile Sequence for Example 27J and Example 27K

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	260	5	25
16	110	260	5	25
17	3	275	1	25
18	110	275	1	25
19	2	275	400	0
20	1	275	760	0

Example 28

[00667] This example illustrates the preparation of polyesters utilizing different thermal stabilizers and showing their effect on the stability of the polyester melts during processing.

[00668] A variety of polyesters were prepared as described below from 100 mole% DMT, and different concentrations of CHDM, and TMCD. The mole% of TMCD for the experiments of this example is reported in Table 16 below, with the glycol balance being CHDM. The DMT, CHDM, and TMCD were of the same origin as in Example 26. The catalyst was either dimethyltin oxide (Strem Chemical Co., Batch B4058112) or butyltin-tris-2-ethylhexonate (Aldrich, Batch 06423CD). The thermal stabilizer is indicated in Table 16 and was chosen from Merpol A (an octyl alcohol phosphate ester mixture from DuPont), triethylphosphate (Aldrich), Irgafos 168 (tris(2,4-di-tert-butylphenyl)phosphate, Ciba Specialty Chemicals), Doverphos 9228 (CAS# 154862-43-8, bis(2,4-dicumylphenyl) pentaerythritol diphosphite, Dover), Weston 619g (CAS# 85190-63-2, 2-propanol, 1,1',1"-nitrilotris-, mixt. with 3,9-bis(octadecyloxy)-2,4,8,10-tetraoxa-3,9-diphosphaspiro[5.5]undecane, GE SC), triphenylphosphine oxide (Aldrich), triphenylphosphate (Aldrich or FERRO), NaH_2PO_4 (Aldrich), $Zn_3(PO_4)_2$ (Aldrich), and H_3PO_4 (Aldrich). Unless otherwise indicated in Table 16, the source of phosphorous was added upfront, with the rest of the polyester reagents. The cis/trans ratio of the CHDM was as described above while the cis/trans ratio of the TMCD is reported in Table 16.

Table 16

Composition and inherent viscosity for the polyesters of Example 28

Example	Melt IV (dL/g)	TMCD (mole%)	TMCD %cis	Sn (ppm)	P (ppm) theo/meas	Sn/P actual wt ratio	Final Pz Temp (°C)
A	0.564	45.7	49.7	211[2]	28/26	8.1	265
B	0.167	29.2	58.2	218[2]	28/39	5.6	265
C	0.647	45.2	49.2	195[2]	20/19	10.3	265
D	0.674	46.3	48.7	196[2]	20/18	10.9	265
E	0.700	45.6	49.4	195[2]	20/0	*	265
F	0.738	45.9	49.0	214[2]	20/8	26.8	265
G	0.672	46.4	49.7	192[2]	20/11	17.5	265
H	0.714	46.0	48.5	189[2]	20/7	27.0	265
I	0.73	42.3	45.1	212[1]	0	*	265
J	0.58	44.4	44.5	209[1]	28/27	7.7	265
K	0.53	43.4	45.0	213[1]	28/28	7.6	265
L	0.69	44.3	44.4	209[1]	28/20	10.5	265
M	0.61	43.7	45.4	211[1]	28/25	8.4	265
N	0.76	43.9	44.4	200[1]	28/20	10.0	265
O	0.66	44.6	44.3	58[1]	0	*	265
P	0.6	42.4	44.7	60[1]	7/7	8.6	265
Q	0.5	42.9	45.4	57[1]	7/7	8.1	265
R	0.51	43.8	45.1	52[1]	200/55[4]	0.9	265
S	0.64	44.0	44.4	58[1]	200/71[4]	0.8	265

1 butyltin tris-2-ethylhexanoate was used as the source of tin
2 dimethyl tin oxide was used as the source of tin
3 dibutyl tin oxide was used as the source of tin
4 polymer was hazy due to insolubles

[00669] The data in Table 17 shows the stability of polymer melts using different sources of phosphorous as thermal stabilizers. The data shows that phosphate esters and phosphorous compounds that can be hydrolyzed to phosphate esters provide stable melt and acceptable polyester products. The

melt level stability and the visual grading reported in Table 17 are based on the scales disclosed in Example 26.

Table 17

Properties of the polyesters of Example 28

Example	L*	a*	b*	Phosphorus source	Melt level stability	Polymer color observations	% foam in polyester	Visual grading of polyester
A	83.87	-1.09	1.61	Merpol A	1	NM	NM	NM
B	NM	NM	NM	H_3PO_4	1	Good color: No yellow tint	7%	1
C	84.84	-0.94	1.40	Merpol A	1	Good color: No yellow tint	22%	3
D	85.86	-0.69	1.07	Merpol A added after EE	1	Slight yellow tint	21%	3
E	83.77	-1.12	1.91	Triethyl phosphate	2	Slight yellow tint	25%	4
F	84.05	-2.06	8.66	Triethyl phosphate	2	Brownish-yellow tint	22%	4
G	77.63	-0.82	3.33	Irgafos 168	3	NM	NM	NM
H	78.68	-0.83	3.34	Irgafos 168 added after EE	3	Brownish-yellow tint	24%	4
I	NM	NM	NM	none	NN	Slight yellow tint	26%	4
J	NM	NM	NM	Doverphos 9228	NN	Good color: No yellow tint	21%	3
K	NM	NM	NM	Doverphos 9228	NN	NM	NM	NM
L	NM	NM	NM	Weston 619g	NN	Good color: No yellow tint	21%	4
M	NM	NM	NM	Triphenyl phosphate	NN	Slight yellow tint	14%	2
N	NM	NM	NM	Triphenyl phosphine oxide	NN	Slight yellow tint	23%	3
O	NM	NM	NM	none	NN	Slight yellow tint	19%	2
P	NM	NM	NM	Triphenyl phosphate	NN	NM	NM	NM
Q	NM	NM	NM	Triphenyl phosphate	NN	Good color: No yellow tint	10%	1
R	NM	NM	NM	NaH_2PO_4	NN	Good color: No yellow tint	17%	1
S	NM	NM	NM	$Zn_3(PO_4)_2$	NN	Good color: No yellow tint	16%	2

