SUMMARY

[004a] In a first aspect of the present disclosure, there is provided a polyester comprising:

from about 15 to about 40 weight percent monomer repeat units of isosorbide, based on the total weight of the polyester;

from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride, based on the total weight of the polyester; and

from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol, based on the total weight of the polyester,

wherein the polyester has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05 and

wherein the dicarboxylic acid or anhydride comprises a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof.

[004b] In another aspect of the present disclosure, there is provided a polymer composition comprising:

from about 50 to about 95 weight percent of a biodegradable polymer selected from the group consisting of poly(lactic acid), poly(hydroxyalkanoates), and mixtures thereof; and

from about 5 to about 50 weight percent of an impact modifying polyester, wherein the impact modifying polyester comprises

from about 15 to about 40 weight percent monomer repeat units of isosorbide, based on the total weight of the polyester;

from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride, based on the total weight of the polyester; and

from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol, based on the total weight of the polyester,

wherein the polyester has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05 and

wherein the dicarboxylic acid or anhydride comprises a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof.

[004c] In yet another aspect of the present disclosure, there is provided a molded sheet comprising the polymer composition as disclosed herein.

[004d] In a further aspect of the present disclosure, there is provided a molded article comprising the polymer composition as disclosed herein, wherein the molded article is formed by thermoforming, injection molding, or blow molding.

[004e] In another aspect of the present disclosure, there is provided a film comprising the polymer composition as disclosed herein, wherein the film is a blown film or a cast film.

[004f] In yet another aspect of the present disclosure, there is provided a fiber comprising the polymer composition as disclosed herein.

[005] The above and other needs are met by a compostable polyester according to the present disclosure.

[006] In a first example, the present disclosure provides a polyester. According to certain examples, this polyester is made up of: (1) from about 15 to about 40 weight percent monomer repeat units of isosorbide; (2) from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride; and (3) from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol. All of these weight percentages are based on the total weight on the polyester.

[007] The polyester also has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05. More preferably, the polyester has a weight average molecular weight from about 10,000 to about 15,000 Daltons, as determined by ASTM D5296-05.

[008] In certain examples, the dicarboxylic acid or anhydride is preferably selected from the group consisting of succinic acid, succinic anhydride, glutaric acid,

pimelic acid, undecanoic acid, dodecanoic acid, dodecanedioic acid, suberic acid, azelaic acid, sebacic acid, adipic acid, phthalic anhydride, dimethyl terephthalate, terephthalic acid, isophthalic acid, 1,8-naphthalic anhydride, 1,8-naphthalic dicarboxylic acid, 1,8-dimethyl naphthalate, dimethyl isophthalate, phthalic acid, pyromellitic anhydride, mellitic anhydride, mellitic acid, trimellitic anhydride, 3,3'4,4'-benzophenone tetracarboxylic anhydride, 3,3'4,4'-benzophenone tetracarboxylic acid, trimellitic acid, nadic anhydride, methyl nadic anhydride, C36 dimer acid, partially hydrogenated C36 dimer acid, polyethylene terephthalate recycled polymer, polybutylene terephthalate recycled polymer, polyethylene terephthalate virgin polymer, polybutylene terephthalate virgin polymer, and mixtures thereof.

[009] More preferably, the dicarboxylic acid or anhydride is selected from the group consisting of succinic acid, succinic anhydride, nadic anhydride, methyl nadic anhydride, sebacic acid, C36 dimer acid, partially hydrogenated C36 dimer acid, and mixtures thereof.

[010] In a particularly preferred example, the dicarboxylic acid or anhydride is made up of a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof. For this example, the polyester is preferably from about 25to about 35 weight percent succinic acid or succinic anhydride and from about 10 to about 25 weight percent nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid.

[011] In some examples, the polyhydric alcohol is preferably selected from the group consisting of glycerin, ethylene glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 2-methyl, neopentyl glycol, propylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, tripropylene glycol, tetrapropylene glycol, trimethylene glycol, 1,1,1-trimethylol ethane, 1,2,3-trimethylolpropane, methyl propanediol, pentaerythritol, and poly(oxyalkylene) polyols comprising monomer repeat units of ethylene oxide, propylene oxide, or butylene oxide, and mixtures thereof.

