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Inventor(s)

DANDA; Kranthi Chaitanya et al.

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### BLOWN FILM COMPOSITIONS CONTAINING NANOCOMPOSITE AND COMPATIBILIZER

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#### Abstract

Disclosed is a composition useful for forming blown films. The composition includes (a) an ungrafted ethylene-based polymer, (b) a nanocomposite containing a polyamide and montmorillonite, (c) a compatibilizer comprising a maleic anhydride grafted ethylene-methyl acrylate copolymer and/or a maleic anhydride grafted ethylene-butyl acrylate copolymer, and (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer. Also disclosed is a blown film made from a composition containing an ungrafted ethylene-based polymer, a nanocomposite containing a polyamide and montmorillonite, a compatibilizer comprising a maleic anhydride grafted ethylene-based polymer, and optionally, an EVOH copolymer. These films can have improved optical and/or mechanical properties compared to films made without the nanocomposite.

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**Inventors:** DANDA; Kranthi Chaitanya (Longview, TX), SMITH; Darren Lavon (Kilgore, TX)

**Applicant:** Westlake Longview Corporation (Houston, TX)

**Family ID:** 94824175

**Assignee:** Westlake Longview Corporation (Houston, TX)

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## **Background/Summary**

CROSS-REFERENCE TO RELATED APPLICATION/PRIORITY CLAIM [0001] Priority of U.S. Provisional Patent Application No. 63/552,299 filed on Feb. 12, 2024, is hereby claimed; the entire content of which is hereby incorporated by reference.

### **FIELD OF THE INVENTION**

[0002] The invention generally relates to polymeric compositions useful for forming blown films, blown films containing the compositions, and methods for making the blown films.

### **BACKGROUND OF THE INVENTION**

[0003] Compatibilization of polar polymers, such as polyamide (PA) and/or ethylene-vinyl alcohol (EVOH) copolymer, with non-polar polymers, such as polyethylene (PE), is commonly carried out with maleic anhydride (MAH) grafted polymers. However, such multi-component compositions can produce films having less than desirable optical and/or mechanical properties.

[0004] There is a need in the art for compositions that can form films containing compatibilized blends of PA, PE, and optionally, EVOH copolymer, having improved optical and/or mechanical properties.

[0005] The present invention addresses this need as well as others, which will become apparent from the following description and the appended claims.

### **SUMMARY OF THE INVENTION**

[0006] The invention is as set forth in the appended claims.

[0007] Briefly, in one aspect, the present invention provides a composition for forming a blown film. The composition comprises: [0008] (a) an ungrafted ethylene-based polymer; [0009] (b) a nanocomposite comprising a polyamide and montmorillonite; [0010] (c) a compatibilizer; and [0011] (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.

[0012] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-based polymer.

[0013] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-methyl acrylate copolymer or a maleic anhydride grafted ethylene-butyl acrylate copolymer.

[0014] In a second aspect, the invention provides a blown film comprising the composition according to the invention.

[0015] In a third aspect, the invention provides a method of making a blown film. The method

includes the steps of: [0016] (a) extruding a polymeric melt through an annular die to form a tube of polymer; [0017] (b) injecting air into the tube; and [0018] (c) cooling the tube to obtain the blown film, wherein the polymeric melt comprises the composition according to the invention.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIGS. 1A-1C show optical microscopy images of the blown film formed from Example 2.

[0020] FIG. 1D is an enlarged view of area X from FIG. 1A.

[0021] FIGS. 2A-2C show optical microscopy images of the blown film formed from Example 3.

[0022] FIGS. 3A-3C show optical microscopy images of the blown film formed from Example 4.

[0023] FIGS. 4A-4C show optical microscopy images of the blown film formed from Example 5.

[0024] FIGS. 5A-5C show optical microscopy images of the blown film formed from Example 7.

[0025] FIGS. 6A-6C show optical microscopy images of the blown film formed from Example 8.

[0026] FIGS. 7A-7C show optical microscopy images of the blown film formed from Example 9.

[0027] FIGS. 8A-8C show optical microscopy images of the blown film formed from Example 10.

### DETAILED DESCRIPTION OF THE INVENTION

[0028] It has been surprisingly discovered that blown films containing compatibilized blends of polar and non-polar polymers having improved optical and/or mechanical properties can be obtained by adding a nanocomposite comprising nylon and montmorillonite. The improved optical and/or mechanical properties include one or more of the following: higher gloss; lower haze; higher strength; higher elongation; higher toughness; higher dart impact; higher Elmendorf tear; higher puncture resistance; and fewer voids, gels, and immiscibility.

#### Composition

[0029] Thus, in one aspect, the present invention provides a composition adapted for making blown films. The composition comprises: [0030] (a) an ungrafted ethylene-based polymer; [0031] (b) a nanocomposite comprising a polyamide and montmorillonite; [0032] (c) a compatibilizer; and [0033] (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.

[0034] The composition may contain from 1 to 99 wt %, from 10 to 99 wt %, from 20 to 99 wt %, from 30 to 99 wt %, from 40 to 99 wt %, from 50 to 99 wt %, from 55 to 99 wt %, from 60 to 99 wt %, from 65 to 99 wt %, from 70 to 99 wt %, from 75 to 99 wt %, from 80 to 99 wt %, from 85 to 99 wt %, from 90 to 99 wt %, from 93 to 99 wt %, from 95 to 99 wt %, or from 97 to 99 wt % of the ungrafted ethylene-based polymer, based on the weight of the composition.

[0035] The composition may contain from 0.1 to 40 wt %, from 0.1 to 35 wt %, 0.1 to 30 wt %, from 0.1 to 25 wt %, from 0.1 to 20 wt %, from 0.1 to 15 wt %, from 0.1 to 10 wt %, from 1 to 7 wt %, or from 3 to 5 wt % of the nanocomposite, based on the weight of the composition.

[0036] The composition may contain from 0.1 to 15 wt %, from 0.1 to 10 wt %, from 1 to 15 wt %, or from 1 to 10 wt % of the compatibilizer, based on the weight of the composition.

[0037] In various embodiments, the composition includes an EVOH copolymer. In various other embodiments, the composition excludes an EVOH copolymer.

[0038] If included, the composition may contain from 0.1 to 30 wt %, from 0.1 to 25 wt %, from 0.1 to 20 wt %, from 0.1 to 15 wt %, from 0.1 to 10 wt %, or from 0.1 to 5 wt % of the EVOH copolymer, based on the weight of the composition.