EE = ester exchange; NM = not measured; NN = nor noted

The sample of Example R was hazy so visual grading may have been impaired

Example 28A to Example 28H

[00670] These polyesters were prepared as follows. A mixture of 77.6 g (0.4 mol) dimethyl terephthalate, 32.3 g (0.224 mol) 1,4-cyclohexanedimethanol, 36.8 g (0.256 mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol was placed in a 500-ml flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The catalyst was also added to the reaction flask. The amount and type of catalyst are in detailed in Table 16. The phosphorus compounds were also added to the reaction flask. The theoretical and measured amount of phosphorus compound for each experiment in this example is detailed in Table 16. The flask was placed in a Wood's metal bath already heated to 200°C. The temperature/pressure/stir rate sequence were controlled by the Camile software for each experiment and is reported below. In some cases, where noted (Example 28D and Example 28H), the phosphorus additive was added after ester exchange. This corresponds to the end of stage 9 in the corresponding Camile sequence.

Example 28I to Example 28S

[00671] These polyesters were prepared as follows. A mixture of 77.6 g (0.4 mol) dimethyl terephthalate, 33.31 g (0.231 mol) 1,4-cyclohexanedimethanol, 35.91 g (0.249 mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol was placed in a 500-ml flask equipped with an inlet for nitrogen, a metal stirrer, and a short distillation column. The catalyst was also added to the reaction flask. The amount and type of catalyst are in detailed in Table 16. The source of phosphorous was weighed into the flask in the amounts recited in Table 16, which includes the theoretical and measured amount of phosphorus compound for each experiment. The flask was placed in a Wood's metal bath already heated to 200°C. The temperature/pressure/stir rate sequence controlled by the Camile software for each example is reported below.

[00672] The glycol/acid ratio for all experiments in this example was 1.2/1 with the excess being 2% CHDM and the rest of the 20% excess being TMCD. The catalyst was weighed into the flask, either as a solid or liquid.

[00673] The set points and data collection were facilitated by a Camile process control system. Once the reactants were melted, stirring was initiated and slowly increased as indicated below in the corresponding Camile sequences. The temperature of the reactor also gradually increased with run time.

[00674] The temperature/pressure/stir rate sequence controlled by the Camile software for each example is reported in the following tables. The final polymerization temperature (Pz Temp.) for the experiments of this example was 265°C.

[00675] Camile Sequence for Example 28A and Example 28B

Viscosity constrained sequence

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	0.1	220	760	200
11	30	220	760	200
12	5	245	760	50
13	3	245	375	50
14	30	245	375	50
15	3	250	20	50
16	30	250	20	50
17	3	255	3	25
18	110	255	3	25
19	3	265	1	25
20	110	265	1	25

[00676] Camile Sequence for Example 28C to Example 28S

Viscosity constrained sequence, low vacuum

Stage	Time (minutes)	Temperature , C	Vacuum (torr)	Stirring (RPM)
1	3	200	760	0
2	0.1	200	760	25
3	2	200	760	25
4	0.1	200	760	100
5	1	200	760	100
6	0.1	200	760	200
7	90	200	760	200
8	0.1	210	760	200
9	120	210	760	200
10	5	245	760	50
11	3	245	375	50
12	30	245	375	50
13	3	250	20	50
14	30	250	20	50
15	3	255	3	25
16	110	255	3	25
17	3	265	1	25
18	110	265	1	25
19	2	265	400	0
20	1	265	760	0

Example 29

[00677] This example illustrates the preparation of polyesters at a pilot plant scale comprising at least one thermal stabilizer, reaction products thereof, and mixtures thereof, resulting in improved stability of the polyester melts during processing..

[00678] A variety of polyesters were prepared as described below from 100 mole% DMT, CHDM, and TMCD. The mole% of TMCD for the experiments of this example is reported in Table 18 below, with the glycol balance being CHDM. The DMT, CHDM, and TMCD were of the same origin as in Example 26. The catalyst was either dimethyltin oxide (Strem Chemical Co., Batch B4058112) or butyltin-tris-2-ethylhexonate (Aldrich, Batch 06423CD). The thermal stabilizer was triphenyl phosphate (TPP) (Aldrich). Unless otherwise indicated below, the source of phosphorous was added upfront, with the rest of the polyester reagents. The cis/trans ratio of the CHDM was as described above while the cis/trans ratio of the TMCD is reported in Table 18.

Table 18

Composition and inherent viscosity for the polyesters of Example 29

Example	Melt IV (dL/g)	TMCD (mole%)	TMCD %cis	Sn (ppm)	P (ppm) theo	L*	a*	b*
A	0.553	46.1	45.8	228[2]	300	80.50	-1.51	4.27
B	0.620	46.0	46.0	204[1]	100	83.42	-1.18	4.92
C	0.613	45.1	46.3	193[1]	100	77.60	-1.80	4.85
D	0.624	45.4	46.2	209[2]	100	79.69	-1.71	6.45

1 butyltin tris-2-ethylhexanoate was used as the source of tin
2 dimethyl tin oxide was used as the source of tin

Example 29A

[00679] 84.96 lbs (198.83 gram-mol) dimethyl terephthalate, 35.38 lbs (111.54 gram-mol) 1,4-cyclohexanedimethanol, 40.30 lbs (127.06 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of dimethyltin oxide as tin catalyst and 300 ppm triphenylphosphate (16.35 grams). The reaction was carried out under a nitrogen gas purge in an 74-gallon stainless steel pressure vessel which was fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The agitator speed was then decreased to 15 RPM, the temperature of the reaction mixture was then increased to 270°C, and the pressure was decreased to ≤1-mm. The reaction mixture was held at 270°C and a pressure of ≤1 mm of Hg for 3.75 hours. The pressure of the vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel using an extrusion die. The extruded polymer strands were then pulled through a cold water bath to cool them after which the strands were pelletized. The pelletized polymer had an inherent

viscosity of 0.553. NMR analysis showed that the polymer was composed of 53.9 mol% 1,4-cyclohexanedimethanol moiety and 46.1 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol moiety. The polymer had color values of: L*= 80.50, a*= -1.51, and b*= 4.27.

