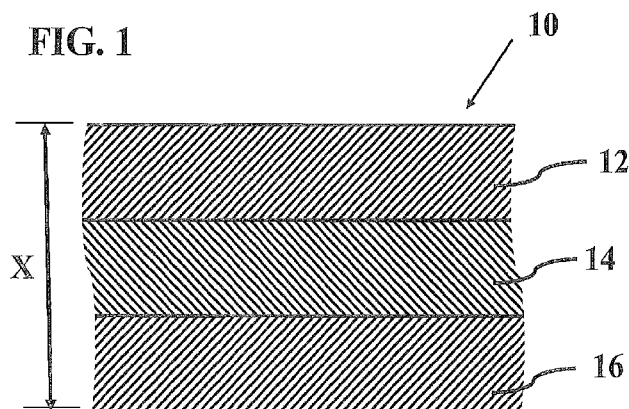




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(54) Title: METHODS OF IMPROVING POLYETHYLENE STRETCH FILMS



(57) Abstract: Methods of improving polyethylene stretch film that include providing interpolymer resin particles, forming a polyethylene blend composition by blending from about 0.1 to about 10 percent by weight based on the weight of the blend composition of interpolymer resin particles into one or more polyethylene resins; and forming a film from the polyethylene blend composition. The interpolymer resin particles contain a styrenic polymer intercalated within a first polyolefin, where the first polyolefin is present at from about 20% to about 80% by weight based on the weight of the particles, and the styrenic polymer is present at from about 20% to about 80% by weight based on the weight of the particles.



METHODS OF IMPROVING POLYETHYLENE STRETCH FILMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to polyethylene stretch films and related multilayer polyethylene film and structures and methods of improving the physical properties of such films.

5

2. Background Art

Stretch films are widely used in a variety of bundling and packaging applications. The term "stretch film" indicates films capable of stretching and applying a bundling force, and includes films stretched at the time of application as well as "pre-stretched" films, i.e., films which are provided in a pre-stretched form for use without additional stretching. Stretch films can be monolayer films or multilayer films, and can include cling-enhancing additives such as tackifiers, and non-cling or slip additives, as desired, to tailor the slip/cling properties of the film. Typical polymers used in the cling layer of conventional stretch films include, for example, ethylene vinyl acetate, ethylene methyl acrylate, and very low density polyethylenes having a density of less than about 0.912 g/cm³.

It is desirable to maximize the degree to which a stretch film is stretched, as expressed by the percent of elongation of the stretched film relative to the unstretched film, and termed the "stretch ratio." At relatively larger stretch ratios, the film imparts greater holding force. Further, films which can be used at larger stretch ratios with adequate holding force and film strength offer economic advantages, since less film is required for packaging or bundling.

The application of polyethylene films in stretch wrapping has been considerably enhanced by the use of linear low density polyethylene (LLDPE) type products. When formed into a film for stretch wrap application, LLDPE

products typically combine a high extensibility with good mechanical properties to provide a wrapping or collation function to be achieved in an economic and effective manner. In this respect, LLDPE has significant advantages over LDPE which, due to both its behavior in extension and its
5 mechanical performance, is not normally regarded as a product of choice for stretch wrapping applications.

For example, in a single layered or composite stretch film containing a low density polyethylene or an ethylene/vinyl acetate copolymer, an elongation maximum of about 150% is often observed. If stretched more than
10 that the film often breaks during the stretching.

In the case of a film made of a linear low density polyethylene, after wrapping, an excessive stress is likely to be exerted to a wrapped product, whereby the wrapped product or its tray is likely to be deformed, or the strength after wrapping tends to be weak, or the film tends to undergo non-
15 uniform stretching, so that the appearance of a commercial product after wrapping tends to be poor. Some efforts to solve this problem have been to lower the density of the linear low density polyethylene, however, the resulting pellets or film tend to be excessively sticky, which causes problems during the production or handling of wrapped products after wrapping.