[0039] The composition may further comprise additional polar polymers, such as a non-composited polyamide.

[0040] In various embodiments, the composition further comprises a non-composited polyamide.

[0041] If included, the composition may contain from 0.1 to 40 wt %, from 0.1 to 35 wt %, 0.1 to 30 wt %, from 0.1 to 25 wt %, from 0.1 to 20 wt %, from 0.1 to 15 wt %, from 0.1 to 10 wt %, or from 0.1 to 5 wt % of the non-composited polyamide, based on the weight of the composition.

[0042] In various embodiments, the ungrafted ethylene-based polymer, the non-composited polyamide, the EVOH copolymer, or combinations thereof may be sourced from post-industrial or post-consumer waste.

[0043] Post-industrial waste refers to manufacturing scrap, while post-consumer waste refers to waste produced by the end-user.

[0044] The inventive composition may contain one or more conventional additives in typical amounts. Examples of the additives include heat stabilizers, antioxidants, lubricants, antistatic agents, dispersants, plasticizers, flame retardants, viscosity enhancers, ultraviolet light absorbers, light stabilizers, slip agents, anti-blocking agents, dyes, pigments, and fillers.

[0045] The composition may be a concentrate/masterbatch or a fully formulated/compounded formulation.

[0046] The terms “masterbatch” and “concentrate” are used interchangeably. They refer to a composition that has a higher concentration of any component (e.g., the nanocomposite, EVOH, and/or compatibilizer) than a fully compounded or a fully formulated composition. The masterbatch can include a carrier resin. One or more of the ungrafted ethylene-based polymers may be used as the carrier resin. The masterbatch is typically diluted with a letdown resin to form the fully formulated composition. One or more of the ungrafted ethylene-based polymers may be used as the letdown resin. The letdown resin may be the same or different polymer than the carrier resin. The masterbatch can be formed by dry mixing and/or melt blending the components. The fully formulated composition is what is used to form a shaped object, such as a film.

[0047] The composition may be prepared by melt blending the ingredients by any suitable method, such as by single-screw extrusion, co- or counter-rotating twin-screw extrusion, batch mixers, and any combination thereof. The ingredients may be introduced in the form of pellet, shred, grind, regrind, fluff, scrap, or any combination thereof.

[0048] Alternatively, the composition may be prepared by passing a film or films (containing one or more of the composition ingredients) through film shredding equipment, such as an Erema plastic recycling system. One or more ingredients of the composition may enter the recycling system in film form and may exit in pellet form, grind form, fluff form, or any combination thereof.

[0049] The film(s) introduced into the plastic recycling system may be virgin, post-consumer recycled (PCR), post-industrial recycled (PIR), or any combination thereof.

[0050] In various embodiments, the composition comprises: [0051] (a) an ungrafted ethylene-based polymer; [0052] (b) a nanocomposite comprising a polyamide and montmorillonite; [0053] (c) a compatibilizer comprising a maleic anhydride grafted ethylene-based polymer; and [0054] (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.

[0055] In various embodiments, the composition comprises: [0056] (a) an ungrafted ethylene-based polymer; [0057] (b) a nanocomposite comprising a polyamide and montmorillonite; [0058] (c) a compatibilizer comprising a maleic anhydride grafted ethylene-methyl acrylate copolymer; and [0059] (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.

[0060] In various embodiments, the composition comprises: [0061] (a) an ungrafted ethylene-based polymer; [0062] (b) a nanocomposite comprising a polyamide and montmorillonite; [0063] (c) a compatibilizer comprising a maleic anhydride grafted ethylene-butyl acrylate copolymer; and [0064] (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.

#### Ethylene-Based Polymer

[0065] The terms “ethylene-based polymer” and “polyethylene” are used interchangeably herein. They refer to a polymer that contains more than 50 weight percent of polymerized ethylene monomer (based on the total amount of polymerizable monomers) and, optionally, may contain at least one comonomer. Ethylene-based polymer includes ethylene homopolymer and ethylene copolymers (meaning units derived from ethylene and one or more comonomers). Examples of ethylene-based polymer (polyethylene) include high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), very-low-density polyethylene

(VLDPE), VLDPE with long branches, and ultra-low-density polyethylene (ULDPE) (also known as plastomers).

[0066] Generally, polyethylene may be produced in gas-phase, fluidized-bed reactors; liquid-phase, slurry process reactors; or liquid-phase, solution process reactors, using a heterogeneous catalyst system, such as Ziegler-Natta catalyst; a homogeneous catalyst system comprising Group 4 transition metals; and ligand structures, such as metallocene, non-metallocene metal-centered, heteroaryl, heterovalent aryloxyether, phosphine-imine, and others. Combinations of heterogeneous and/or homogeneous catalysts may also be used in either single-reactor or dual-reactor configurations.

[0067] In various embodiments, the ethylene-based polymer includes HDPE, LDPE, LLDPE, VLDPE, ULDPE, or combinations thereof.

[0068] In various embodiments, the ethylene-based polymer includes LLDPE.

[0069] In various embodiments, the ethylene-based polymer has a melt index (I.sub.2) of 0.1 to 50 g/10 minutes, of 0.1 to 40 g/10 minutes, of 0.1 to 30 g/10 minutes, of 0.1 to 20 g/10 minutes, of 0.1 to 15 g/10 minutes, of 0.1 to 10 g/10 minutes, or of 0.1 to 5 g/10 minutes (measured according to ASTM D1238 at Condition 190/2.16).

### Polyamide

[0070] The terms “amide-based polymer” and “polyamide” are used interchangeably. They refer to a polymer that contains more than 50 percent of amide bonds between monomers and, optionally, may contain at least one other bond type. Amide-based polymers include homopolymers and copolymers (meaning more than one kind of monomer used to form the amide-based polymer). Examples of amide-based polymers (polyamides) include aliphatic and semi-aromatic. Examples of aliphatic polyamides include polycaprolactam, poly(hexamethylene adipamide), poly(hexamethylene succinimide), polylauro lactam, poly(11-aminoundecanoic acid), and poly(hexamethylene sebacimide). Examples of semi-aromatic polyamides include poly(hexamethylene terephthalamide), poly(hexamethylene isophthalamide), and polymers utilizing both terephthalic acid and isophthalic acid along with an aliphatic diamine.