[00680] Example 29B to Example 29D were prepared in a similar manner to Example 29A, having the composition disclosed in Table 18.

[00681] Example 29E represents PCTG Eastar DN001 from Eastman Chemical Company, having an IV of 0.73 dL/g with a nominal composition of 100 mole% terephthalic acid residues, 62 mole% CHDM residues and 38 mole % ethylene glycol residues. Example 29F represents the polycarbonate Makrolon 2608 from Bayer, with a nominal composition of 100 mole% bisphenol A residues and 100 mole% diphenyl carbonate residues. Example 29G represents an Eastman Chemical Company polyester, with a nominal composition of 100 mole% terephthalic acid residues, 55 mole% CHDM residues and 45 mole % TMCD residues. Example 29H represents PETG Eastar 6763 from Eastman Chemical Company, with a nominal composition of 100 mole% terephthalic acid, 31 mole% cyclohexanedimenthanol (CHDM) and 69 mole % ethylene glycol.

Example 29I

[00682] The polyester of Example 29I is a blend of 10 different polyesters, each prepared in the following manner. 84.96 lbs (198.83 gram-mol) dimethyl terephthalate were reacted in the presence of 200 ppm of tin catalyst (as butyltin-tris-ethylhexanoate) with 50.45 to 51.46-lbs (159.06 162.24 gram-mol, depednign on the batch) 1,4-cyclohexanedimethanol and 24.22 to 31.53-lbs (76.36 to 99.41 gram-mol, also depending on the batch) 2,2,4,4-tetramethyl-1,3-cyclobutanediol. The reaction was carried out under a nitrogen gas purge in an 74-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator, to provide glycol/dimethyl terephthalate molar ratios of 1.2/1 to 1.3/1. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The agitator

speed was then decreased to 15 RPM, the temperature of the reaction mixture was then increased to 260-270°C, and the pressure was decreased to 90 mm of Hg. The reaction mixture was held at 260-270°C and 90-mm pressure for 1 hour. The temperature of the reaction mixture was then increased to 275-290°C and the pressure was decreased to ≤1 mm of Hg. The reaction mixture was held at 275-290°C and ≤1 mm of Hg for 1.5-3 hours to complete the polycondensation stage. The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel into a cold water bath. The cooled, extruded polymer was ground to pass a 6-mm screen.

[00683] Ten separate batches were prepared using the above procedure. The following table contains the NMR compositions, IV values, and color values that were obtained on the 10 batches. The final polyester blend had an IV of 0.63 dL/g, a 100 mole% terephthalic acid residues and a target of 20 mole % TMCD residues and 80 mole% CHDM residues.

Batch	Target Composition	% TMCD by NMR	IV (dL/g)	Color		
				L*	a*	b*
1	20% TMCD; 80% CHDM	16.8	0.665	73.95	-0.61	10.31
2	20% TMCD; 80% CHDM	17.5	0.691	70.48	-0.49	10.68
3	20% TMCD; 80% CHDM	16.4	0.650	71.14	-0.68	10.16
4	20% TMCD; 80% CHDM	22.2	0.685	79.80	-1.80	7.43
5	20% TMCD; 80% CHDM	24.9	0.668	74.47	-1.11	7.83
6	20% TMCD; 80% CHDM	22.6	0.705	67.94	1.28	26.91
7	20% TMCD; 80% CHDM	22.1	0.627	72.43	0.41	22.68
8	20% TMCD; 80% CHDM	25.3	0.712	76.70	0.41	10.73
9	20% TMCD; 80% CHDM	23.5	0.697	74.21	0.79	15.23
10	20% TMCD; 80% CHDM	25.3	0.724	73.55	-0.61	9.52

[00684] Plaques (4 inch x 4 inch x 1/8 inch thick) were prepared in a Toyo 110 injection molding press from the polyesters of Table 18. Pellets of each polyester were feed into the press and heated to the temperatures reported in Table 19. The residence time of the molten polymer in the barrel before injection is also reported in Table 19. Once the part had cooled sufficiently, it was visually analyzed and the splay generated during the injection molding process was recorded.

[00685] The data in Table 19 shows the effect of molding conditions on splay generation in injection-molded plaques made out of the polyesters in Table 18.

Table 19

Splay generation in molded parts made out of the polyesters of Example 29

Temp. Setpoint, °F	Residence Time, min	Splay in part made out of polyester in Table 18						
		A	B	C	D	E	F	G
520	0.47	0	0	0	0	0	0	0
(271°C)	1.02	0	0	0	0	0	0	0
	1.59	0	0	0	0	0	0	0
	2.7	0	0	0	0	0	0	0
	4.94	0	0	0	0	0	0	0
	9.4	0	0	0	0	0	0	1
550	0.47	0	0	0	0	0	0	0
(288°C)	1.02	0	0	0	0	0	0	0
	1.59	0	0	0	0	0	0	0
	2.7	0	0	0	0	0	0	0
	4.94	0	0	0	0	0	0	1
	9.4	0	1	1	1	0	0	2-3
580	0.47	0	0	0	0	0	0	0
(304°C)	1.02	0	0	0	0	0	0	0
	1.59	0	0	0	0	0	0	1
	2.7	0	0	1	0	0	0	1-2
	4.94	0	1-2	1-2	1-2	0	0	2-3
	9.4	1-2	2-3	2-3	2-3	1-2	0	3
610	0.47	0	0	0	0	NA	NA	NA
(321°C)	1.02	0	0	0	0	NA	NA	NA
	1.59	0	0	0	0	NA	NA	NA
	2.7	0	1-2	1-2	1-2	NA	NA	NA
	4.94	1-3	2-3	2-3	2-3	NA	NA	NA
	9.4	3	3	3	3	NA	NA	NA

Splay Ratings: none (0), light (1), moderate (2), heavy (3); NA = not available

[00686] The data in Table 20 shows the quality of films made out of the polyesters in Table 18.