[012] More preferably, the polyhydric alcohol is selected from the group consisting of 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, methyl propanediol, and mixtures thereof. Even more preferably, the polyhydric alcohol includes 1,3-propanediol.

[013] In some instances, the dicarboxylic acid or anhydride preferably includes succinic acid or anhydride, and the polyhydric alcohol preferably includes 1,3-propanediol.

[014] In an alternative example, the isosorbide may be omitted from the polyester. In such instances, the polyester is made up of: (1) from about 35 to about 65 weight percent monomer repeat units of a dicarboxylic acid or anhydride selected from the group consisting of the dicarboxylic acid or anhydride is selected from the group consisting of succinic acid, succinic anhydride, nadic anhydride, methyl nadic anhydride, sebacic acid, C36 dimer acid, partially hydrogenated C36 dimer acid, and mixtures thereof; and (2) from about 35 to about 65 weight percent monomer repeat units of a polyhydric alcohol.

[015] In a preferred example, the dicarboxylic acid or anhydride is made up of a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic

anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof. For this example, the polyester is preferably from about 30 to about 40 weight percent succinic acid or succinic anhydride and from about 10 to about 20 weight percent nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid.

[016] Suitable polyhydric alcohols for this alternative polyester are the same as the polyhydric alcohols noted above for the polyester, including the isosorbide. Also, for the alternative polyester, the weight average molecular weight of the polyester is at least 8000 Daltons, as determined by ASTM D5296-05. More preferably, the polyester has a weight average molecular weight from about 10,000 to about 15,000 Daltons, as determined by ASTM D5296-05.

[017] In a second example, the present disclosure provides a polymer composition. The polymer composition typically includes from about 50 to about 95 weight percent of a biodegradable polymer selected from the group consisting of poly(lactic acid), poly(hydroxyalkanoates), and mixtures thereof. The polymer composition also includes from about 5 to about 50 weight percent of an impact modifying polyester. The impact modifying polyester, in turn, is made up of: (1) from about 15 to about 40 weight percent monomer repeat units of isosorbide, based on the total weight of the polyester; (2) from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride, based on the total weight of the polyester; and (3) from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol, based on the total weight of the polyester. The impact modifying polyester also has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05.

[018] In certain examples, the dicarboxylic acid or anhydride is preferably selected from the group consisting of succinic acid, succinic anhydride, glutaric acid, pimelic acid, undecanoic acid, dodecanoic acid, dodecanedioic acid, suberic acid, azelaic acid, sebacic acid, adipic acid, phthalic anhydride, dimethyl terephthalate, terephthalic acid, isophthalic acid, 1,8-naphthalic anhydride, 1,8-naphthalic dicarboxylic acid, 1,8-dimethyl naphthalate, dimethyl isophthalate, phthalic acid, pyromellitic anhydride, mellitic anhydride, mellitic acid, trimellitic anhydride, 3,3'4,4'-benzophenone tetracarboxylic anhydride, 3,3'4,4'-

benzophenone tetracarboxylic acid, trimellitic acid, nadic anhydride, methyl nadic anhydride, C36 dimer acid, partially hydrogenated C36 dimer acid, polyethylene terephthalate recycled polymer, polybutylene terephthalate recycled polymer, polyethylene terephthalate virgin polymer, polybutylene terephthalate virgin polymer, and mixtures thereof.

[019] More preferably, the dicarboxylic acid or anhydride is selected from the group consisting of succinic acid, succinic anhydride, nadic anhydride, methyl nadic anhydride, sebacic acid, C36 dimer acid, partially hydrogenated C36 dimer acid, and mixtures thereof.

[020] In a particularly preferred example, the dicarboxylic acid or anhydride is made up of a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof. For this example, the polyester is preferably from about 25 to about 35 weight percent succinic acid or succinic anhydride and from about 10 to about 25 weight percent nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid.