[0071] The polyamide may be nylon 4.6, nylon 6, nylon 6.6, nylon 6.10, nylon 7, nylon 8, nylon 9, nylon 11, nylon 12, nylon 46, MXD6, amorphous polyamide, a copolymerized polyamide containing at least two of these, or a mixture of at least two of these.

[0072] Amorphous polyamide refers to a polyamide having insufficient crystallinity, that is, not having an endothermic crystalline melting peak when measured by differential scanning calorimetry (DSC) (ASTM D-3417, 10° C./min).

[0073] In general, the polyamide can be prepared using diamine and dicarboxylic acid. Examples of the diamine include hexamethylenediamine, 2-methylpentamethylenediamine, 2,2,4-trimethylhexamethylenediamine, 2,4,4-trimethylhexamethylenediamine, bis(4-aminocyclohexyl) methane, 2,2-bis(4-aminocyclohexyl) isopropylidene, 1,4-diaminocyclohexane, 1,3-diaminocyclohexane, meta-xylenediamine, 1,5-diaminopentane, 1,4-diaminobutane, 1,3-diaminopropane, 2-ethyldiaminobutane, 1,4-diaminomethylcyclohexane, methane-xylenediamine, alkyl-substituted or unsubstituted m-phenylenediamine and p-phenylenediamine, etc. Examples of the dicarboxylic acid include alkyl-substituted or unsubstituted isophthalic acid, terephthalic acid, adipic acid, sebacic acid, butanedicarboxylic acid, etc.

[0074] Polyamide prepared using an aliphatic diamine and an aliphatic dicarboxylic acid is generally semicrystalline polyamide. The semicrystalline polyamide is generally prepared using lactam, such as nylon 6 or nylon 11, or an amino acid, but may also be prepared by condensing a diamine, such as hexamethylenediamine, with a dibasic acid, such as succinic acid, adipic acid, or sebacic acid. The polyamide may be a copolymer or a terpolymer such as a copolymer of hexamethylenediamine/adipic acid and caprolactam (nylon 6,66). A mixture of two or more semicrystalline polyamides can also be used.

[0075] Amorphous polyamide is typically obtained when either diamine or dicarboxylic acid is

aromatic, and the other is aliphatic. Examples of aliphatic groups of the amorphous polyamide include C.sub.1-C.sub.15 aliphatic or C.sub.4-C.sub.8 alicyclic alkyls. Examples of aromatic groups of the amorphous polyamide include substituted C.sub.1-C.sub.6 mono- or bicyclic aromatic groups.

[0076] Examples of amorphous polyamides include hexamethylenediamine isophthalamide, a mixture of 2,2,4- and 2,4,4-trimethylhexamethylenediamine terephthalamide, a copolymer of hexamethylenediamine or 2-methylpentamethylenediamine and an isophthalic acid, terephthalic acid, or mixtures thereof.

[0077] The semicrystalline and amorphous polyamides may be prepared by condensation polymerization, as well-known in the art.

[0078] In various embodiments, the polyamide includes nylon 4.6, nylon 6, nylon 6.6, nylon 6.10, nylon 6.12, nylon 11, nylon 12, amorphous nylon, or combinations thereof. In various embodiments, the polyamide includes nylon 6.

#### Montmorillonite

[0079] The other component of the nanocomposite is montmorillonite.

[0080] Montmorillonite is a very soft phyllosilicate group of minerals that form when they precipitate from water solution as microscopic crystals, known as clay. Montmorillonite is a 2:1 clay, meaning that it has two tetrahedral sheets of silica sandwiching a central octahedral sheet of alumina. The particles are plate-shaped with average dimension of 1 nm thick and 70-150 nm wide. Chemically, it is hydrated sodium calcium aluminum magnesium silicate hydroxide (Na,Ca).sub.0.33(Al,Mg).sub.2(Si.sub.4O.sub.10)(OH).sub.2.Math.nH.sub.2O. Potassium, iron, and other cations are common substitutes, and the exact ratio of cations varies with the source.

[0081] The clay may or may not be modified with organic compounds having polar or ionic pendants, such as quaternary ammonium, phosphonium, maleate, succinate, acrylate, benzylic hydrogen, and oxazoline. If used, the content of the organic material may range from 1 to 45 wt %, based on the weight of the clay.

[0082] The clay layers can have a thickness of 1 to 100 nm and a length of 20 to 1000 nm. The clay's unit cell charge may vary from 0.3 to 0.8. The surface area of this material may vary from 400 to 1000 m.sup.2/g.

#### Nanocomposite

[0083] The clay may be incorporated into the polyamide to form the nanocomposite using any suitable method, such as solid-melt blending, suspension-liquid feeding, solution-liquid feeding, or may be added during synthesis of the polyamide. The preferred method of incorporation is addition during synthesis of the polyamide.

[0084] The nanocomposite may contain from 1 to 20 wt %, or from 2 to 8 wt % of montmorillonite, based on the weight of the nanocomposite.

[0085] The nanocomposite may contain from 80 to 99 wt %, or from 92 to 98 wt % of polyamide, based on the weight of the nanocomposite.

#### EVOH

[0086] The composition optionally further comprises an ethylene-vinyl alcohol (EVOH) copolymer.

[0087] The EVOH copolymer may have an ethylene content ranging from 25 to 50 mol %, or from 27 to 44 mol % of ethylene, based on the total moles of the EVOH copolymer.

#### Compatibilizer

[0088] A compatibilizer is typically used to improve the compatibility of a non-polar polymer, such as a polyolefin, with a polar polymer, such as polyamide and ethylene-vinyl alcohol (EVOH) copolymer.

[0089] Examples of compatibilizers include an epoxy-modified polystyrene copolymer, an ethylene-(meth)acrylate copolymer, an ethylene-alkyl (meth)acrylate copolymer (such as ethylene-methyl acrylate copolymer (block or random) and ethylene-butyl acrylate copolymer (block or

random)), an ethylene-vinyl acetate copolymer, and combinations thereof.

[0090] Additional examples of compatibilizers include anhydride and/or carboxylic acid functionalized ethylene-based polymers. Examples of anhydride and/or carboxylic acid functional groups include acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, citraconic acid, maleic anhydride, tetrahydrophthalic anhydride, norborn-5-ene-2,3-dicarboxylic acid anhydride, nadic anhydride, and himic anhydride. Maleic anhydride is preferred.

[0091] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-based polymer.