20 Application of stretch wrap films may be either by hand or by machine. The film may be either wrapped directly onto the article or articles to be packaged, or it may undergo a pre-stretching operation prior to wrapping. Pre-stretching typically enhances the mechanical property of the film and provides a more effective packaging and more efficient coverage for a given
25 unit mass of film. Hence, the response of the film to either a pre-stretch or the stretch applied during wrapping is an important parameter affecting film performance. In particular for a given film width and thickness the efficiency with which an object is wrapped is affected by the degree to which the film can be thinned during the stretching and the loss of film width which may

occur at the same time. The resistance to sudden impact events, puncture by sharp objects and the ability to maintain a tension sufficient to maintain the package in the desired shape and configuration are also important parameters.

5 A further requirement in many stretch wrapping applications is that the film displays a certain degree of adhesive or cling behavior enabling a film closure of the package to be achieved without resort to use of additional securing measures such as straps, glues or heat sealing operations. For monolayer films, such adhesion may be provided by the intrinsic film
10 properties or by using a "cling" additive in the film formulation. An example of a cling additive which is widely used is poly(isobutene) (PIB) which term is taken to include polybutenes produced from mixed isomers of butene. For multi-layer films, it is relatively easy to provide one or more surface layers which are specifically formulated to provide cling. In general this method
15 allows a more flexible approach to film manufacture as choice of product for the main body of the film may be made on the basis of mechanical performance and the surface layers can be specially formulated for adhesion. Those skilled in the art will appreciate the multiplicity and flexibility of the choices of possible film structures.

20 In some stretch films, as the film is stretched a small decrease in the film thickness due to small fluctuations in thickness uniformity can result in a large fluctuation in elongation, giving rise to bands of weaker and more elongated film transverse to the direction of stretching, a defect known as "tiger striping". Thus, it is desirable to avoid tiger striping over typical
25 thickness variations of, for example, $\pm 5\%$. In addition, since the extent of elongation correlates inversely with the amount of film that must be used to bundle an article, it is desirable for the film to be stretchable to a large elongation. In principle the elongation at break is the maximum possible elongation. Thus, it is desirable to have a large elongation to break. Other

desirable properties include, but are not limited to, high cling force and good puncture resistance.

Stretch films are often stretched at the time of use, which requires the application of force in order to stretch the film as much as 200% to properly contain a load. In many cases, stretch films are "pre-stretched" by a film converter prior to delivery to the end-user. Pre-stretched films are described as films that are taken from master rolls of film that have already been produced, stretched in a separate step, and re-wound onto film rolls for later use. Many end-users use pre-stretched films to increase the rate at which loads can be wrapped and to minimize the force required to wrap loads.

Pre-stretched films are typically made from various polyethylene resins and may be single or multilayer products. Cling additives are frequently used to ensure that adjacent layers of film will cling to each other. After the cling has fully developed, pre-stretched films are stretched in a separate operation. This process orients the molecules in the film in a longitudinal direction, parallel to the direction of the film's travel through the stretching machine. This orientation in the machine direction removes most of the stretch in the film. The resulting film is relatively stiff for its thickness and has very little residual orientation or stretch remaining before the film fails in the machine direction. These characteristics are desirable because much less effort is required to secure a load using pre-stretched film as compared to conventional handheld stretch films.

However, the pre-stretching operation requires additional material handling, dedicated converting equipment, increased warehouse space, and the manpower needed to manage the operation. Additionally, the pre-stretching can end with the film tearing or otherwise failing if it does not have sufficient strength. Film tearing or failure during pre-stretching operations results in increased film scrap and higher raw material usage, further increasing the cost and decreasing the efficiency of making pre-stretched film.

While prior efforts have resulted in films having improved performance in one or several of the above-described properties, known films have not successfully displayed the combination of mechanical strength such as puncture resistance, breaking strength or elongation at break, stretchability, and elastic recovery. Such properties are needed for stretch packaging films useful for packaging products applied by a hand wrapper or a stretch wrapping machine.

SUMMARY OF THE INVENTION

The present invention is directed to methods of improving polyethylene stretch film that include providing interpolymer resin particles, forming a polyethylene blend composition by blending from about 0.1 to about 10 percent by weight based on the weight of the blend composition of interpolymer resin particles into one or more polyethylene resins; and forming a film from the polyethylene blend composition. The interpolymer resin particles contain a styrenic polymer intercalated within a first polyolefin, where the first polyolefin is present at from about 20% to about 80% by weight based on the weight of the particles, and the styrenic polymer is present at from about 20% to about 80% by weight based on the weight of the particles.