[021] In some examples, the polyhydric alcohol is preferably selected from the group consisting of glycerin, ethylene glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 2-methyl, neopentyl glycol, propylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, tripropylene glycol, tetrapropylene glycol, trimethylene glycol, 1,1,1-trimethylol ethane, 1,2,3-trimethylolpropane, methyl propanediol, pentaerythritol, and poly(oxyalkylene) polyols comprising monomer repeat units of ethylene oxide, propylene oxide, or butylene oxide, and mixtures thereof.

[022] More preferably, the polyhydric alcohol is selected from the group consisting of 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, methyl propanediol, and mixtures thereof. Even more preferably, the polyhydric alcohol includes 1,3-propanediol.

[023] In some instances, the dicarboxylic acid or anhydride preferably includes succinic acid or anhydride, and the polyhydric alcohol preferably includes 1,3-propanediol.

[024] According to certain examples, the polymer composition more preferably includes from about 60 to about 85 weight percent of the biodegradable polymer and from about 5 to about 30 weight percent of the impact modifying polyester. Even more preferably, the polymer composition includes from about 7.5 to about 15 weight percent of the impact modifying polyester.

[025] In some instances, the biodegradable polymer preferably includes poly(lactic acid). In other examples, the biodegradable polymer preferably includes at least one poly(hydroxyalkanoate). In some examples, the biodegradable polymer preferably includes a mixture of poly(lactic acid) and poly(hydroxyalkanoates). For instance, in some examples, the polymer composition may include from about 5 to about 25 weight percent of poly(lactic acid) and from about 70 to about 90 weight percent of at least one poly(hydroxyalkanoate), based on the total weight of the polymer composition.

[026] According to certain examples wherein the polymer composition includes a poly(hydroxyalkanoate), the at least one poly(hydroxyalkanoate) is preferably made up of poly-3-hydroxybutyrate-co-3-hydroxyhexanoate ("P(3HB-co-3HHx)").

[027] In some instances, this (3HB-co-3HHx) is preferably made up of from about 75 to about 99 mole percent hydroxybutyrate and from about 1 to about 25 mole percent hydroxyhexanoate. More preferably, the (3HB-co-3HHx) is made up of from about 93 to about 98 mole percent hydroxybutyrate and from about 2 to about 7 mole percent hydroxyhexanoate.

[028] In still other examples, the at least one poly(hydroxyalkanoate) may include a terpolymer made up from about 75 to about 99.9 mole percent monomer repeat units of 3-hydroxybutyrate, from about 0.1 to about 25 mole percent monomer repeat units of 3-hydroxyhexanoate, and from about 0.1 to about 25 mole percent monomer repeat units of a third 3-hydoxyalkanoate having from 5 to 12 carbon atoms.

[029] According to certain examples the at least one poly(hydroxyalkanoate) preferably has a weight average molecular weight from about 50,000 Daltons to about 2.5 million Daltons, as determined by ASTM D5296-05. More preferably, the at least one

poly(hydroxyalkanoate) has a weight average molecular weight from about 500,000 Daltons to about 750,000 Daltons, as determined by ASTM D5296-05.

[030] The polymer composition may also include further additives. In some examples, the polymer compositions may also include from about 1 to about 10 weight percent of at least one plasticizer; from about 0.1 to about 5 weight percent of at least one nucleating agent; and from about 0.1 to about 10 weight percent of a filler.

[031] In some instances, the polymer composition may include an additional biodegradable polymer besides poly(lactic acid) and/or poly(hydroxyalkanoates). Thus, in certain examples, the polymer composition may also include comprising from about 5 to about 50 weight percent of at least one biodegradable polymer selected from the group consisting of poly(caprolactone), poly(ethylene sebacate), poly(butylene succinate), poly(butylene succinate-co-adipate), poly(butylene adipate terephthalate), poly(vinyl acetate) and mixtures thereof.

[032] According to certain examples, the polymer composition is preferably biodegradable as determined using ASTM standard D5988. Further, in some examples, the polymer composition is preferably home compostable as determined using ASTM standard D6868.