[0092] Examples of maleic anhydride grafted ethylene-based polymers include maleic anhydride grafted HPDE, maleic anhydride grafted LPDE, maleic anhydride grafted LLPDE, maleic anhydride grafted VLPDE, maleic anhydride grafted ULDPE, maleic anhydride grafted ethylene-(meth)acrylate copolymer, maleic anhydride grafted ethylene-alkyl (meth)acrylate copolymer (such as maleic anhydride grafted ethylene-methyl acrylate copolymer (block or random) and maleic anhydride grafted ethylene-butyl acrylate copolymer (block or random)), maleic anhydride grafted ethylene-vinyl acetate copolymer, or combinations thereof.

[0093] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-hexene copolymer.

[0094] In various embodiments, the maleic anhydride grafted ethylene-hexene copolymer has a density of 0.905 to 0.910 g/cm<sup>3</sup>.

[0095] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ULDPE.

[0096] In various embodiments, the maleic anhydride grafted ULDPE has a density of less than 0.880 g/cm<sup>3</sup>.

[0097] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-methyl acrylate copolymer.

[0098] In various embodiments, the maleic anhydride grafted ethylene-methyl acrylate copolymer comprises from 15 to 25 wt % of methyl acrylate, based on the weight of the ethylene-methyl acrylate copolymer.

[0099] In various embodiments, the compatibilizer comprises a maleic anhydride grafted ethylene-butyl acrylate copolymer.

[0100] In various embodiments, the maleic anhydride grafted ethylene-butyl acrylate copolymer comprises from 18 to 24 wt % of butyl acrylate, based on the weight of the ethylene-butyl acrylate copolymer.

[0101] The functionalized ethylene-based polymer may contain from 0.1 to 3.0 wt %, from 0.5 to 2.5 wt %, from 0.5 to 2.0 wt %, or from 1.0 to 2.0 wt % of the anhydride and/or carboxylic acid functional group, based on the weight of the functionalized ethylene-based polymer.

[0102] In various embodiments, the compatibilizer has a melt index of 0.5 to 1,500 g/10 min, of 0.5 to 1,000 g/10 min, of 30 to 1,000 g/10 min, or of 30 to 500 g/10 min (measured according to ASTM D1238 at Condition 190/2.16).

#### Films

[0103] The compositions of the invention are particularly suitable for making films, particularly flexible films for packaging.

[0104] Thus, in a second aspect, the invention provides a film, particularly a blown film, comprising the compositions described herein.

[0105] In various embodiments, the film is a flexible film.

[0106] The film may be single-layer or multilayer.

[0107] In various embodiments, the film is a single-layer blown film.

[0108] In various other embodiments, the film is a multilayer blown film.

[0109] In the case of a multilayer film, one or more layers may contain the compositions of the invention.

[0110] The film may have a thickness in the range of 5 to 250  $\mu\text{m}$ , or 5 to 125  $\mu\text{m}$ .

## Method of Making Film

[0111] The films according to the invention may be made by blown-film extrusion.

[0112] Thus, in a third aspect, the invention provides a method of making a blown film. The method includes the steps of: [0113] (a) extruding a polymeric melt through an annular die to form a tube of polymer; [0114] (b) injecting air into the tube; and [0115] (c) cooling the tube to obtain the blown film, [0116] wherein the polymeric melt comprises the compositions according to the invention.

[0117] In the extrusion step, resin pellets (or other suitable forms of the ingredients) are typically gravity fed into a heated barrel of an extruder. The pellets are conveyed down the barrel by a screw that first compacts and then melts the pellets through shear-induced heat. The last section of the screw, also known as the metering section, ensures a homogeneous melt and uniform output.

[0118] Next, the polymer melt is forced through a tubular-shaped (or annular) die. After exiting the die, the molten tube of polymer is injected with air and generally pulled upward by a set of nip rolls, although in some cases, it can be pulled horizontally or downward. As film thickness is reduced, the tube expands because of internal bubble pressure and forms a tube of larger diameter. Air rings aid in film cooling by supplying air flow around the molten tube. The tube is then drawn down to a desired final film thickness, for example, in the range of 5 to 250  $\mu\text{m}$ , or from 10 to 125  $\mu\text{m}$ .

## General Provisions

[0119] To remove any doubt, the present invention includes and expressly contemplates and discloses any and all combinations of embodiments, features, characteristics, parameters, and/or ranges mentioned herein. That is, the subject matter of the present invention may be defined by any combination of embodiments, features, characteristics, parameters, and/or ranges mentioned herein.

[0120] It is contemplated that any ingredient, component, or step that is not specifically named or identified as part of the present invention may be explicitly excluded.

[0121] Any process/method, apparatus, compound, composition, embodiment, or component of the present invention may be modified by the transitional terms “comprising,” “consisting essentially of,” or “consisting of,” or variations of those terms.

[0122] As used herein, the indefinite articles “a” and “an” mean one or more, unless the context clearly suggests otherwise. Similarly, the singular form of nouns includes their plural form, and vice versa, unless the context clearly suggests otherwise.

[0123] While attempts have been made to be precise, the numerical values and ranges described herein may be considered approximations. These values and ranges may vary from their stated numbers depending upon the desired properties sought to be obtained by the present disclosure as well as the variations resulting from the standard deviation found in the measuring techniques. Moreover, the ranges described herein are intended and specifically contemplated to include all sub-ranges and values within the stated ranges. For example, a range of 50 to 100 is intended to include all values within the range including sub-ranges such as 60 to 90, 70 to 80, etc.

[0124] Any two numbers of the same property or parameter reported in the working examples may define a range. Those numbers may be rounded off to the nearest thousandth, hundredth, tenth, whole number, ten, hundred, or thousand to define the range.

[0125] The content of all documents cited herein, including patents as well as non-patent literature, is hereby incorporated by reference in their entirety. To the extent that any incorporated subject matter contradicts with any disclosure herein, the disclosure herein shall take precedence over the incorporated content.

[0126] This invention can be further illustrated by the following working examples, although these examples are included merely for purposes of illustration and are not intended to limit the scope of the invention.

## EXAMPLES

### Analytical Methods



[0127] Gloss at 45° was measured according to ASTM D-2457. [0128] Haze was measured according to ASTM D-1003. [0129] Tensile strength, tensile toughness, elongation, and secant modulus were measured according to ASTM D-882. [0130] Puncture resistance was measured according to ASTM D-5748. [0131] Dart impact strength was measured according to ASTM D-1709 method A. [0132] Elmendorf tear was measured according to ASTM D-1922.