The present invention also provides polyethylene stretch films made using the above described method.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross sectional representation of a multilayer film structure according to an embodiment of the present invention; and

FIG. 2 is a graph showing the results when Composition A and Composition B are plotted against Total Energy (ft. lbs.)(DYNATUP) versus the weight percentages of polystyrene, which is a component of Composition A and Composition B.

DETAILED DESCRIPTION OF THE INVENTION

Other than in the operating examples or where otherwise indicated, all numbers or expressions referring to quantities of ingredients, reaction
5 conditions, etc. used in the specification and claims are to be understood as modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that can vary depending upon the desired properties, which the present invention desires to obtain. At the very
10 least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

Notwithstanding that the numerical ranges and parameters setting forth
15 the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical values, however, inherently contain certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

20 Also, it should be understood that any numerical range recited herein is intended to include all sub-ranges subsumed therein. For example, a range of "1 to 10" is intended to include all sub-ranges between and including the recited minimum value of 1 and the recited maximum value of 10; that is, having a minimum value equal to or greater than 1 and a maximum value of
25 equal to or less than 10. Because the disclosed numerical ranges are continuous, they include every value between the minimum and maximum values. Unless expressly indicated otherwise, the various numerical ranges specified in this application are approximations.

As used herein, the term "blown film techniques", refers to an extrusion technique where a thermoplastic exits through a die, which is an upright cylinder with a circular opening. The molten thermoplastic is pulled upwards from the die by a pair of nip rolls above the die.

5 As used herein, the term "cast film techniques" refers to polyethylene films where the polymer melt from the extruder is fed into a wide flat die. The extrudate comes out of the die as a thin, wide curtain of film. This molten curtain is cast directly into a quench tank or onto a chill roll. A nip roll arrangement then pulls the film, which is latter wound into rolls.

10 As used herein, the term "continuous phase" refers to a material into which an immiscible material is dispersed. In embodiments of the present invention, polyolefins provide a continuous phase into which a monomer mixture is dispersed. In other embodiments of the invention, polyolefin particles are dispersed in an aqueous continuous phase during
15 polymerization.

As used herein, the term "dispersed phase" refers to a material in droplet or particulate form which is distributed within an immiscible material. In embodiments of the present invention, a monomer mixture provides a dispersed phase in a continuous phase containing one or more polyolefins.
20 In other embodiments of the invention, the present interpolymer resin particles make up a dispersed phase within a thermoplastic, in many cases a polyolefin, continuous phase.

As used herein, the term "elastomer" refers to materials that have the ability to undergo deformation under the influence of a force and regain its
25 original shape once the force is removed. In many embodiments of the invention, elastomers include homopolymers and copolymers containing polymerized residues derived from isoprene and/or butadiene.

As used herein, the term "extrusion techniques" refers to methods where a thermoplastic material is fed through an opening near the rear of an

extruder barrel, heated to the desired melt temperature of the material, coming into contact with a screw. The rotating screw forces the thermoplastic forward through the barrel exiting through a die and then pulled through a set of cooling rolls.

5 As used herein, the term "first polyolefin" refers to one or more polyolefins incorporated into the interpolymer resin particles described herein.

 As used herein, the term "HDPE" refers to high density polyethylene, which generally has a density of greater or equal to 0.941 g/cm^3 . HDPE has a low degree of branching. HDPE is often produced using chromium/silica
10 catalysts, Ziegler-Natta catalysts or metallocene catalysts.

 As used herein, the term "intercalated" refers to the insertion of one or more polymer molecules within the domain of one or more other polymer molecules having a different composition. In embodiments of the invention, as described herein below, styrenic polymers are inserted into polyolefin
15 particles by polymerizing a styrenic monomer mixture within the polyolefin particles.

 As used herein, the term "LDPE" refers to low density polyethylene, which is a polyethylene with a high degree of branching with long chains. Often, the density of a LDPE will range from $0.910 - 0.940 \text{ g/cm}^3$. LDPE is
20 created by free radical polymerization.