[033] The present disclosure also provides various end-use products which may be formed from the aforementioned polymer composition. Thus, according to one example, the present disclosure provides a molded sheet made up of the polymer composition. In a second example, the present disclosure provides a molded article made up of the polymer composition, wherein the molded article is formed by thermoforming, injection molding, or blow molding. In another example, the present disclosure provides a film made up of the polymer composition, wherein the film is a blown film or a cast film. In still another example, the present disclosure provides a fiber made up of the polymer composition.

WHAT IS CLAIMED IS

Claim 1. A polyester comprising:

from about 15 to about 40 weight percent monomer repeat units of isosorbide, based on the total weight of the polyester;

from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride, based on the total weight of the polyester; and

from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol, based on the total weight of the polyester,

wherein the polyester has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05 and

wherein the dicarboxylic acid or anhydride comprises a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof.

Claim 2. The polyester of Claim 1, wherein the polyester comprises from about 25 to about 35 weight percent succinic acid or succinic anhydride and from about 10 to about 25 weight percent nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid.

Claim 3. The polyester of claim 1, wherein the polyhydric alcohol is selected from the group consisting of glycerin, ethylene glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 2-methyl, neopentyl glycol, propylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, tripropylene glycol, tetrapropylene glycol, trimethylene glycol, 1,1,1-trimethylol ethane, 1,2,3-trimethylolpropane, methyl propanediol, pentaerythritol, and poly(oxyalkylene) polyols comprising monomer repeat units of ethylene oxide, propylene oxide, or butylene oxide, and mixtures thereof.

Claim 4. The polyester of claim 1, wherein the polyhydric alcohol is selected from the group consisting of 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, methyl propanediol, and mixtures thereof.

Claim 5. The polyester of claim 1, wherein the polyhydric alcohol comprises 1,3-propanediol.

Claim 6. The polyester of claim 1, wherein the dicarboxylic acid or anhydride comprises succinic acid or anhydride, and the polyhydric alcohol comprises 1,3-propanediol.

Claim 7. The polyester of Claim 1, wherein the polyester has a weight average molecular weight from 10,000 to 15,000 Daltons, as determined by ASTM D5296-05.

Claim 8. A polymer composition comprising:

from about 50 to about 95 weight percent of a biodegradable polymer selected from the group consisting of poly(lactic acid), poly(hydroxyalkanoates), and mixtures thereof; and

from about 5 to about 50 weight percent of an impact modifying polyester, wherein the impact modifying polyester comprises

from about 15 to about 40 weight percent monomer repeat units of isosorbide, based on the total weight of the polyester;

from about 25 to about 60 weight percent monomer repeat units of a dicarboxylic acid or anhydride, based on the total weight of the polyester; and

from about 10 to about 20 weight percent monomer repeat units of a polyhydric alcohol, based on the total weight of the polyester,

wherein the polyester has a weight average molecular weight of at least 8000 Daltons, as determined by ASTM D5296-05 and

wherein the dicarboxylic acid or anhydride comprises a mixture of (1) succinic acid or succinic anhydride and (2) nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid, and mixtures thereof.

Claim 9. The polymer composition of claim 8, wherein the polyester comprises from about 25 to about 35 weight percent succinic acid or succinic anhydride and from about 10 to about 25 weight percent nadic anhydride, methyl nadic anhydride, C36 dimer acid, or partially hydrogenated C36 dimer acid.

Claim 10. The polymer composition of claim 8, the polyhydric alcohol is selected from the group consisting of glycerin, ethylene glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 2-methyl, neopentyl glycol, propylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, tripropylene

glycol, tetrapropylene glycol, trimethylene glycol, 1,1,1-trimethylol ethane, 1,2,3-trimethylolpropane, methyl propanediol, pentaerythritol, and poly(oxyalkylene) polyols comprising monomer repeat units of ethylene oxide, propylene oxide, or butylene oxide, and mixtures thereof.

Claim 11. The polymer composition of claim 8, wherein the polyhydric alcohol is selected from the group consisting of 1,3-propanediol, 1,4-butanediol, 1,6-hexanediol, methyl propanediol, and mixtures thereof.