[00687] The polymers were extruded on a 1.5" Killion extruder using a General Purpose screw. The polymers were extruded at temperatures of 572°F (300°C) and 527°F (275°C). The following extruder conditions were used for each polymer in the 572°F extrusions:

Sample	Zone Temp	Die Temp	Adapter Temp	Clamp Ring Temp	Melt Temp	Pressure (PSI)	Screw Speed (RPM)	Chill Roll Speed (RPM)
1	572	572	572	572	612	1200	70	4.3
2	572	572	572	572	619	1450	35	2.2
3	572	572	572	572	618	2500	105	7.2

[00688] The following extruder conditions were used for each polymer in the 527°F extrusions:

Sample	Zone Temp	Die Temp	Adapter Temp	Clamp Ring Temp	Melt Temp	Pressure (PSI)	Screw Speed (RPM)	Chill Roll Speed (RPM)
1	527	527	527	527	569	1600	70	4.2
2	527	527	527	527	565	900	35	2.3
3	527	527	527	527	571	2200	105	7.2

Table 20

Quality of films made out of the polyesters of Example 29

Extrusion Conditions	Example					
	A	B	C	D	H	I
275°C: 35 RPM	1	2	2	2	1	4
275°C; 70 RPM	1	2	2	2	1	3
275°C; 105 RPM	1	1	2	2	1	3
300°C: 35 RPM	2	3	3	3	1	4
300°C; 70 RPM	1	2	3	2	1	4
300°C; 105 RPM	1	2	2	1	1	4

Rating Key	Rating
Good film quality; no visual bubbles were observed exiting the die or in melt bank: nice film, very difficult to visually detect bubbles.	1
Good film quality; occasional bubbles observed leaving the die; bubbles in the film are visually easier to detect but sparse.	2
Mediocre film quality; bubbles are easily seen leaving the die lips and are very evident in the finished film.	3
Very poor film quality; bubbles evident in the melt bank and exiting the die lips; very poor color.	4

[00689] It can be clearly seen from a comparison of the data in the above relevant working examples that the polyesters of the present invention offer an advantage over the commercially available polyesters with regard to at least one

of bubbling, splaying, color formation, foaming, off-gassing, and erratic melt levels in the polyester's production and processing systems.

[00690] The invention has been described in detail with reference to the embodiments disclosed herein, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %,

wherein the total mole % of the glycol component is 100 mole %;

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and

wherein the polyester has a Tg from 85 to 200°C.

2. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is chosen from at least one of the following: trialkyl phosphates, triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

3. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is chosen from at least one of the following: triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

4. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is chosen from at least one of the following: dibutylphenyl phosphate, triphenyl phosphate, tricresyl phosphate, tributyl phosphate, tri-2-ethylhexyl phosphate, trioctyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

5. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is chosen from dibutylphenyl phosphate, triphenyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

6. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is chosen from triphenyl phosphate and Merpol A.

7. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is present in the amount of about 1 ppm to about 5000 ppm based on the total weight of the polyester.

8. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is present in the amount of about 50 ppm to about 3000 ppm based on the total weight of the polyester.

9. The polyester composition of Claim 1, wherein the at least one thermal stabilizer is present in the amount of about 1 ppm to about 100 ppm based on the total weight of the polyester.

10. The polyester composition of Claim 9 wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g.

11. The polyester composition of Claim 10 wherein the inherent viscosity of the polyester is from 0.35 to 1 dL/g.

12. The polyester composition of Claim 11 wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g.

13. The polyester composition of Claim 12 wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g.

14. The polyester composition of Claim 13 wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g.

15. The polyester composition of Claim 14 wherein the inherent viscosity of the polyester is from 0.55 to 0.75 dL/g.

16. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg of 85 to 145°C.

17. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg of 85 to 120°C.

18. The polyester composition of Claim 1 wherein the polyester has a Tg of 90 to 145°C.

19. The polyester composition of Claim 18 wherein the polyester has a Tg of 90 to 135°C.

20. The polyester composition of Claim 19 wherein the polyester has a Tg of 95 to 125°C.

21. The polyester composition of Claim 20 wherein the polyester has a Tg of 95 to 115°C.

22. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg from 100 to 180°C.

23. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg from 100 to 160°C.

24. The polyester composition of Claim 23 wherein the polyester has a Tg from 100 to 150°C.

25. The polyester composition of Claim 24 wherein the polyester has a Tg from 100 to 125°C.

26. The polyester composition of Claim 24 wherein the polyester has a Tg from 100 to 123°C.

27. The polyester composition of Claim 26 wherein the polyester has a Tg from 100 to 120°C.

28. The polyester composition of Claim 27 wherein the polyester has a Tg from 100 to 115°C.

29. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg from 110 to 160°C.

30. The polyester composition of any of Claims 1 and 13 wherein the polyester has a Tg from 110 to 150°C.

31. The polyester composition of Claims 1 and 13 wherein the polyester has a Tg from 120 to 150°C.

32. The polyester composition of Claims 1 and 13 wherein the polyester has a Tg from 125 to 140°C.

33. The polyester composition of Claims 1 and 13 wherein the polyester has a Tg from 130 to 140°C.

34. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 1 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 20 to 99 mole % cyclohexanedimethanol residues.

35. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 1 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 40 to 99 mole % cyclohexanedimethanol residues.

36. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 1 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 85 to 99 mole % cyclohexanedimethanol residues.

37. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 1 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 90 to 99 mole % cyclohexanedimethanol residues.

38. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 1 to 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 95 to 99 mole % cyclohexanedimethanol residues.

39. The polyester composition of any of Claims 1 and 13 wherein the glycol component of the polyester comprises 5 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and greater than 50 up to 95 mole % cyclohexanedimethanol residues.

40. The polyester composition of Claim 39 wherein the glycol component of the polyester comprises 10 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and greater than 50 up to 90 mole % cyclohexanedimethanol residues.