 As used herein, the term "LLDPE" refers to linear low density polyethylene, which is a polyethylene with significant numbers of short branches resulting from copolymerization of ethylene with at least one C_{3-12} α -olefin comonomer, e.g., butene, hexene or octene. Typically, LLDPE has a
25 density in the range of 0.915 to 0.925 g/cm^3 . In many cases, the LLDPE is an ethylene hexene copolymer, ethylene octene copolymer or ethylene butene copolymer. The amount of comonomer incorporated can be from 0.5 to 12 mol %, in some cases from 1.5 to 10 mole %, and in other cases from 2 to 8 mole % relative to ethylene.

As used herein, the term "MDPE" refers to medium density polyethylene, which is a polyethylene with some branching and a density in the range of 0.926 to 0.940 g/cm³. MDPE can be produced using chromium/silica catalysts, Ziegler-Natta catalysts or metallocene catalysts.

5 As used herein, the terms "(meth)acrylic" and "(meth)acrylate" are meant to include both acrylic and methacrylic acid derivatives, such as the corresponding alkyl esters often referred to as acrylates and (meth)acrylates, which the term "(meth)acrylate" is meant to encompass.

10 As used herein, the term "monomer" refers to small molecules containing at least one double bond that reacts in the presence of a free radical polymerization initiator to become chemically bonded to other monomers to form a polymer.

15 As used herein, the term, "olefinic monomer" includes, without limitation, α -olefins, and in particular embodiments ethylene, propylene, 1-butene, 1-hexene, 1-octene and combinations thereof.

As used herein, the term "polyolefin" refers to a material, which is prepared by polymerizing a monomer composition containing at least one olefinic monomer.

20 As used herein, the term "polyethylene" includes, without limitation, homopolymers of ethylene and copolymers of ethylene and one or more of propylene, 1-butene, 1-hexene and 1-octene.

As used herein, the terms "PP" and "polypropylene" include, without limitation, homopolymers of propylene, including iso-tactic polypropylene, syndio-tactic polypropylene and copolymers of propylene and ethylene.

25 As used herein, the term "polymer" refers to macromolecules composed of repeating structural units connected by covalent chemical bonds and is meant to encompass, without limitation, homopolymers, random copolymers, block copolymers and graft copolymers.

As used herein, the term "styrenic polymer" refers to a polymer derived from polymerizing a mixture of one or more monomers that includes at least 50 wt.% of one or more monomers selected from styrene, p-methyl styrene, α-methyl styrene, tertiary butyl styrene, dimethyl styrene, nuclear brominated or chlorinated derivatives thereof and combinations thereof.

As used herein, the term "thermoplastic" refers to a class of polymers that soften or become liquid when heated and harden when cooled. In many cases, thermoplastics are high-molecular-weight polymers that can be repeatedly heated and remolded. In many embodiments of the invention, thermoplastic resins include polyolefins and elastomers that have thermoplastic properties.

As used herein, the terms "thermoplastic elastomers" and "TPE" refer to a class of copolymers or a blend of polymers (in many cases a blend of a thermoplastic and a rubber) which includes materials having both thermoplastic and elastomeric properties.

As used herein, the terms "thermoplastic olefin" or "TPO" refer to polymer/filler blends that contain some fraction of polyethylene, polypropylene, block copolymers of polypropylene, rubber, and a reinforcing filler. The fillers can include, without limitation, talc, fiberglass, carbon fiber, wollastonite, and/or metal oxy sulfate. The rubber can include, without limitation, ethylene-propylene rubber, EPDM (ethylene-propylene-diene rubber), ethylene-butadiene copolymer, styrene-ethylene-butadiene-styrene block copolymers, styrene-butadiene copolymers, ethylene-vinyl acetate copolymers, ethylene-alkyl (meth)acrylate copolymers, very low density polyethylene (VLDPE) such as those available under the Flexomer® resin trade name from the Dow Chemical Co., Midland, MI, styrene-ethylene-ethylene-propylene-styrene (SEEPS). These can also be used as the materials to be modified by the interpolymer to tailor their rheological properties.

As used herein, the term "VLDPE" refers to very low density polyethylene, which is a polyethylene with high levels of short chain branching with a typical density in the range of 0.880 to 0.915 g/cc. In many cases VLDPE is a substantially linear polymer. VLDPE is typically
5 produced by copolymerization of ethylene with short-chain alpha-olefins (e.g., 1-butene, 1-hexene, or 1-octene). VLDPE is most commonly produced using metallocene catalysts.

