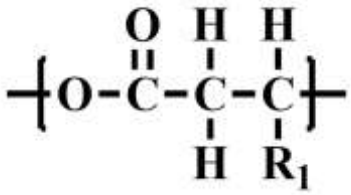
SUMMARY

[005a] In a first aspect of the present disclosure, there is provided a polymer composition comprising a blend of a first polymer and a second polymer, wherein the first polymer comprises at least 10 mole percent repeat units of (3-hydroxypropionate) and the second polymer comprises a poly(hydroxyalkanoate) which does not include repeat units of (3-hydroxypropionate), wherein the polymer composition further comprises at least one additional biopolymer selected from the group consisting of polycaprolactone, poly(butylene succinate), poly(butylene succinate-co-butylene adipate), poly(lactic acid), poly(butylene adipate-co-terephthalate) and mixtures thereof.

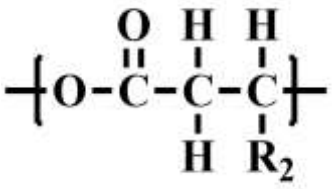
[005b] In another aspect of the present disclosure, there is provided a converted article comprising the polymer composition as disclosed herein, wherein the converted article is selected from the group consisting of films, fibers, sheets, molded articles, rotomolded articles, extrusion blow molded articles, injection stretch blow molded articles, foams, melt coatings on substrates, and calendared sheets.

[006] In a first example, the present disclosure provides a polymer composition. According to one example, the polymer composition includes at least a first polymer and a second polymer. The first polymer is made up of at least 10 mole percent repeat units of (3-hydroxypropionate). The second polymer is made up of a poly(hydroxyalkanoate) which does not include repeat units of (3-hydroxypropionate).

[007] In other examples, the first polymer is a copolymer or a terpolymer. This copolymer or terpolymer includes at least a first repeat unit which is (3-hydroxypropionate) and a second repeat unit according to Formula I

	Formula I.

[008] Optionally, the copolymer or terpolymer may also include a third repeat unit according to Formula II,



Formula II.

[009] For Formulas I and II above, R1 and R2 are each independently selected from the group consisting of linear or branched alkyl groups having from 1 to 22 carbon atoms.

[010] In certain examples, the polymer composition is preferably made up of about 1 to about 99 weight percent of the first polymer and from about 99 to about 1 weight percent of the second

polymer. More preferably, the polymer composition is made up of from about 25 to about 75 weight percent of the first polymer and from about 75 to about 25 weight percent of the second polymer. Even more preferably, the polymer composition is made up of from about 40 to about 60 weight percent of the first polymer and from about 60 to about 40 weight percent of the second polymer.

[011] In some instances, the polymer composition may also include at least one additional biopolymer, which is selected from the group consisting of polycaprolactone, poly(butylene succinate), poly(butylene succinate-co-butylene adipate), poly(lactic acid), poly(butylene adipate-co-terephtalate) and mixtures thereof. In some examples, the polymer composition may include from about 5 to about 75 weight percent of the least one additional biopolymer.

[012] As for the second polymer, in certain examples, the second polymer is preferably made up of 2-hydroxyalkanoate repeat units, 3-hydroxyalkanaoate repeat units, or 4-hydroxyalkanoate repeat units, each with or without branching from 1 carbon branches to 12 carbon branches.

[013] In some examples, the second polymer is preferably made up of poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) ("P(3HB-co-3HHx)"). More particularly, in some examples, this P(3HB-co-3HHx) is itself preferably made up of from about 75 to about 99 mole percent hydroxybutyrate repeat units and from about 1 to about 25 mole percent hydroxyhexanoate repeat units. Even more preferably, the P(3HB-co-3HHx) is made up of from about 93 to about 98 mole percent hydroxybutyrate repeat units and from about 2 to about 7 mole percent hydroxyhexanoate repeat units.

[014] The polymer composition may also include various additives in addition to the aforementioned polymers.