41. The polyester composition of Claim 40 wherein the glycol component of the polyester comprises 15 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and greater than 50 up to 85 mole % cyclohexanedimethanol residues.

42. The polyester composition of Claim 41 wherein the glycol component of the polyester comprises 15 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 70 to 85 mole % cyclohexanedimethanol residues.

43. The polyester composition of Claim 42 wherein the glycol component of the polyester comprises 15 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 75 to 85 mole % cyclohexanedimethanol residues.

44. The polyester composition of Claim 1 wherein the glycol component of the polyester comprises 17 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 75 to 85 mole % cyclohexanedimethanol residues.

45. The polyester composition of any of Claims 1 and 13 wherein the glycol component of the polyester comprises 40 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 35 to 60 mole % cyclohexanedimethanol residues.

46. The polyester composition of Claim 45 wherein the glycol component of the polyester comprises 40 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 40 to 60 mole % cyclohexanedimethanol residues.

47. The polyester composition of Claim 46 wherein the glycol component of the polyester comprises 40 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 40 to 60 mole % cyclohexanedimethanol residues.

48. The polyester composition of Claim 47 wherein the glycol component of the polyester comprises 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 45 to 55 mole % cyclohexanedimethanol residues.

49. The polyester composition of Claim 1 wherein the polyester comprises 1,3-propanediol or 1,4-butanediol or mixtures of 1,3-propanediol and 1,4-butanediol.

50. The polyester composition of Claim 1 wherein the polyester comprises from 1 to 80 mole % cyclohexanedimethanol residues.

51. The polyester composition of Claim 1 wherein the polyester comprises from 1 to 30 mole % cyclohexanedimethanol residues.

52. The polyester composition of Claim 1 wherein the polyester comprises from 1 to 15 mole % cyclohexanedimethanol residues.

53. The polyester composition of Claim 1 wherein the polyester comprises from 1 to 10 mole % cyclohexanedimethanol residues.

54. The polyester composition of Claim 1 wherein the dicarboxylic acid component of the polyester comprises 80 to 100 mole % of terephthalic acid or an ester thereof.

55. The polyester composition of Claim 1 wherein the dicarboxylic acid component of the polyester comprises 90 to 100 mole % of terephthalic acid or an ester thereof.

56. The polyester composition of any of Claims 1 and 54 wherein the glycol component of the polyester comprises ethylene glycol residues.

57. The polyester composition of Claim 1 wherein the 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues of the polyester are pure cis, pure trans, or a mixture thereof.

58. The polyester composition of Claim 1 wherein the 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues is a mixture comprising 40 to 60 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 40 to 60 mole % of trans-2,2,4,4-tetramethyl-1,3-cyclobutanediol residues.

59. The polyester composition of Claim 1 comprising at least one polymer of poly(etherimides), polyphenylene oxides, poly(phenylene oxide)/polystyrene blends, polystyrene resins, polyphenylene sulfides, polyphenylene sulfide/sulfones, poly(ester-carbonates), polycarbonates, polysulfones; polysulfone ethers, poly(ether-ketones), polyesters other than those of Claim 1, and mixtures thereof.

60. The polyester composition of Claim 1 wherein the polyester composition comprises at least one polycarbonate.

61. The polyester composition of Claim 1 wherein the polyester composition comprises a branching agent for the polyester.

62. The polyester composition of Claim 61 wherein the polyester comprises a branching agent in the amount of 0.01 to 10 weight % based on the total weight of the polyester.

63. The polyester composition of Claim 62 wherein the polyester comprises a branching agent in the amount of 0.01 to 5 weight % based on the total weight of the polyester.

64. The polyester composition of Claim 1 wherein the polyester contains no branching agent for the polyester.

65. The polyester composition of Claim 1 wherein the polyester composition which does not contain polycarbonate.

66. The polyester composition of Claim 1 wherein the melt viscosity of the polyester is less than 30,000 poise as measured at 1 radian/second on a rotary melt rheometer at 290°C.

67. The polyester composition of Claim 1 wherein the polyester is amorphous.

68. The polyester composition of Claim 1 wherein the polyester has a crystallization half-time of greater than 5 minutes at 170°C.

69. The polyester composition of Claim 1 wherein the polyester has a density of less than 1.2 g/ml at 23°C.

70. The polyester composition of Claim 1 wherein the polyester composition comprises at least one additive of colorants, mold release agents, thermal stabilizers other than those described in Claim 1, plasticizers, nucleating agents, UV stabilizers, glass fiber, carbon fiber, fillers, impact modifiers, or a mixture thereof.

71. The polyester composition of Claim 1 wherein the polyester is produced using a polycondensation catalyst comprising a tin compound.

72. The polyester composition of Claim 1 wherein the polyester has a notched Izod impact strength of at least 3 ft-lbs/in at 23°C according to ASTM D256 with a 10-mil notch using a 1/8-inch thick bar.

73. A polyester composition comprising the polyester composition of any of Claims 1 and 13 wherein the polyester has a notched Izod impact strength of at least 3 ft-lbs/in at 23°C according to ASTM D256 with a 10-mil notch in a 1/4-inch thick bar.

74. An article of manufacture comprising the polyester composition of Claim 1 wherein the polyester composition is formed by extrusion molding.

75. An article of manufacture comprising the polyester composition of Claim 1 wherein the polyester composition is formed by extrusion stretch blow molding.

76. An article of manufacture comprising the polyester composition according to Claim 1 wherein the polyester composition was produced by injection molding.

77. An article of manufacuture comprising the polyester composition according to Claim 1 wherein the polyester composition is formed by injection blow molding.

78. An article of manufacuture comprising the polyester composition according to Claim 1 wherein the polyester composition is formed by injection stretch blow molding.