Unless otherwise specified, all molecular weight values are determined using gel permeation chromatography (GPC). Typically, the GPC analysis is
10 done using an instrument sold under the tradename "Waters 150c". For polystyrene, the samples are dissolved in toluene, which is the mobile phase, and the results compared against appropriate polystyrene standards. For polyethylene, the samples are dissolved in 1,2,4-trichlorobenzene, the mobile phase at 140°C. The samples are prepared by dissolving the polymer in this
15 solvent and run without filtration. Molecular weights are expressed as polyethylene equivalents with a relative standard deviation of 2.9% for the number average molecular weight ("Mn") and 5.0% for the weight average molecular weight ("Mw"). Unless otherwise indicated, the molecular weight values indicated herein are weight average molecular weights (Mw).

20 The present invention is directed to methods of producing polyethylene stretch films. The film can contain one layer or multiple layers, and the composition of each layer may vary.

In the film according to the invention, at least one layer (termed the "film layer") includes a blend of one or more polyethylenes and novel
25 interpolymers resin particles (termed "polyethylene blend"). The polyethylenes that may be used to produce the film layer can include, but are not limited to MDPE, LDPE, LLDPE, polyethylene copolymers, polyethylene terpolymers, and polyethylene blends.

The interpolymer resin particles contain a styrenic polymer intercalated within a first polyolefin, wherein the first polyolefin is present at from about 20% to about 80% by weight based on the weight of the particles, and the styrenic polymer is present at from about 20% to about 80% by weight based on the weight of the particles.

The polyethylene blend composition is formed by blending from about 0.1 to about 10 percent by weight based on the weight of the blend composition of the interpolymer resin particles into one or more polyethylene resins. The film layer is formed from the polyethylene blend composition.

In embodiments of the invention, the polyethylene stretch film includes more than one layer. In particular embodiments of the invention, the polyethylene stretch film includes at least three layers, where the film layer, which is situated between a second layer and a third layer. The film layer contains the blend of one or more polyethylenes and interpolymer resin particles. The second layer directly contacts a first surface of the film layer and includes at least one thermoplastic resin. The third layer directly contacts a second surface of the film layer and includes at least one thermoplastic resin, that can be same or different than the thermoplastic resins in the second layer.

Thus, in this embodiment, the thermoplastic resins can include polyethylene and/or polypropylene. When the thermoplastic resin includes polyethylene it can be selected from homopolyethylene; copolymers of ethylene and one or more C₃-C₁₀ α-olefins, copolymers ethylene and vinyl acetate; copolymers of ethylene and butadiene; copolymers ethylene and isoprene; and combinations thereof. When the thermoplastic resin includes polypropylene it can be selected from homopolypropylene; copolymers of propylene and one or more C₂-C₁₀ α-olefins, copolymers propylene and vinyl acetate; copolymers of propylene and butadiene; copolymers propylene and isoprene; and combinations thereof.

Referring to FIG. 1, a multilayer film structure according to embodiments of the present invention includes at least three layers. In one embodiment, the multilayer film structure 10 includes an inner second layer 12 an outer third layer 16 and a core film layer 14 between the second and third layers. The structure 10 is also understood to have a thickness 'X'.

In embodiments of the invention, the film layer can be a film containing a polymer composition that includes from about 0.1 to about 50 percent by weight of interpolymer resin particles and from about 50 to about 99.9 percent by weight of at least one polyethylene. The interpolymer resin particles include a styrenic polymer intercalated within a polyolefin. The interpolymer resin particles contain from about 20% to about 80% by weight based on the weight of the particles of a polyolefin and from about 20% to about 80% by weight based on the weight of the particles of the styrenic polymer.

In particular embodiments of the invention, the film layer is a film containing a polymer composition that includes interpolymer resin particles that include a styrenic polymer intercalated within a first polyolefin and at least one polyethylene. In aspects of the invention, the multilayer films show improved Dart impact properties as well as higher tensile yield strength and modulus values compared with multilayer films where the film layer does not contain interpolymer resin particles.

In embodiments of the invention, the interpolymer resin particles have little or no gel content. In particular embodiments of the invention, the interpolymer resin particles can have, at least in part, a crystalline morphology. The interpolymer resin includes a polyolefin and an intercalated polymer that contains repeat units derived from one or more styrenic monomers.