#### Example 1—Control

##### Preparation of Polyethylene (PE) Film

[0133] 100% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>) was added to the feed of a monolayer film blowing line. The extrusion barrel temperature set point was 325° F. in zone 1, 450° F. in zone 2, 450° F. in zone 3, 420° F. in zone 4, 420° F. in zone 5, and 450° F. in all die zones. The screw speed was between 62 and 96 rpm, the melt pressure was between 1,848 and 2,399 psi, the nip pressure was 45 psi, the air temp was 58° F., the film speed was 110 fpm (feet per minute), the bubble height was 15' (feet), the bubble width was 22.5" (inches), and the film thickness was 1.4 to 1.6 mils. The die gap was 100 mil, and the blow-up ratio was 2.5:1. The output of the process was 170 lbs/hr.

[0134] This film was then subjected to testing for packing film properties. The results are reported in Table 1 below.

#### Example 2—Inventive

##### Preparation of PE Film Containing Nanocomposite and Compatibilizer (RETAIN®)

[0135] 55% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>), 30% (wt./wt.) of a polyamide 6 nanocomposite (Domo Chemical 1300 IF 102.3), 10% (wt./wt.) of an ethylene-vinyl alcohol copolymer (Kuraray EVAL F104B), and 5% (wt./wt.) of a maleated polyethylene copolymer compatibilizer (Dow RETAIN® 3000 having a melt index of 660 g/10 min. and a density of 0.870 g/cm<sup>3</sup> and containing 1.4 wt % of grafted maleic anhydride) were added in pellet form to a twin-screw extruder and melt blended to form a concentrate. The extrusion barrel temperature set point was 150° C. in zone 1, 200° C. in zone 2, 205° C. in zone 3, 245° C. in zone 4, 250° C. in zone 5 through zone 10, 240° C. in zone 11, 215° C. in zone 12, and 215° C. at the die. The screw speed was 275 RPM (revolutions per minute) with a 25 SCFH (Standard Cubic Foot per Hour) nitrogen purge rate and a total output of 12.5 pounds per hour. The melt blend concentrate was pelletized for further processing.

[0136] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were added to the feed of a monolayer film blowing line as a pellet blend to form a blown film. The film blowing line was operated at the same conditions as Example 1.

[0137] This film was then subjected to testing for packing film properties. The results are reported in Table 1 below.

#### Example 3—Comparative

##### Preparation of PE Film Containing Nylon and Compatibilizer (RETAIN®)

[0138] Pellets of a concentrate containing 55% (wt./wt.) of a linear low-density polyethylene (HIFOR® LF2020AA), 30% (wt./wt.) of a polyamide 6 without nanoparticles (Domo Chemical Domamide H40 F), 10% (wt./wt.) of an ethylene-vinyl alcohol copolymer (Kuraray EVAL F104B), and 5% (wt./wt.) of a maleated polyethylene copolymer compatibilizer (Dow RETAIN® 3000) were prepared using the procedure and conditions of Example 2.

[0139] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were pellet blended and formed into a monolayer blown film using the procedure and conditions of Example 1.

[0140] This film was then subjected to testing for packing film properties. The results are reported in Table 1 below.

#### Example 4—Inventive

##### Preparation of PE Film Containing Nanocomposite and Compatibilizer (Mal-EMAC®)

[0141] Pellets of a concentrate containing 55% (wt./wt.) of a linear low-density polyethylene (HIFOR® LF2020AA), 30% (wt./wt.) of a polyamide 6 nanocomposite (Domo Chemical 1300 IF 102.3), 10% (wt./wt.) of an ethylene-vinyl alcohol copolymer (Kuraray EVAL F104B), and 5% (wt./wt.) of a maleated ethylene-methyl acrylate copolymer compatibilizer (melt index of 600 g/10 min., 24 wt % methyl acrylate, and 1.4 wt % of grafted maleic anhydride) were prepared using the procedure and conditions of Example 2.

[0142] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were pellet blended and formed into a monolayer blown film using the procedure and conditions of Example 1.

[0143] This film was then subjected to testing for packing film properties. The results are reported in Table 1 below.

#### Example 5—Comparative

##### Preparation of PE Film Containing Nylon and Compatibilizer (Mal-EMAC®)

[0144] Pellets of a concentrate containing 55% (wt./wt.) of a linear low-density polyethylene (HIFOR® LF2020AA), 30% (wt./wt.) of a polyamide 6 without nanoparticles (Domo Chemical Domamide H40 F), 10% (wt./wt.) of an ethylene-vinyl alcohol copolymer (Kuraray EVAL F104B), and 5% (wt./wt.) of a maleated ethylene-methyl acrylate copolymer compatibilizer (melt index of 600 g/10 min., 24 wt % methyl acrylate, and 1.4 wt % of grafted maleic anhydride) were prepared using the procedure and conditions of Example 2.

[0145] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were pellet blended and formed into a monolayer blown film using the procedure and conditions of Example 1.

[0146] This film was then subjected to testing for packing film properties. The results are reported in Table 1 below.

| TABLE-US-00001 TABLE 1 |    |    |    |      |   |   |    |   |    | Ex. 1 | Ex. 2 | Ex. 3 | Ex. 4 | Ex. 5 | Concentrate Comp. (wt %) | LLDPE —   |
|------------------------|----|----|----|------|---|---|----|---|----|-------|-------|-------|-------|-------|--------------------------|---|
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Nanocomposite   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | EVOH —  |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 10 10 10 10 mal-  |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | PE —  |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 5 5 — — mal-EMAC® — — — 5 5   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Film Comp. (wt. %) Concentrate — 35 35 35 35                              |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | LLDPE 100 65 65 65 65   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Film Thickness 1.4 1.5 1.4 1.5 1.6 (mil)                                  |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Optical Properties Gloss at 45°   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 45.5 9.2 11.6 20 16.5   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Haze (%) 14.3 69.5 68.6 39.5 51.6   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Tensile Strength (psi) At Break TD 6268                                   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 4142 2971 4201 2469 MD 6245 5381 5054 5784 3944                           |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | At Yield TD 1586 1744 1371 1976 1334                                      |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | MD 1542 1886 1732 1996 1531   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Tensile Toughness (ft-lbs/in.sup.3) TD 2295 1933 1300 1852 1058           |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | MD 2617 2374 2202 2574 1732   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Elongation (%) TD 1047 1011 856 941 790                                   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | MD 1026 943 886 958   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 839 Secant Modulus (psi) TD 35100 34800 36200 48100 30600                 |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | MD 30900 44900 34300 37300  |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 34900 Puncture Resistance Force per mil 8.44 5.93 5.56 6.21 2.7 (lbs/mil) |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Load at Break 11.82 8.9   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 8.35 7.45 4.05 (lbs) Energy to Break 4.54 2.1 1.85 1.82 1.75 (in-lbs)     |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Penetration 4.24 2.7 2.45 2.5   |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 2.4 (inches) Dart Impact 152 161 116 136 85                               |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | Strength (F50) (g) Elmendorf Tear (g) TD 887 941                          |
| 55                     | 55 | 55 | 55 | PA 6 | — | — | 30 | — | 30 | PA 6  | —     | 30    | —     | 30    | —                        | 722 1125 988 MD 531 509 340 473 341                                       |