[015] According to certain examples, the polymer composition also preferably includes a nucleating agent selected from the group consisting of erythritols, pentaerythritol, dipentaerythritols, artificial sweeteners, stearates, sorbitols, mannitols, inositols, polyester waxes, nanoclays, behenamide, erucamide, stearamide, oleamide, poly(hydroxybutyrate), thymine, cyanuric acid, cytosine, adenine, uracil, guanine, boron nitride and mixtures thereof.

[016] In accordance with some examples, the polymer composition also preferably includes a plasticizer selected from the group consisting of sebacates, citrates, fatty esters of adipic,

succinic, and glucaric acids, lactates, alkyl diesters, citrates, alkyl methyl esters, dibenzoates, propylene carbonate, caprolactone diols having a number average molecular weight from 200-10,000 g/mol, poly(ethylene glycols) having a number average molecular weight of 400-10,000 g/mol, esters of vegetable oils, long chain alkyl acids, adipates, glycerol, isosorbide derivatives or mixtures thereof, polymeric plasticizers, poly(hydroxyalkanoates) copolymers comprising at least 18 mole percent monomer residues of hydroxyalkanoates other than hydroxybutyrate, and mixtures thereof.

[017] In some instances, the polymer composition also preferably includes a filler selected from the group consisting of calcium carbonate, talc, nano clays, nanocellulose, hemp fibers, kaolin, carbon black, wollastonite, glass fibers, carbon fibers, graphite fibers , mica, silica, dolomite, barium sulfate, magnetite, halloysite, zinc oxide, titanium dioxide, montmorillonite, feldspar, asbestos, boron, steel, carbon nanotubes, cellulose fibers, flax, cotton, starch, polysaccharides, aluminum hydroxide, magnesium hydroxide, modified starches, chitins and chitosans, alginates, gluten, zein, casein, collagen, gelatin, polysaccharides, guar gum, xanthan gum, succinoglycan, natural rubbers; rosinic acid, lignins, natural fibers, jute, kenaf, hemp, ground nut shells, wood flour, and mixtures thereof.

[018] In certain examples, the polymer composition also preferably includes an impact modifier selected from the group consisting of group consisting of acrylic-based resins and emulsions, isosorbide derivatives, natural rubbers, aliphatic polyesters, or mixtures thereof.

[019] In some instances, the polymer composition preferably also includes at least one additive selected from the group consisting of lubricants, antioxidants, stabilizers, moisture scavengers, coupling agents, nucleators, or flame retardants.

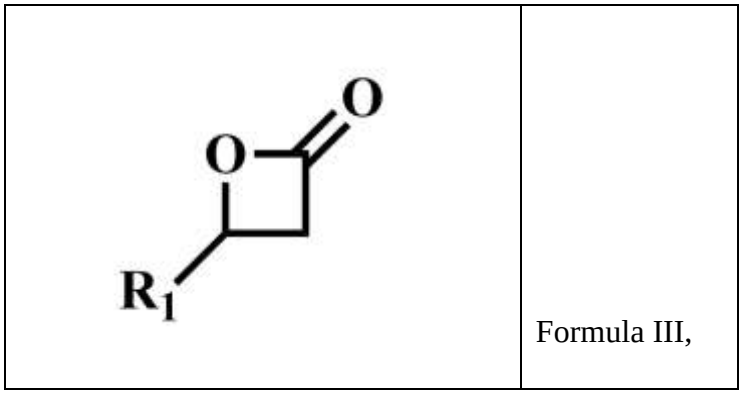
[020] Optionally, the first polymer and the second polymer may be further reacted with one another. Thus, in some instances, the polymer composition preferably includes a catalyst or an initiator which induces reaction of the poly(3-hydroxypropionate) and the at least one additional poly(hydroxyalkanoate). The polymer composition thus also includes a reaction product formed from reaction the poly(3-hydroxypropionate) and the at least one additional poly(hydroxyalkanoate).