In particular embodiments of the invention, the interpolymer resin particles can include the unexpanded interpolymer resin particles described in

U.S. Pat. No. 7,411,024, the disclosure of which is incorporated herein by reference in its entirety.

In embodiments of the invention, the interpolymer resin particles include at least about 20, in some cases at least about 25, in other cases at
5 least about 30, in some instances at least about 35 and in other instances at least about 40 wt.% of one or more polyolefins. Also, the interpolymer resin particles include up to about 80, in some instances up to about 60, in some cases up to about 55, and in other cases up to about 50 wt.% of one or more polyolefins. The polyolefin content of the interpolymer resin particles can be
10 any value or range between any of the values recited above.

In embodiments of the invention, the polyethylene in the interpolymer resin particles can include a homopolymer of ethylene, ethylene copolymers that include at least 50 mole % and in some cases at least 70 mole %, of an ethylene unit and a minor proportion of a monomer copolymerizable with
15 ethylene, ethylene-vinyl acetate copolymers many cases at least 60% by weight, of the ethylene homopolymer or copolymer with another polymer, HDPE, MDPE, LDPE, LLDPE, VLDPE, and a blend of at least 50% by weight.

In other embodiments of the invention, the polyolefin in the interpolymer resin particles includes one or more of polyethylene,
20 polypropylene, ethylene-vinyl acetate copolymers, thermoplastic olefins (TPO's), and thermoplastic elastomers (TPE's) resins. In particular embodiments of the invention, the polyethylene is one or more of linear low density polyethylene and low density polyethylene. Suitable polyolefins are those that provide for desirable properties in the interpolymer resin particles,
25 and in particular in the polyolefin films as described herein.

Non-limiting examples of monomers copolymerizable with ethylene include vinyl acetate, vinyl chloride, propylene, butene, hexene, octene, (meth)acrylic acid and its esters, butadiene, isoprene, styrene and combinations thereof.

Non-limiting examples of the other polymer that may be blended with the ethylene homopolymer or copolymer include any polymer compatible with it. Non-limiting examples include polypropylene, polybutadiene, polyisoprene, polychloroprene, chlorinated polyethylene, polyvinyl chloride, a styrene/-
5 butadiene copolymer, a vinyl acetate/ethylene copolymer, an acrylonitrile/-butadiene copolymer, a vinyl chloride/vinyl acetate copolymer, etc. Particular species that can be used include polypropylene, polybutadiene, styrene/-butadiene copolymer and combinations thereof.

10 In embodiments of the invention, the polyolefin in the interpolymer resin particles can be polyethylene, ethylene/vinyl acetate copolymer (EVA) or a blend of EVA and polyethylene, polypropylene, ethylene/propylene copolymer or a combination thereof.

In embodiments of the invention, the polyolefin resin particles used to form the interpolymer resin particles of the invention can have a melt index
15 (MI) of about 0.3 to 15, in some cases 0.3 to 10 and in other cases 0.3 to 5 g/10 minutes under 190°C/2.16 kg conditions (equivalent to 11.9 g/10 minutes under 230°C/5.0 kg conditions) (ASTM D1238); a number average molecular weight of 20,000 to 60,000; an intrinsic viscosity, at 75°C in xylene, of 0.8 to 1.1; a density of 0.910 to 0.940 g/cm³, and a VICAT softening temperature
20 greater than 60°C, in some cases greater than 70°C and in other cases greater than 85°C.

In embodiments of the invention, the polyolefin of the in the interpolymer resin particles has a VICAT softening temperature greater than 85°C, in some cases at least about 90°C and in other cases at least about
25 95°C and can be up to about 115°C.

In embodiments of the invention, the polyolefin of the in the interpolymer resin particles has a melt flow of at least 0.2, in some cases at least about 0.5, in other cases at least about 1.0, in some instances at least about 2.1, in other instance at least about 2.5, in some situations at least

about 3.0 and in other situations at least about 4.0 g/10 minutes (230°C/2.16 kg under ASTM D1238).