[0147] As seen in Table 1, the film containing the nylon nanocomposite and the RETAIN® compatibilizer (Example 2) had comparable optical properties, but better mechanical properties (e.g., tensile strength, tensile toughness, elongation, dart impact, and Elmendorf tear) than the corresponding film without the nylon nanocomposite (Example 3). The film containing the nylon nanocomposite and the mal-EMAC® compatibilizer (Example 4) had better optical (e.g., gloss and haze) and mechanical properties (e.g., tensile strength, tensile toughness, elongation, Secant modulus, puncture resistance, dart impact, and Elmendorf tear) than the corresponding film without the nylon nanocomposite (Example 5). And surprisingly, the film containing the mal-EMAC® compatibilizer (Example 4) had better optical properties than the corresponding film with the RETAIN® compatibilizer (Example 2), both with and without the nylon nanocomposite.

#### Example 6—Control

#### Preparation of PE Film

[0148] 100% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>) was added to the feed of a monolayer film blowing line. The extrusion barrel temperature set point was 325° F. in zone 1, 450° F. in zone 2, 450° F. in zone 3, 420° F. in zone 4, 420° F. in zone 5, and 450° F. in all die zones. The screw speed was between 61 and 65 rpm, the melt pressure was between 1,861 and 2,470 psi, the nip pressure was 50 psi, the air temperature was 53-54° F., the film speed was 123-156 fpm (feet per minute), the bubble height was 19' (feet), the bubble width was 22.5" (inches), and the film thickness was between 1.25 and 1.45 mil. The die gap was 100 mil, and the blow-up ratio was 2.5:1. The output of the process was 170 lbs/hr.

[0149] This film was then subjected to testing for packing film properties. The results are reported in Table 2 below.

#### Example 7—Comparative

##### Preparation of PE Film Containing Nylon and Compatibilizer (RETAIN®)

[0150] 65% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>), 30% (wt./wt.) of a polyamide 6 without nanoparticles (BASF B40), and 5% (wt./wt.) of a maleated polyethylene copolymer compatibilizer (Dow RETAIN® 3000 having a melt index of 660 g/10 min. and a density of 0.870 g/cm<sup>3</sup> and containing 1.4 wt % of grafted maleic anhydride) were added in pellet form to a 40 mm twin-screw extruder and melt blended to form a concentrate. The extrusion barrel temperature set point was 245° C. in zone 2 through zone 12 and 245° C. at the die. The screw speed was 250 RPM (revolutions per minute) with a 25 SCFH (Standard Cubic Foot per Hour) nitrogen purge rate and a total output of 80 pounds per hour. The melt blend concentrate was pelletized for further processing.

[0151] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were added to the feed of a monolayer film blowing line as a pellet blend to form a blown film. The film blowing line was operated at the same conditions as Example 6.

[0152] This film was then subjected to testing for packing film properties. The results are reported in Table 2 below.

#### Example 8—Inventive

##### Preparation of PE Film Containing Nanocomposite and Compatibilizer (RETAIN®)

[0153] Pellets of a concentrate containing 65% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>), 30% (wt./wt.) of a polyamide 6 nanocomposite (Domo Chemical 1300 IF 102.3), and 5% (wt./wt.) of a maleated polyethylene copolymer compatibilizer (Dow RETAIN® 3000) were prepared using the procedure and conditions of Example 7.

[0154] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were added to the feed of a monolayer film blowing line as a pellet blend to form a blown film. The film blowing line was operated at the same conditions as Example 6.

[0155] This film was then subjected to testing for packing film properties. The results are reported in Table 2 below.

#### Example 9—Comparative

##### Preparation of PE Film Containing Nylon and Compatibilizer (Mal-EMAC®)

[0156] Pellets of a concentrate containing 65% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>), 30% (wt./wt.) of a polyamide 6 without nanoparticles (BASF B40), and 5% (wt./wt.) of a maleated ethylene-methyl acrylate copolymer compatibilizer (melt index of 600 g/10 min., 24 wt % methyl acrylate, and 1.4 wt % of grafted maleic anhydride) were prepared using the

procedure and conditions of Example 7.

[0157] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were added to the feed of a monolayer film blowing line as a pellet blend to form a blown film. The film blowing line was operated at the same conditions as Example 6.

[0158] This film was then subjected to testing for packing film properties. The results are reported in Table 2 below.

### Example 10—Inventive

## Preparation of PE Film Containing Nanocomposite and Compatibilizer (Mal-EMAC®)

[0159] Pellets of a concentrate containing 65% (wt./wt.) of a linear low-density polyethylene (Westlake Chemical HIFOR® LF2020AA having a melt index of 1.0 g/10 min. and density of 0.919 g/cm<sup>3</sup>), 30% (wt./wt.) of a polyamide 6 nanocomposite (Domo Chemical 1300 IF 102.3), and 5% (wt./wt.) of a maleated ethylene-methyl acrylate copolymer compatibilizer (melt index of 600 g/10 min., 24 wt % methyl acrylate, and 1.4 wt % of grafted maleic anhydride) were prepared using the procedure and conditions of Example 7.

[0160] 35% (wt./wt.) of the resulting concentrate pellets and 65% (wt./wt.) of the linear low-density polyethylene resin (HIFOR® LF2020AA) were added to the feed of a monolayer film blowing line as a pellet blend to form a blown film. The film blowing line was operated at the same conditions as Example 6.