79. An article of manufacture comprising the polyester composition of Claim 1 wherein the article is a bottle.

80. An article of manufacture comprising the polyester composition of Claim 1 wherein the article is a water bottle.

81. An article of manufacture comprising the polyester composition of Claim 1 wherein the article is a two liter bottle.

82. An article of manufacture comprising the polyester composition of Claim 1 wherein the article is a beverage bottle.

83. An article of manufacture comprising the polyester composition of Claim 1 wherein the article is a baby bottle.

84. An article of manufacture comprising the polyester composition of Claim 1 which is a bottle comprising at least one handle.

85. An article of manufacture comprising the polyester composition of Claim 1 which comprises a film or sheet.

86. An article of manufacture comprising the polyester composition of Claim 1 which a baby bottle wherein the glycol component of the polyester comprises 40 to 65 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 35 to 60 mole % of cyclohexanedimethanol residues; and the inherent viscosity of the polyester is from 0.6 to 0.72 dL/g.

87. An article of manufacture comprising the polyester composition of any of Claims 1, 13, 23-27 comprising a buffet steam pan or tray.

88. A polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) from 15 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) from 60 to 86 mole % cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and

wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 110°C to 160°C.

89. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is chosen from at least one of the following: trialkyl phosphates, triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

90. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is chosen from at least one of the following: triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

91. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is chosen from at least one of the following: dibutylphenyl phosphate, triphenyl phosphate, tricresyl phosphate, tributyl phosphate, tri-2-ethylhexyl phosphate, trioctyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

92. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is chosen from dibutylphenyl phosphate, triphenyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

93. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is chosen from at least one of triphenyl phosphate, Merpol A and 2-ethylhexyl diphenyl phosphate.

94. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is present in the amount of about 1 ppm to about 500 ppm based on the total weight of the polyester.

95. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is present in the amount of about 1 ppm to about 100 ppm based on the total weight of the polyester.

96. The polyester composition of Claim 88, wherein the at least one thermal stabilizer is present in the amount of about 50 ppm to about 2500 ppm based on the total weight of the polyester.

97. The polyester composition of Claim 88 wherein the inherent viscosity of the polyester is from 0.35 to 1 dL/g.

98. The polyester composition of Claim 88 wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g.

99. The polyester composition of Claim 88 wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g.

100. The polyester composition of Claim 88 wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g.

101. The polyester composition of Claim 88 wherein the inherent viscosity of the polyester is from 0.55 to 0.75 dL/g.

102. The polyester composition of Claim 88 wherein the polyester has a Tg from 110 to 160°C.

103. The polyester composition of Claim 88 wherein the polyester has a Tg from 110 to 150°C.

104. The polyester composition of Claim 88 wherein the polyester has a Tg from 120 to 150°C.

105. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises 20 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 60 to 80 mole % cyclohexanedimethanol residues.

106. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises 30 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 60 to 70 mole % cyclohexanedimethanol residues.

107. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises 25 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 60 to 75 mole % cyclohexanedimethanol residues.

108. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises 25 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 to 75 mole % cyclohexanedimethanol residues.

109. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises 30 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 65 to 70 mole % cyclohexanedimethanol residues.

110. The polyester composition of Claim 88 wherein the polyester comprises 1,3-propanediol or 1,4-butanediol or mixtures of 1,3-propanediol and 1,4-butanediol.

111. The polyester composition of Claim 88 wherein the dicarboxylic acid component of the polyester comprises 80 to 100 mole % of terephthalic acid or an ester thereof.

112. The polyester composition of Claim 88 wherein the dicarboxylic acid component of the polyester comprises 90 to 100 mole % of terephthalic acid or an ester thereof.

113. The polyester composition of Claim 88 wherein the glycol component of the polyester comprises ethylene glycol residues.

114. The polyester composition of Claim 88 comprising at least one polymer of poly(etherimides), polyphenylene oxides, poly(phenylene oxide)/polystyrene blends, polystyrene resins, polyphenylene sulfides, polyphenylene sulfide/sulfones, poly(ester-carbonates), polycarbonates, polysulfones; polysulfone ethers, poly(ether-ketones), polyesters other than those of Claim 1, and mixtures thereof.

115. The polyester composition of Claim 88 wherein the polyester composition comprises at least one polycarbonate.

116. The polyester composition of Claim 88 wherein the polyester composition comprises a branching agent for the polyester.

117. The polyester composition of Claim 88 wherein the polyester comprises a branching agent in the amount of 0.01 to 10 weight % based on the total weight of the polyester.

118. The polyester composition of Claim 88 wherein the polyester contains no branching agent for the polyester.

119. The polyester composition of Claim 88 wherein the polyester composition which does not contain polycarbonate.

120. The polyester composition of Claim 88 wherein the polyester composition comprises at least one additive of colorants, mold release agents, thermal stabilizers other than those described in Claim 83, plasticizers, nucleating agents, UV stabilizers, thermal stabilizers, glass fiber, carbon fiber, fillers, impact modifiers, or a mixture thereof.

121. The polyester composition of Claim 88 wherein the polyester is produced using a polycondensation catalyst comprising a tin compound.

122. The polyester composition of Claim 88 wherein the polyester has a notched Izod impact strength of at least 3 ft-lbs/in at 23°C according to ASTM D256 with a 10-mil notch using a 1/8-inch thick bar.

123. An article of manufacture comprising the polyester composition of Claim 88 wherein the article is a bottle.

124. An article of manufacture comprising the polyester composition of Claim 88 wherein the article is a water bottle.

125. An article of manufacture comprising the polyester composition of Claim 88 wherein the article is a baby bottle.

126. An article of manufacture comprising the polyester composition of Claim 88 which is a bottle comprising at least one handle.

127. An article of manufacture comprising the polyester composition of Claim 88 which comprises a film or sheet.

128. A polyester composition comprising:

(I) at least one polyester which comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) from 10 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) from 70 to 90 mole % cyclohexanedimethanol residues; and

(II) at least one thermal stabilizer chosen from at least one of alkyl phosphate esters, aryl phosphate esters, mixed alkyl aryl phosphate esters, mixed alkyl aryl phosphate esters, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component is 100 mole %, and the total mole % of the glycol component is 100 mole %; and
wherein the inherent viscosity of the polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the polyester has a Tg from 85°C to 120°C.