The styrenic polymer is a polymer derived from polymerizing a monomer mixture of one or more styrenic monomers and optionally one or more other monomers. Any suitable styrenic monomer can be used in the invention. Suitable styrenic monomers are those that provide the desirable properties in the present interpolymer resin particles as described below. Non-limiting examples of suitable styrenic monomers include styrene, p-methyl styrene, α -methyl styrene, ethyl styrene, vinyl toluene, tertiary butyl styrene, isopropylxylene, dimethyl styrene, nuclear brominated or chlorinated derivatives thereof and combinations thereof.

When the monomer mixture includes other monomers, the styrenic monomers are present in the monomer mixture at a level of at least 50%, in some cases at least 60% and in other cases at least 70% and can be present at up to 99%, in some cases up to 95%, in other cases up to 90%, and in some situations up to 85% by weight based on the monomer mixture. The styrenic monomers can be present in the monomer mixture at any level or can range between any of the values recited above.

Suitable other monomers that can be included in the monomer mixture include, without limitation, maleic anhydride, C₁-C₄ alkyl (meth)acrylates, acrylonitrile, vinyl acetate, and combinations thereof.

When the monomer mixture includes other monomers, the other monomers are present in the monomer mixture at a level of at least 1%, in some cases at least 5%, in other cases at least 10%, in some instances at least 15%, in other instances at least 20%, in some situations at least 25% and in other situations at least 30% and can be present at up to 50%, in some cases up to 40%, and in other cases up to 30% by weight based on the monomer mixture. The other monomers can be present in the monomer mixture at any level or can range between any of the values recited above.

In embodiments of the invention, the interpolymer resin particles include at least about 40, in some cases at least about 45 and in other cases at least about 50 wt.% of one or more styrenic polymers. Also, the interpolymer resin particles include up to about 80, in some cases up to about 75, in other cases up to about 70, in some instances up to about 65 and in other instances up to about 60 wt.% of one or more styrenic polymers. The styrenic polymer content of the interpolymer resin particles can be any value or range between any of the values recited above.

In embodiments of the invention, cross-linking of the polyolefin resin particles in the interpolymer resin particles is minimized or eliminated as reflected by the gel content in the interpolymer resin. In particular embodiments of the invention, the gel content of the interpolymer resin is 0 and can be up to about 5 wt.%, in other cases up to about 2.5 wt.%, in other cases up to about 1.5 wt.%, in some instances up to about 1 wt.% and in other instances up to about 0.5 wt.%. The gel content of the interpolymer resin particles can range between 0 and any of the values recited above.

In many embodiments of the invention, the polyolefin in the interpolymer resin particles are not crosslinked.

In embodiments of the invention, the VICAT softening temperature of the interpolymer resin particles can be at least about 85°C, in some cases at least about 90°C, and in other cases at least about 95°C and can be up to about 115°C, in some cases up to about 110°C and in other cases at least about 105°C. The VICAT softening temperature of the interpolymer resin particles can be any value or range between any of the values recited above.

In embodiments of the invention, the melt index value of the interpolymer resin particles can be at least about 0.1, in some cases at least about 0.25, and in other cases at least about 0.5 g/10 minutes (230°C/5.0 kg) and can be up to about 4, in some cases up to about 3, in other cases up to about 2.5, in some instances up to about 2 and in some instances up to about

1.5 g/10 minutes (230°C/5.0 kg). The melt index value of the interpolymer resin particles can be any value or range between any of the values recited above.

In embodiments of the invention, the interpolymer resin particles are prepared using a process that includes: providing the above described polyolefin resin particles suspended in an aqueous medium; minimizing or eliminating cross-linking in the polyolefin resin particles; adding to the aqueous suspension a monomer mixture that includes a vinyl aromatic monomer, and a polymerization initiator for polymerizing the monomer mixture within the polyolefin resin particles; and polymerizing the monomer mixture in the polyolefin resin particles to form the interpolymer resin particles.

In embodiments of the invention, the interpolymer resin particles are formed as follows: in a reactor, the polyolefin resin particles are dispersed in an aqueous medium prepared by adding 0.01 to 5%, in some cases 2 to 3%, by weight based on the weight of the water of a suspending or dispersing agent such as water soluble high molecular materials, e.g., polyvinyl alcohol, methyl cellulose, and slightly water soluble inorganic materials, e.g., calcium phosphate or magnesium pyrophosphate, and then the vinyl aromatic monomers are added to the suspension and polymerized inside the polyolefin resin particles to form an interpenetrating network of polyolefin and polymer of vinyl aromatic monomers.