[0161] This film was then subjected to testing for packing film properties. The results are reported in Table 2 below.

|                     |               |                |                                     |        |               |        |                        |                    |                    |              |
|---------------------|---------------|----------------|-------------------------------------|--------|---------------|--------|------------------------|--------------------|--------------------|--------------|
| TABLE-US-00002      | TABLE 2       | Ex. 6          | Ex. 7                               | Ex. 8  | Ex. 9         | Ex. 10 | Concentrate            | Comp.              | (wt %)             | LLDPE —      |
| 65                  | 65            | 65             | 65                                  | PA 6 — | 30            | 0      | 30                     | 0                  | PA 6 —             | 0            |
| 30                  | 0             | 30             | 0                                   | 30     | Nanocomposite | EVOH — | 0                      | 0                  | 0                  | 0            |
| mal-PE —            | 5             | 5              |                                     |        |               |        |                        |                    |                    |              |
| 0                   | 0             | mal-EMAC ® —   | 0                                   | 0      | 5             | 5      | Film Comp.             | (wt. %)            | Concentrate —      | 35           |
| 35                  | 35            | 35             | 35                                  | LLDPE  | 100           | 65     | 65                     |                    |                    |              |
| 65                  | 65            | Film Thickness | 1.1                                 | 1.4    | 1.3           | 1.3    | 1.2                    | (mil)              | Optical Properties | Gloss at 45° |
| 47.9                | 6.9           | 17.1           | 8.5                                 |        |               |        |                        |                    |                    |              |
| 22.1                | Haze (%)      | 17.6           | 78                                  | 38.1   | 83.9          | 30.3   | Tensile Strength (psi) | At Break           | TD                 | 5095         |
| 2189                | 3769          | 2345           |                                     |        |               |        |                        |                    |                    |              |
| 4198                | MD            | 6819           | 3912                                | 4796   | 3456          | 6195   | At Yield               | TD                 | 1636               | 1525         |
| 1649                | 1554          | 1855           | MD                                  | 1672   | 3982          |        |                        |                    |                    |              |
| 1758                | 3511          | 2066           | Tensile Toughness (ft-lbs/in.sup.3) | TD     | 2229          | 878    | 1611                   | 933                | 1755               | MD           |
| 2413                | 1560          |                |                                     |        |               |        |                        |                    |                    |              |
| 1740                | 1168          | 2315           | Elongation (%)                      | TD     | 1073          | 580    | 935                    | 646                | 931                | MD           |
| 886                 | 727           | 788            | 619                                 | 842    | Secant        |        |                        |                    |                    |              |
| Modulus (psi)       | TD            | 41300          | 46000                               | 55500  | 45100         | 50100  | MD                     | 39900              | 58700              | 49300        |
| 44700               | 41700         |                |                                     |        |               |        |                        |                    |                    |              |
| Puncture Resistance | Force per mil | 9.48           | 2.04                                | 6.1    | 1.94          | 6.89   | (lbs/mil)              | Load at Break      | 10.43              | 2.66         |
| 7.93                |               |                |                                     |        |               |        |                        |                    |                    |              |
| 2.52                | 8.27          | (lbs)          | Energy to Break                     | 3.44   | 0.76          | 2.2    | 0.65                   | 2.7                | (in-lbs)           | Penetration  |
| 4.49                | 1.6           | 3.03           | 1.59                                | 3.04   |               |        |                        |                    |                    |              |
| (inches)            | Dart Impact   | 148            | 110                                 | 133    | 127           | 158    | Strength (F50) (g)     | Elmendorf Tear (g) | TD                 | 796          |
| 747                 | 872           |                |                                     |        |               |        |                        |                    |                    |              |
| 656                 | 869           | MD             | 446                                 | 365    | 573           | 263    | 478                    |                    |                    |              |

[0162] As seen in Table 2, the film containing the nylon nanocomposite and the RETAIN® compatibilizer (Example 8) had better optical and mechanical properties (e.g., tensile strength, tensile toughness, elongation, dart impact, and Elmendorf tear) than the corresponding film without the nylon nanocomposite (Example 7). Similarly, the film containing the nylon nanocomposite and the mal-EMAC® compatibilizer (Example 10) had better optical (e.g., gloss and haze) and mechanical properties (e.g., tensile strength, tensile toughness, elongation, Secant modulus, puncture resistance, dart impact, and Elmendorf tear) than the corresponding film without the nylon nanocomposite (Example 9). And surprisingly, the films containing the mal-EMAC® compatibilizer (Examples 9 and 10) had comparable optical properties and better mechanical properties than the corresponding film with the RETAIN® compatibilizer (Examples 7 and 8), both with and without the nylon nanocomposite.

## Optical Microscopy Analysis

[0163] The films from Examples 2-5 and 7-10 were also analyzed by optical microscopy.

[0164] The films were cut and placed between precleaned microslides made of Swiss glass with dimensions 25×75×1 mm. A Keyence VHX-2000E optical microscope with a VH-Z100R/W/T lens was employed for imaging. Software interface was VHX-2000 version 2.3.5.1. The permissible

magnification for this lens was 100-1000×. The micrographs were captured at 200× magnification (unless otherwise noted) in reflectance mode.

[0165] Three representative micrographs are shown for each composition in FIGS. 1-8, respectively.

[0166] For each composition, micrograph labeled (A) is representative of voids or unmelts, micrograph (B) is representative of gels, and micrograph labeled (C) is representative of immiscibility within the film.

[0167] Voids could be a physical opening in the film. Gels could be globs of likely dissimilar material thicker than surrounding film. Gels pose an obstruction to normal deformation by acting as stress concentration points. Immiscibility could be observed as surface roughness or inhomogeneity.

[0168] As seen in FIGS. 1A-1C (nanocomposite and RETAIN® compatibilizer (Example 2)), the microscopic images show a significant number of gels, immiscible phases, and some voids within the film.

[0169] FIG. 1D is an enlarged view of area X from FIG. 1A. It shows a large void in the film.

[0170] As seen in FIGS. 2A-2C (nylon and RETAIN® compatibilizer (Example 3)), the microscopic images show an excessive and detrimental number of unmelts (which were originally thought to be voids), gels, and immiscible phases within the film.

[0171] As seen in FIGS. 3A-3C (nanocomposite and mal-EMAC® compatibilizer (Example 4)), the microscopic images show no observable voids or immiscible phases, and an insignificant presence of only small gels.