Claim 12. The polymer composition of claim 8, wherein the polyhydric alcohol comprises 1,3-propanediol.

Claim 13. The polymer composition of claim 8, wherein the dicarboxylic acid or anhydride comprises succinic acid or anhydride, and the polyhydric alcohol comprises 1,3-propanediol.

Claim 14. The polymer composition of Claim 8, wherein the impact modifying polyester has a weight average molecular weight from about 10,000 to about 15,000 Daltons, as determined by ASTM D5296-05.

Claim 15. The polymer composition of Claim 8, wherein the polymer composition comprises from about 60 to about 85 weight percent of the biodegradable polymer and from about 5 to about 30 weight percent of the impact modifying polyester.

Claim 16. The polymer composition of Claim 8, wherein the biodegradable polymer comprises poly(lactic acid).

Claim 17. The polymer composition of Claim 8, wherein the biodegradable polymer comprises at least one poly(hydroxyalkanoate).

Claim 18. The polymer composition of Claim 17, wherein the at least one poly(hydroxyalkanoate) comprises poly-3-hydroxybutyrate-co-3-hydroxyhexanoate ("P(3HB-co-3HHx)").

Claim 19. The polymer composition of Claim 18, wherein the P(3HB-co-3HHx) comprises from about 75 to about 99 mole percent hydroxybutyrate and from about 1 to about 25 mole percent hydroxyhexanoate.

Claim 20. The polymer composition of Claim 18, wherein the P(3HB-co-3HHx) comprises from about 93 to about 98 mole percent hydroxybutyrate and from about 2 to about 7 mole percent hydroxyhexanoate.

Claim 21. The polymer composition of Claim 17, wherein the at least one poly(hydroxyalkanoate) comprises a terpolymer made up from about 75 to about 99.9 mole percent monomer repeat units of 3-hydroxybutyrate, from about 0.1 to about 25 mole percent monomer repeat units of 3-hydroxyhexanoate, and from about 0.1 to about 25 mole percent monomer repeat units of a third 3-hydoxyalkanoate having from 5 to 12 carbon atoms.

Claim 22. The polymer composition of Claim 17, wherein the at least one poly(hydroxyalkanoate) has a weight average molecular weight from about 50,000 Daltons to about 2.5 million Daltons, as determined by ASTM D5296-05.

Claim 23. The polymer composition of Claim 17, wherein the at least one poly(hydroxyalkanoate) has a weight average molecular weight from about 500,000 Daltons to about 750,000 Daltons, as determined by ASTM D5296-05.

Claim 24. The polymer composition of Claim 8, wherein the polymer composition comprises from about 5 to about 25 weight percent of poly(lactic acid) and from about 70 to about 90 weight percent of at least one poly(hydroxyalkanoate), based on the overall weight of the polymer composition.

Claim 25. The polymer composition of Claim 8, further comprising

from about 1 to about 10 weight percent of at least one plasticizer;

from about 0.1 to about 5 weight percent of at least one nucleating agent; and

from about 0.1 to about 10 weight percent of a filler.

Claim 26. The polymer composition of Claim 8, wherein the polymer composition is biodegradable as determined using ASTM standard D5988.

Claim 27. The polymer composition of Claim 8, wherein the polymer composition is home compostable as determined using ASTM standard D6868.

Claim 28. The polymer composition of Claim 8 further comprising from about 5 to about 50 weight percent of at least one biodegradable polymer selected from the group consisting of poly(caprolactone), poly(ethylene sebacate), poly(butylene succinate),

poly(butylene succinate-co-adipate), poly(butylene adipate terephthalate), poly(vinyl acetate) and mixtures thereof.

Claim 29. A molded sheet comprising the polymer composition of Claim 8.

Claim 30. A molded article comprising the polymer composition of Claim 8, wherein the molded article is formed by thermoforming, injection molding, or blow molding.

Claim 31. A film comprising the polymer composition of Claim 8, wherein the film is a blown film or a cast film.

Claim 32. A fiber comprising the polymer composition of Claim 8.