properties. In comparison to other packaging materials, oriented films are lightweight and energy-efficient to produce.

[0006] The primary materials for biaxially-oriented films are polypropylene, polyester, and polyamide. Polyethylene and polylactic acid are also biaxially-oriented in commercial processes and used in commercial packaging applications. With the exception of polylactic acid, the conventional biaxially-oriented films are made from petroleum-based materials that are not biodegradable. In view of the foregoing, what is needed is an industrial or home-compostable biaxially-oriented film for use as print films and barrier films that can be converted into packaging structures that meet the performance demands and the required end-use certifications of a variety of packaging applications.

[0007] In view of the foregoing, there is provided an industrial and/or home-compostable biaxially oriented composite film that may be produced using the materials and methods described herein.

[0008] In one example of the disclosure there is provided a biaxially-oriented industrial or home compostable film web that contains at least 3 co-extruded layers selected from: a skin film layer, a sealant film layer, and a core layer, wherein each of the sealant film layer and the skin film layer includes a blend of from 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 20 to about 100 weight percent polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers; and a core film layer containing a blend of from about 30 to about 80 wt.% polyhydroxalkanoate (PHA), from about 20 to about 40 wt.% polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers. The core film layer is disposed between a combination of the skin film layer and the sealant film layer, is disposed between two sealant film layers, or is disposed between two skin film layers, wherein each of the sealant film layer and the skin film layer contains the same or different amounts of PHA, PLA, and other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers.

[0008a] In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable film web comprising at least 3 co-extruded layers selected from the group consisting of: a skin film layer, a sealant film layer, and a combination of a sealant film layer and a skin film layer, wherein each of the sealant film layer and the skin film layer comprises a blend of from 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 20 to about 100 weight percent polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers; and

a core film layer comprising a blend of from about 30 to about 80 wt.% polyhydroxalkanoate (PHA), from about 20 to about 40 wt.% polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein the core film layer is disposed between a combination of the skin film layer and the sealant film layer, is disposed between two sealant film layers, or is disposed between two skin film layers, wherein each of the sealant film layer and the skin film layer comprises the same or different amounts of PHA, PLA, and other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, and wherein the PHA of the core film layer, the sealant film layer, and the skin film layer comprise from about 2 to about 10 mole percent 3-hydroxyhexanoate and the balance 3-hydroxybutyrate.

[0009] In another example there is provided a method for improving the dimensional stability of a biaxially-oriented industrial or home compostable film web that contains at least three co-extruded layers. The method includes extruding a composite poly(hydroxyalkanoate)-based

polymer film; and annealing the composite poly(hydroxyalkanoate) polymer film at a temperature ranging from about 110 ºC to about 130 ºC during a biaxial orientation process. In one aspect, the present disclosure refers to a method for improving the dimensional stability of a biaxially-oriented industrial or home compostable film web comprising at least three co-extruded layers, comprising extruding a composite poly(hydroxyalkanoate)-based polymer film; and annealing the composite poly(hydroxyalkanoate) polymer film at a temperature ranging from about 110 ºC to about 130ºC during a biaxial orientation process. In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable film web made by the disclosed method. In another aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable film web comprising at least three co- extruded layers made by the disclosed method. In yet another aspect, the present disclosure refers to a biaxially-oriented barrier web made by the disclosed method, further comprising coating and/or metallizing the barrier web. In a further aspect, the present disclosure refers to a biaxially-oriented print web made by the disclosed method, further comprising printing on the print web.

[00010] In some examples, the biaxially-oriented industrial or home compostable film web includes: at least two sealant film layers wherein the at least two sealant film layers comprise a blend of from about 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 20 to about 100 weight percent polylactic acid (PLA), and, optionally, other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein each of the two sealant film layers may have same or different amounts of PHA, PLA, and other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers; and a core film layer comprising a blend of from about 30 to about 80 wt.% polyhydroxalkanoate (PHA), from about 20 to about 40 wt.% polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein the core film layer is disposed between the at least two sealant film layers.

[00011] In some examples, the biaxially-oriented industrial or home compostable film web includes: at least two skin film layers wherein the at least two skin film layers comprise a blend of from about 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 20 to about 100 weight percent polylactic acid (PLA), and, optionally, other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein each of the two sealant film layers may have same or different amounts of PHA, PLA, and other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers; and a core film layer comprising a blend of from about 30 to about 80 wt.% polyhydroxalkanoate (PHA), from about 20 to about 40 wt.% polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein the core film layer is disposed between the at least two skin film layers.

