SUMMARY

[005a] In a first aspect of the present disclosure, there is provided a biodegradable polymeric composition comprising: (1) from about 5 weight percent to about 95 weight percent poly(hydroxyalkanoates); (2) from about 5 weight percent to about 95 weight percent of at least one biodegradable polymer selected from the group consisting of poly(butylene succinate), poly(butylene succinate-co-adipate), poly(butylene adipate-co-terephthalate, poly(caprolactone), poly(lactic acid), cellulose esters, thermoplastic starch, and mixtures thereof; and (3) from about 0.1 weight percent to about 5 weight percent of a nucleating agent.

[005b] In another aspect of the present disclosure, there is provided a product package for a consumer goods product, wherein the product package comprises at least one biodegradable package portion which comprises the polymeric composition as disclosed herein.

[006] In one example, the present disclosure provides a biodegradable polymeric composition. In one example, this polymeric composition includes at least (1) from about 5 weight percent to about 95 weight percent poly(hydroxyalkanoates); (2) from about 5 weight percent to about 95 weight percent of at least one biodegradable polymer selected from the group consisting of poly(butylene succinate), poly(butylene succinate-co-adipate), poly(butylene adipate-co-terephthalate, poly(caprolactone), poly(lactic acid), cellulose esters (such as cellulose acetate) thermoplastic starch, and mixtures thereof; and (3) from about 0.1 weight percent to about 5 weight percent of a nucleating agent,.

[007] In certain examples, the polymeric composition preferably includes from about 35 weight percent to about 90 weight percent poly(hydroxyalkanoates). More preferably, the polymeric composition includes from about 40 weight percent to about 70 weight percent poly(hydroxyalkanoates)

[008] In some examples, the polymeric composition preferably includes from about 5 weight percent to about 50 weight percent poly(butylene succinate). More preferably, the polymeric composition includes from about 10 weight percent to about 30 weight percent poly(butylene succinate).

[009] According to some examples, the polymeric composition preferably includes from about 5 weight percent to about 50 weight percent poly(butylene succinate-co-adipate).

More preferably, the polymeric composition includes from about 10 weight percent to about 30 weight percent poly(butylene succinate-co-adipate).

[010] In some instances, the polymeric composition preferably includes from about 10 weight percent to about 70 weight percent poly(lactic acid). More preferably, the polymeric composition includes from about 20 weight percent to about 60 weight percent poly(lactic acid).

[011] In certain examples, the polymeric composition preferably includes from about 5 weight percent to about 50 weight percent cellulose esters, such as cellulose acetate. More preferably, the polymeric composition includes from about 10 weight percent to about 30 weight percent cellulose esters.

[012] In some examples, the poly(hydroxyalkanoates) in the composition are preferably made up of a mixture of a first copolymer and a second copolymer. The first copolymer includes from about 90 to about 99.9 mole percent monomer residues of 3-hydroxybutyrate and from about 0.1 to about 10 mole percent monomer residues of a second 3-hydoxyalkanoate having from 5 to 12 carbon atoms. The second copolymer includes at least 70 mole percent monomer residues of 3-hydroxybutyrate and monomer residues of the second 3-hydoxyalkanoate having from 5 to 12 carbon atoms in amount which at least 6 mole percent less than the amount of the second 3-hydoxyalkanoate in the first polymer.

[013] According to certain examples, the nucleating agent is preferably selected from the group consisting of erythritols, pentaerythritol, dipentaerythritols, artificial sweeteners, stearates, polysaccharides, sorbitols, mannitols, inositols, polyester waxes, nanoclays, behenamide, erucamide, stearamide, oleamide, polyhydroxybutyrate, thymine, cyanuric acid, cytosine, adenine, uracil, guanine, boron nitride and mixtures thereof.

[014] In some examples, the polymeric composition preferably also includes up to about 15 weight percent of a plasticizer. This plasticizer may be 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. More preferably, the polymeric composition includes from about 5 weight percent to about 15 weight percent of the plasticizer.

[015] In certain instances, the polymeric composition preferably also includes up to about 50 weight percent of a filler. This filler may be 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., and mixtures thereof. More preferably, the polymeric composition includes from about 5 weight percent to about 40 weight percent of the filler.

[016] According to some examples, the polymeric composition preferably also includes up to about 20 weight percent of an impact modifier. This impact modifier may be selected from the group consisting of acrylic-based resins and emulsions, isosorbide derivatives, natural rubbers, aliphatic polyesters, or mixtures thereof. More preferably, the polymeric composition includes from about 5 weight percent to about 15 weight percent of the impact modifier.

[017] According to some examples, further additives may also be included in the polymeric composition. In some instances, the composition also includes up to 50 weight percent of one or more additives selected from the group consisting of poly(vinyl alcohols), poly(vinyl acetate), poly(vinyl laurate), poly(ethylene vinyl acetate), poly(glycolic acid), furandicarboxylic acid-based polyesters, cellulose, nanocellulose, glucans, and mixtures thereof..

[018] In general, the poly(hydroxyalkanoates) of the polymeric composition may be either homopolymers or copolymers, including terpolymers. Thus, in certain examples, the poly(hydroxyalkanoates) are preferably a copolymer made up of from about 75 to about 99.9 mole percent monomer residues of 3-hydroxybutyrate and from about 0.1 to about 25 mole percent monomer residues of a second 3-hydoxyalkanoate having from 5 to 12 carbon atoms. In other example, the poly(hydroxyalkanoates) are preferably a terpolymer made up from about 75 to about 99.9 mole percent monomer residues of 3-hydroxybutyrate and from about 0.1 to about 25 mole percent monomer residues of 3-hydroxyhexanoate, and from about 0.1 to about 25 mole percent monomer residues of a third 3-hydoxyalkanoate having from 5 to 12 carbon atoms.

[019] In certain examples, the poly(hydroxyalkanoates) and the at least one biodegradable polymer are preferably reacted with each other in a transesterification.

[020] In other examples, the poly(hydroxyalkanoates) and the at least one biodegradable polymer are preferably reacted with each other in a reactive extrusion process.

[021] Further, in certain examples, the poly(hydroxyalkanoates) of the polymeric composition preferably have a weight average molecular weight from about 50,000 Daltons to about 7.5 million Daltons, and more preferably have a weight average molecular weight from about 300,000 Daltons to about 3.0 million Daltons.

[022] In a further example, the present disclosure also provides a product package for a consumer goods product, wherein the product package includes at least one biodegradable package portion which comprises the aforementioned polymeric composition.

[023] In certain examples, this at least biodegradable package portion is preferably formed a method selected from the group consisting of injection molding, compression molding, thermoforming, cast and blown film formation, extrusion coating, extrusion blow molding, injection stretch blow molding, and extrusion profiling.