129. The polyester composition of Claim 128 wherein the glycol component of the polyester comprises 15 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 76 to 85 mole % cyclohexanedimethanol residues.

130. The polyester composition of Claim 128, wherein at least one thermal stabilizer is chosen from at least one of the following: trialkyl phosphates, triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

131. The polyester composition of Claim 128, wherein at least one thermal stabilizer is chosen from at least one of the following: triaryl phosphates, alkyl diaryl phosphates, and mixed alkyl aryl phosphates.

132. The polyester composition of Claim 128, wherein at least one thermal stabilizer is chosen from at least one of the following: dibutylphenyl phosphate, triphenyl phosphate, tricresyl phosphate, tributyl phosphate, tri-2-ethylhexyl phosphate, trioctyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

133. The polyester composition of Claim 128, wherein at least one thermal stabilizer is chosen from dibutylphenyl phosphate, triphenyl phosphate, isocetyl diphenyl phosphate, and 2-ethylhexyl diphenyl phosphate.

134. The polyester composition of Claim 128, wherein at least one thermal stabilizer is chosen from at least one of triphenyl phosphate and Merpol A.

135. The polyester composition of Claim 128, wherein at least one thermal stabilizer is present in the amount of about 1 ppm to about 100 ppm based on the total weight of the polyester.

136. The polyester composition of Claim 128, wherein at least one thermal stabilizer is present in the amount of about 4 ppm to about 60 ppm based on the total weight of the polyester.

137. The polyester composition of Claim 128, wherein at least one thermal stabilizer is present in the amount of about 50 ppm to about 2500 ppm based on the total weight of the polyester.

138. The polyester composition of Claim 128 wherein the inherent viscosity of the polyester is from 0.35 to 1 dL/g.

139. The polyester composition of Claim 128 wherein the inherent viscosity of the polyester is from 0.35 to 0.75 dL/g.

140. The polyester composition of Claim 128 wherein the inherent viscosity of the polyester is from 0.50 to 1.2 dL/g.

141. The polyester composition of Claim 128 wherein the inherent viscosity of the polyester is from 0.50 to 0.75 dL/g.

142. The polyester composition of Claim 128 wherein the inherent viscosity of the polyester is from 0.55 to 0.75 dL/g.

143. The polyester composition of Claim 128 wherein the polyester has a Tg of 90 to 120°C.

144. The polyester composition of Claim 128 wherein the polyester has a Tg of 95 to 120°C.

145. The polyester composition of Claim 128 wherein the polyester has a Tg of 100 to 120°C.

146. The polyester composition of Claim 128 wherein the polyester has a Tg of 105 to 115°C.

147. The polyester composition of any of Claims 1, 128, and 145 wherein the glycol component of the polyester comprises 15 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 75 to 85 mole % cyclohexanedimethanol residues.

148. The polyester composition of Claim 128 wherein the glycol component of the polyester comprises 17 to 23 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues and 75 to 85 mole % cyclohexanedimethanol residues.

149. The polyester composition of Claim 128 wherein the polyester comprises 1,3-propanediol or 1,4-butanediol or mixtures of 1,3-propanediol and 1,4-butanediol.

150. The polyester composition of Claim 128 wherein the dicarboxylic acid component of the polyester comprises 80 to 100 mole % of terephthalic acid or an ester thereof.

151. The polyester composition of Claim 128 wherein the dicarboxylic acid component of the polyester comprises 90 to 100 mole % of terephthalic acid or an ester thereof.

152. The polyester composition of Claim 128 wherein the glycol component of the polyester comprises ethylene glycol residues.

153. The polyester composition of Claim 128 comprising at least one polymer of poly(etherimides), polyphenylene oxides, poly(phenylene oxide)/polystyrene blends, polystyrene resins, polyphenylene sulfides, polyphenylene sulfide/sulfones, poly(ester-carbonates), polycarbonates, polysulfones; polysulfone ethers, poly(ether-ketones), polyesters other than those of Claim 1, and mixtures thereof.

154. The polyester composition of Claim 128 wherein the polyester composition comprises at least one polycarbonate.

155. The polyester composition of Claim 128 wherein the polyester composition comprises a branching agent for the polyester.

156. The polyester composition of Claim 128 wherein the polyester composition comprises at least one additive of colorants, mold release agents, thermal stabilizers other than those described in Claim 1, plasticizers, nucleating agents,

UV stabilizers, thermal stabilizers, glass fiber, carbon fiber, fillers, impact modifiers, or a mixture thereof.

157. The polyester composition of Claim 128 wherein the polyester is produced using a polycondensation catalyst comprising a tin compound.

158. The polyester composition of Claim 128 wherein the polyester has a notched Izod impact strength of at least 3 ft-lbs/in at 23°C according to ASTM D256 with a 10-mil notch using a 1/8-inch thick bar.

159. A polyester composition comprising the polyester composition of Claim 128 wherein the polyester has a notched Izod impact strength of at least 3 ft-lbs/in at 23°C according to ASTM D256 with a 10-mil notch in a 1/4-inch thick bar.

160. An article of manufacture comprising the polyester composition of Claim 128 wherein the polyester composition is formed by extrusion molding.

161. An article of manufacture comprising the polyester composition of Claim 128 wherein the polyester composition is formed by extrusion stretch blow molding.

162. An article of manufacture comprising the polyester composition of Claim 128 which comprises a container.

163. An article of manufacture comprising the polyester composition of Claim 128 which comprises a bottle.

164. An article of manufacture comprising the polyester composition of Claim 128 which comprises a film or sheet.

165. An article of manufacture comprising the polyester composition of Claim 128 comprising a buffet steam pan or tray.

166. A process for making the polyester of any of Claims 1-160 comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of:

(i) at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and (ii) at least one thermal stabilizer chosen from at least one phosphorus compound, reaction products thereof, and mixtures thereof;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

167. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.01-1.5/1.0.

168. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.03-1.5/1.0.

169. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.03-1.3/1.0.

170. The process of Claim166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.5/1.0.

171. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.2/1.0.

172. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.3/1.0.

173. The process of Claim 166 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.15/1.0.

174. The process of any of Claims 166-173 wherein the heating time in Step (II) is 1 to 4 hours.

175. The process of any of Claims 166-174 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 2-10:1.

176. The process of Claim 175 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 5-9:1.

177. The process of Claim 176 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 6-8:1.

178. The process of Claim 177 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 7:1.

179. The process of any of Claims 166-178 wherein the amount of tin atoms present in the final polyester can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

180. The process of Claim 179 wherein the amount of tin atoms present in the final polyester can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

181. The process of Claim 180 wherein the amount of tin atoms present in the final polyester can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

182. The process of any of Claims 166-181 wherein the amount of phosphorus atoms present in the final polyester can be from 1 to 100 ppm tin atoms based on the weight of the final polyester.

183. The process of any of Claims 166-182 wherein the amount of phosphorus atoms present in the final polyester can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester.

184. The process of Claim 183 wherein the amount of phosphorus atoms present in the final polyester can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester.

185. The process of any of Claims 1-184 wherein the catalysts used in Step (I) comprises at least one tin compound and at least one titanium compound.

186. The process of any of Claims 1-184 wherein the catalyst used in Step (I) consists essentially of at least one tin compound.

187. The process of any of Claims 1-186 wherein the tin compound is chosen from at least one of butyltin tris-2-ethylhexanoate, dibutyl tin diacetate, dibutytin oxide, and dimethyl tin oxide.

188. A process for making the polyester of any of Claims 1-165 comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide;

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, in the presence of at least one thermal stabilizer chosen from at least one phosphorus compound, reaction products thereof, and mixtures thereof;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %; wherein the total mole % of the glycol component of the final polyester is 100 mole %; wherein the inherent viscosity of the final polyester is from 0.35 to 1.2 dL/g as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.25 g/50 ml at 25°C; and wherein the final polyester has a Tg from 85 to 200°C.

189. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.01-1.5/1.0.

190. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.03-1.5/1.0.

191. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.03-1.3/1.0.

192. The process of Claim188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.5/1.0.

193. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.2/1.0.

194. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.3/1.0.

195. The process of Claim 188 wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is from 1.05-1.15/1.0.

196. The process of any of Claims 188-195 wherein the heating time in Step (II) is 1 to 4 hours.

197. The process of any of Claims 188-195 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 2-10:1.

198. The process of Claim 197 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 5-9:1.

199. The process of Claim 198 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 6-8:1.

200. The process of Claim 199 wherein the weight ratio of total tin atoms to total phosphorus atoms in the final polyester is 7:1.

201. The process of any of Claims 188-200 wherein the amount of tin atoms present in the final polyester can be from 25 to 400 ppm tin atoms based on the weight of the final polyester.

202. The process of Claim 201 wherein the amount of tin atoms present in the final polyester can be from 40 to 200 ppm tin atoms based on the weight of the final polyester.

203. The process of Claim 201 wherein the amount of tin atoms present in the final polyester can be from 50 to 125 ppm tin atoms based on the weight of the final polyester.

204. The process of any of Claims 188-203 wherein the amount of phosphorus atoms present in the final polyester can be from 1 to 100 ppm tin atoms based on the weight of the final polyester.

205. The process of Claim 201 wherein the amount of phosphorus atoms present in the final polyester can be from 4 to 60 ppm phosphorus atoms based on the weight of the final polyester.

206. The process of Claim 201 wherein the amount of phosphorus atoms present in the final polyester can be from 6 to 20 ppm phosphorus atoms based on the weight of the final polyester.

207. The process of any of Claims 1-206 wherein the catalyst used in Step (I) comprises at least one tin compound and at least one titanium compound.

208. The process of any of Claims 1-206 wherein the catalyst used in Step (I) consists essentially of at least one tin compound.

209. The process of any of Claims 1-208 wherein the tin compound is chosen from at least one of butyltin tris-2-ethylhexanoate, dibutyl tin diacetate, dibutytin oxide, and dimethyl tin oxide.

210. A process for making at least one polyester of any of Claims 1-209 comprising the following steps:

(I) heating a mixture at at least one temperature chosen from 150°C to 200°C, under at least one pressure chosen from the range of 0 psig to 75 psig wherein said mixture comprises:

(a) a dicarboxylic acid component comprising:

(i) 70 to 100 mole % of terephthalic acid residues;

(ii) 0 to 30 mole % of aromatic dicarboxylic acid residues having up to 20 carbon atoms; and

(iii) 0 to 10 mole % of aliphatic dicarboxylic acid residues having up to 16 carbon atoms; and

(b) a glycol component comprising:

(i) 1 to 99 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues; and

(ii) 1 to 99 mole % of cyclohexanedimethanol residues;

wherein the molar ratio of glycol component/dicarboxylic acid component added in Step (I) is 1.0-1.5/1.0;

wherein the mixture in Step (I) is heated in the presence of at least one catalyst comprising at least one tin compound, and, optionally, at least one catalyst chosen from titanium, gallium, zinc, antimony, cobalt, manganese, magnesium, germanium, lithium, aluminum compounds and an aluminum compound with lithium hydroxide or sodium hydroxide; and

(II) heating the product of Step (I) at a temperature of 230°C to 320°C for 1 to 6 hours, under at least one pressure chosen from the range of the final pressure of Step (I) to 0.02 torr absolute, to form a final polyester;

wherein the total mole % of the dicarboxylic acid component of the final polyester is 100 mole %;

wherein the total mole % of the glycol component of the final polyester is 100 mole %;

wherein at least one phosphorus compound, for example, at least one phosphate ester, is added to Step (I), Step (II) and/or Steps (I) and (II); and

wherein the addition of the phosphorus compound(s) results in a weight ratio of total tin atoms to total phosphorus atoms in the final polyester useful in the invention of 2-10:1