[021] In a further example, the present disclosure also provides a converted article which is made up of the aforementioned polymer composition. For instance, in certain examples of the present disclosure, the converted article may be selected from the group consisting of films, fibers, sheets, molded articles, rotomolded articles, extrusion blow molded articles, injection stretch blow molded articles, foams, melt coatings on substrates, and calendared sheets.

[022] In still another example, the present disclosure also provides a method for making a poly(hydroxyalkanoate) copolymer or terpolymer. According to one example, the methods includes a first step of combining:

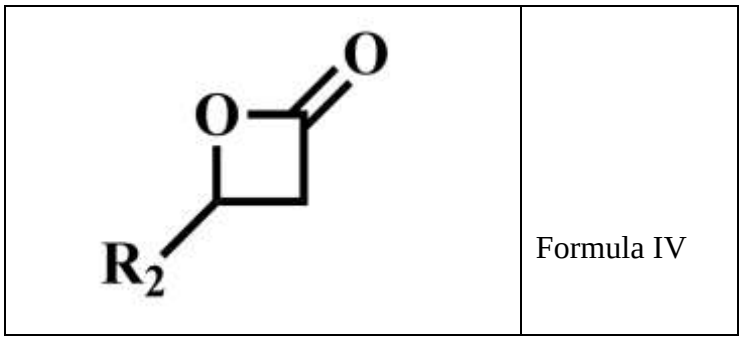
[023] beta-propiolactone,

[024] a first substituted beta-propiolactone according to Formula III



Formula III,

[025] and (3) optionally, a second substituted beta-propiolactone according to Formula IV



Formula IV

[026] to form a reaction mixture. The method also includes a second step of polymerizing the reaction mixture to form a copolymer or terpolymer which comprises

[027] a first repeat unit which is (3-hydroxypropionate),

[028] a second repeat unit according to Formula I

WHAT IS CLAIMED IS

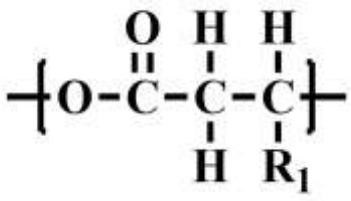
Claim 1. A polymer composition comprising a blend of a first polymer and a second polymer, wherein the first polymer comprises at least 10 mole percent repeat units of (3-hydroxypropionate) and the second polymer comprises a poly(hydroxyalkanoate) which does not include repeat units of (3-hydroxypropionate), wherein the polymer composition further comprises at least one additional biopolymer selected from the group consisting of polycaprolactone, poly(butylene succinate), poly(butylene succinate-co-butylene adipate), poly(lactic acid), poly(butylene adipate-co-terephthalate) and mixtures thereof.

Claim 2. The polymer composition of Claim 1, wherein the first polymer comprises poly(3-hydroxypropionate).

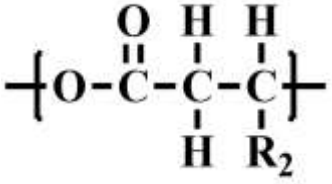
Claim 3. The polymer composition of Claim 1, wherein the first polymer comprises a copolymer or terpolymer, wherein the copolymer or terpolymer comprises

a first repeat unit which is (3-hydroxypropionate),

a second repeat unit according to Formula I

	Formula I ; and

optionally, a third repeat unit according to Formula II,

	Formula II

wherein R1 and R2 are each independently selected from the group consisting of linear or branched alkyl groups having from 1 to 22 carbon atoms.

Claim 4. The polymer composition of Claim 1, wherein the polymer composition comprises from 1 to 99 weight percent of the first polymer and from 99 to 1 weight percent of the second polymer.

Claim 5. The polymer composition of Claim 1, wherein the polymer composition comprises from 25 to 75 weight percent of the first polymer and from 75 to 25 weight percent of the second polymer.

Claim 6. The polymer composition of Claim 1, wherein the polymer composition comprises from 40 to 60 weight percent of the first polymer and from 60 to 40 weight percent of the second polymer.