[0172] As seen in FIGS. 4A-4C (nylon and mal-EMAC® compatibilizer (Example 5)), the microscopic images show an excessive and detrimental extent of unmelts (which were originally thought to be voids) and gels. While not to a similar extent as the composition in Example 3, immiscibility was also observed.

[0173] Of the four (Examples 2-5), the film with the nanocomposite and the mal-EMAC® compatibilizer (Example 4) showed the best of microscopic appearance.

[0174] FIG. 5A was obtained at 100× magnification, and FIGS. 5B and 5C were obtained at 200× magnification. As seen in FIGS. 5A-5C (nylon and RETAIN® compatibilizer (Example 7)), the microscopic images show no detectable voids, but huge unmelts, a high number of gels, and poor miscibility.

[0175] As seen in FIGS. 6A-6C (nanocomposite and RETAIN® compatibilizer (Example 8)), the microscopic images show no detectable voids, but huge unmelts, a considerable number of small and big gels, and average miscibility.

[0176] As seen in FIGS. 7A-7C (nylon and mal-EMAC® compatibilizer (Example 9)), the microscopic images show no detectable voids, but huge unmelts, a small number of gels, and poor miscibility.

[0177] As seen in FIGS. 8A-8C (nanocomposite and mal-EMAC® compatibilizer (Example 10)), the microscopic images show no detectable voids, some small gels, and good miscibility.

[0178] Among Examples 7-10, the film with the nanocomposite and the mal-EMAC® compatibilizer (Example 10) appeared the best by a large extent, followed by the film with the nanocomposite and the RETAIN® compatibilizer (Example 8), then the film with the nylon and the mal-EMAC® compatibilizer (Example 9), and then the film with the nylon and the RETAIN® compatibilizer (Example 7).

[0179] The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be made within the spirit and scope of the invention.

## Claims

1. A composition for forming a blown film, the composition comprising: (a) an ungrafted ethylene-based polymer; (b) a nanocomposite comprising a polyamide and montmorillonite; (c) a compatibilizer comprising a maleic anhydride grafted ethylene-methyl acrylate copolymer, a maleic anhydride grafted ethylene-butyl acrylate copolymer, or both; and (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.
2. The composition of claim 1, wherein the ungrafted ethylene-based polymer comprises high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), very-low-density polyethylene (VLDPE), ultra-low-density polyethylene (ULDPE), or combinations thereof.
3. The composition of claim 1, wherein the ungrafted ethylene-based polymer has a melt index of 0.1 to 50 g/10 min.
4. The composition of claim 1, wherein the ungrafted ethylene-based polymer comprises LLDPE.
5. The composition of claim 1, wherein the polyamide comprises nylon 4.6, nylon 6, nylon 6.6, nylon 6.10, nylon 6.12, nylon 11, nylon 12, amorphous nylon, or combinations thereof.
6. The composition of claim 1, wherein the polyamide comprises nylon 6.
7. The composition of claim 1, which comprises 70 to 99 wt % of the ungrafted ethylene-based polymer.
8. The composition of claim 1, which comprises 1 to 40 wt % of the nanocomposite.
9. The composition of claim 1, which comprises 0.1 to 15 wt % of the compatibilizer.
10. The composition of claim 1, which excludes an EVOH copolymer.
11. A blown film comprising the composition of claim 1.
12. A method of making a blown film, the method comprising: (a) extruding a polymeric melt through an annular die to form a tube of polymer; (b) injecting air into the tube; and (c) cooling the tube to obtain the blown film, wherein the polymeric melt comprises the composition of claim 1.
13. A blown film made from a composition comprising: (a) an ungrafted ethylene-based polymer; (b) a nanocomposite comprising a polyamide and montmorillonite; (c) a compatibilizer comprising a maleic anhydride grafted ethylene-based polymer; and (d) optionally, an ethylene-vinyl alcohol (EVOH) copolymer.
14. The blown film of claim 13, wherein the ungrafted ethylene-based polymer comprises high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), very-low-density polyethylene (VLDPE), ultra-low-density polyethylene (ULDPE), or combinations thereof.
15. The blown film of claim 13, wherein the ungrafted ethylene-based polymer has a melt index of 0.1 to 50 g/10 min.
16. The blown film of claim 13, wherein the ungrafted ethylene-based polymer comprises LLDPE.
17. The blown film of claim 13, wherein the polyamide comprises nylon 4.6, nylon 6, nylon 6.6, nylon 6.10, nylon 6.12, nylon 11, nylon 12, amorphous nylon, or combinations thereof.
18. The blown film of claim 13, wherein the polyamide comprises nylon 6.
19. The blown film of claim 13, wherein the compatibilizer comprises a maleic anhydride grafted HDPE, a maleic anhydride grafted LDPE, a maleic anhydride grafted LLDPE, a maleic anhydride grafted VLDPE, a maleic anhydride grafted ULDPE, a maleic anhydride grafted ethylene-(meth)acrylate copolymer, a maleic anhydride grafted ethylene-alkyl (meth)acrylate copolymer (e.g., maleic anhydride grafted ethylene-methyl acrylate copolymer (block or random) and maleic anhydride grafted ethylene-butyl acrylate copolymer (block or random)), a maleic anhydride grafted ethylene-vinyl acetate copolymer, or combinations thereof.
20. The blown film of claim 13, wherein the compatibilizer comprises a maleic anhydride grafted ULDPE.
21. The blown film of claim 13, wherein the compatibilizer comprises a maleic anhydride grafted ethylene-methyl acrylate copolymer (block or random) or a maleic anhydride grafted ethylene-

butyl acrylate copolymer (block or random).

22. The blown film of claim 13, wherein the compatibilizer has a melt index of 30 to 1,000 g/10 min.

23. The blown film of claim 13, which comprises 70 to 99 wt % of the ungrafted ethylene-based polymer.

24. The blown film of claim 13, which comprises 1 to 15 wt % of the nanocomposite.

25. The blown film of claim 13, which comprises 0.1 to 15 wt % of the compatibilizer.

26. The blown film of claim 13, which excludes an EVOH copolymer.

27. A method of making the blown film of claim 13, the method comprising: (a) extruding a polymeric melt through an annular die to form a tube of polymer; (b) injecting air into the tube; and (c) cooling the tube to obtain the blown film.

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