[00012] In some examples, the biaxially-oriented industrial or home compostable film web includes: a skin film layer comprising a blend of from about 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 50 to about 70 weight percent polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers; a core film layer comprising a blend of from about 30 to about 80 wt.% polyhydroxalkanoate (PHA), from about 20 to about 40 wt.% polylactic acid (PLA), and, optionally, minor amounts of minor amounts of other biopolymers, other polymers, nucleating

agents, chain extenders, fatty amides, and fillers; and a sealant film layer comprising a blend of from 0 to about 80 wt.% polyhydroxyalkanoate (PHA) and from about 20 to about 100 weight percent polylactic acid (PLA), and, optionally, minor amounts of other biopolymers, other polymers, nucleating agents, chain extenders, fatty amides, and fillers, wherein the core film layer is disposed between the skin film layer and the sealant film layer.

[00013] In some examples, the PHA of the core film layer includes from about 2 to about 10 mole percent 3-hydroxyhexanoate and the balance 3-hydroxybutyrate.

[00014] In some examples, the PHA of the sealant film layer includes from about 2 to about 10 mole percent 3-hydroxyhexanoate and the balance 3-hydroxybutyrate.

[00015] In some examples, the PHA of the skin film layer includes from about 2 to about 10 mole percent 3-hydroxyhexanoate and the balance 3-hydroxybutyrate.

[00016] In some examples, the biaxially-oriented industrial or home compostable film has an oven shrinkage of from 0 to less than about 5 % in the machine direction (MD) and an oven shrinkage of from 0 to less than about 15 % in the transverse direction (TD).

[00017] In some examples, the biaxially-oriented industrial or home compostable film has a pin puncture above about 700 grams-force (gf).

[00018] In some examples, there is provided a biaxially-oriented industrial or home compostable print film web having a the core film layer disposed between the combination of the skin film layer and the sealant film layer. In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable print film web comprising the core film layer disposed between the combination of the skin film layer and the sealant film layer disclosed herein.

[00019] In some examples, there is provided a biaxially-oriented industrial or home compostable barrier film web having the core film layer disposed between the combination of the skin film layer and the sealant film layer. In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable barrier film web comprising the core film layer disposed between the combination of the skin film layer and the sealant film layer disclosed herein.

[00020] In some examples, the biaxially-oriented industrial or home compostable print film web has an oven shrinkage of from 0 to less than about 5.0 % in the machine direction (MD) and an oven shrinkage of from 0 to less than about 15 % in the transverse direction (TD).

[00021] In some examples, the biaxially-oriented industrial or home compostable print film has a pin puncture range above about 700 grams-force (gf).

[00022] In some examples, the biaxially-oriented industrial or home compostable print film web has a haze value below 15%.

[00023] In some examples, there is provided biaxially-oriented industrial or home compostable barrier film web having the core film layer disposed between two of the sealant film layers. In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable barrier film web comprising the core film layer disposed between two of the sealant film layers disclosed herein.

[00024] In some examples, the biaxially-oriented barrier film has an oven shrinkage of from 0 to less than about 5.0 % in the machine direction (MD) and an oven shrinkage of from 0 to less than about 15 % in the transverse direction (TD).

[00025] In some examples, the biaxially-oriented barrier film has a pin puncture range above about 700 grams-force (gf).

[00026] In some examples, there is provided a biaxially-oriented industrial or home compostable print film web having the core film layer disposed between two of the skin film layers. In one aspect, the present disclosure refers to a biaxially-oriented industrial or home compostable print film web comprising the core film layer disposed between two of the skin film layers disclosed herein.

[00027] In some examples, prior to or simultaneous with the annealing step, the biaxially-oriented industrial or home compostable film web is relaxed in the transverse direction (TD) from about 5% to about 25% from stretching in the transverse direction (TD).

[00028] In some examples, the biaxially-oriented industrial or home compostable film web is annealed at a temperature ranging from about 110 ºC to about 130 ºC during a biaxial orientation process and prior to or simultaneous with the annealing step, the industrial or home compostable film web is relaxed in the transverse direction (TD) from about 15% to about 25% from stretching in the transverse direction (TD).

[00029] In some examples, there is provided a biaxially-oriented barrier web that is coated and/or metalized.

[00030] As described in more detail below, certain annealing conditions may provide the optimal dimensional stabilities or minimize shrinkage of poly(hydroxyalkanoate)-based films in the MD and TD directions. If annealed properly, the poly(hydroxyalkanoate)-based film should not change in diameter over time, or when exposed to elevated temperatures. Accordingly, examples of the disclosure provide conditions which can provide poly(hydroxyalkanoate)- based films biaxial dimensional stability. Dimensionally stable poly(hydroxyalkanoate)-based films made according to the disclosure may be particularly useful for in the food packaging industry.