Claim 7. The polymer composition of Claim 1, wherein the polymer composition comprises from 5 to 75 weight percent of the least one additional biopolymer.

Claim 8. The polymer composition of Claim 1, wherein the second polymer comprises 2-hydroxyalkanoate repeat units, 3-hydroxyalkanaoate repeat units, or 4-hydroxyalkanoate repeat units, each with or without branching from 1 carbon branches to 12 carbon branches.

Claim 9. The polymer composition of Claim 1, wherein the second polymer comprises poly-3-hydroxybutyrate-co-3-hydroxyhexanoate ("P(3HB-co-3HHx)").

Claim 10. The polymer composition of Claim 9, wherein the P(3HB-co-3HHx) comprises from 75 to 99 mole percent hydroxybutyrate repeat units and from 1 to 25 mole percent hydroxyhexanoate repeat units.

Claim 11. The polymer composition of Claim 9, wherein the P(3HB-co-3HHx) preferably comprises from 93 to 98 mole percent hydroxybutyrate repeat units and from 2 to 7 mole percent hydroxyhexanoate repeat units.

Claim 12. The polymer composition of Claim 1, further comprising a nucleating agent selected from the group consisting of erythritols, pentaerythritol, dipentaerythritols, artificial sweeteners, stearates, sorbitols, mannitols, inositols, polyester waxes, nanoclays, behenamide, erucamide, stearamide, oleamide, poly(hydroxybutyrate), thymine, cyanuric acid, cytosine, adenine, uracil, guanine, boron nitride and mixtures thereof.

Claim 13. The polymer composition of Claim 1, further comprising a plasticizer selected from the group consisting of sebacates, citrates, fatty esters of adipic, succinic, and glucaric acids, lactates, alkyl diesters, citrates, alkyl methyl esters, dibenzoates, propylene carbonate, esters of vegetable oils, long chain alkyl acids, adipates, glycerol, isosorbide derivatives or mixtures thereof,

polymeric plasticizers, poly(hydroxyalkanoates) copolymers comprising at least 18 mole percent monomer residues of hydroxyalkanoates other than hydroxybutyrate, and mixtures thereof.

Claim 14. The polymer composition of Claim 1, further comprising a filler selected from the group consisting of calcium carbonate, talc, nano clays, nanocellulose, hemp fibers, kaolin, carbon black, wollastonite, glass fibers, carbon fibers, graphite fibers , mica, silica, dolomite, barium sulfate, magnetite, halloysite, zinc oxide, titanium dioxide, montmorillonite, feldspar, asbestos, boron, steel, carbon nanotubes, cellulose fibers, flax, cotton, starch, polysaccharides, aluminum hydroxide, magnesium hydroxide, modified starches, chitins and chitosans, alginates, gluten, zein, casein, collagen, gelatin, polysaccharides, guar gum, xanthan gum, succinoglycan, natural rubbers; rosinic acid, lignins, natural fibers, jute, kenaf, hemp, ground nut shells, wood flour, and mixtures thereof.

Claim 15. The polymer composition of Claim 1, further comprising an impact modifier selected from the group consisting of group consisting of acrylic-based resins and emulsions, isosorbide derivatives, natural rubbers, aliphatic polyesters, or mixtures thereof.

Claim 16. The polymer composition of Claim 1, further comprising at least one additive selected from the group consisting of lubricants, antioxidants, stabilizers, moisture scavengers, coupling agents, nucleators, or flame retardants.

Claim 17. The polymer composition of Claim 1, wherein the composition further comprises a catalyst or an initiator which induces reaction of the poly(3-hydroxypropionate) and the at least one additional poly(hydroxyalkanoate) and a reaction product formed from reaction the poly(3-hydroxypropionate) and the at least one additional poly(hydroxyalkanoate).

Claim 18. A converted article comprising the polymer composition of Claim 1, wherein the converted article is selected from the group consisting of films, fibers, sheets, molded articles, rotomolded articles, extrusion blow molded articles, injection stretch blow molded articles, foams, melt coatings on substrates, and calendared sheets.