Any suitable vinyl aromatic monomer can be used in the invention. Examples of suitable vinyl aromatic monomers include, but are not limited to styrene, α -methylstyrene, ethylstyrene, chlorostyrene, bromostyrene, vinyltoluene, vinylbenzene, and combinations thereof. These monomers may be used either alone or in admixture. A mixture of at least 0.1% of the vinyl aromatic monomer and a monomer copolymerizable with it, such as acrylonitrile, methyl (meth)acrylate, butyl (meth)acrylate, or methyl

(meth)acrylate can also be used. As used herein, the term "vinyl aromatic monomer" means a vinyl aromatic monomer used alone or in admixture.

In particular embodiments, the vinyl aromatic monomer is styrene polymerized within the polyolefin resin particles.

5 Any of the conventionally known and commonly used suspending agents for polymerization can be employed. These agents are well known in the art and may be freely selected by one skilled in the art. Water is used in an amount generally from 0.7 to 5, in many cases 3 to 5 times that of the starting polyolefin particles added to the aqueous suspension, on a weight
10 basis.

When the polymerization of the vinyl aromatic monomer is completed, the polymerized vinyl aromatic resin is uniformly dispersed inside the polyolefin particles.

Methods of preparing the interpolymer resin particles are disclosed, as
15 a non-limiting example, in U.S. Pat. No. 7,411,024.

The interpolymer resin particles of the invention may suitably be coated with compositions containing silicones, metal or glycerol carboxylates, suitable carboxylates are glycerol mono-, di- and tri-stearate, zinc stearate, calcium stearate, and magnesium stearate; and mixtures thereof. Examples
20 of such compositions may be those disclosed in GB Patent No. 1,409,285 and in Stickley U.S. Pat. No. 4,781,983. The coating composition can be applied to the interpolymer resin particles via dry coating or via a slurry or solution in a readily vaporizing liquid in various types of batch and continuous mixing devices. The coating aids in transferring the interpolymer resin
25 particles easily through the processing equipment.

The interpolymer resin particles can contain other additives, which can include, without limitation, chain transfer agents, nucleating agents, agents that enhance biodegradability and other polymers.

Suitable chain transfer agents include, but are not limited to, C₂₋₁₅ alkyl mercaptans, such as n-dodecyl mercaptan, t-dodecyl mercaptan, t-butyl mercaptan and n-butyl mercaptan, and other agents such as pentaphenyl ethane and the dimer of α -methyl styrene, and combinations thereof.

5 Suitable nucleating agents, include, but are not limited to, polyolefin waxes. The polyolefin waxes, which include without limitation, polyethylene waxes, have a weight average molecular weight of from 250 to 5,000 and are typically finely divided through the polymer matrix in a quantity of 0.01 to 2.0% by weight, based on the interpolymer resin composition. The interpolymer
10 resin particles can also contain from 0.1 to 0.5% by weight based on the interpolymer resin, talc, organic bromide-containing compounds, and polar agents as described in WO 98/01489, which include isalkylsulphosuccinates, sorbital-C₈₋₂₀-carboxylates, and C₈₋₂₀-alkylxylene sulphonates.

 In some embodiments of the invention, other materials such as
15 elastomers and additives can be added in whole or part to the interpolymer resin particles.

 In various embodiments of the invention, various materials or additives are added to the interpolymer resin particles so that it acts as a carrier for the materials or additives.

20 In many embodiments of the invention, the interpolymer resin can be processed (extruded, dried, etc.) prior to use as a rheology modifier to remove any moisture, unreacted volatiles or reaction decomposition products from the interpolymer.

 The present invention provides a method of improving polyethylene
25 stretch film. The method includes providing the above described interpolymer resin particles; forming a polyethylene blend composition by blending from about 0.1 to about 25 percent by weight based on the weight of the blend composition of interpolymer resin particles into one or more polyethylene resins; and forming a first film from the polyethylene blend composition.

In the present invention, the interpolymer resin particles are generally present in the polyethylene blend composition at a level of at least about 0.1 wt.%, in some cases at least about 0.25 wt.%, in other cases at least about 0.5 wt.%, in some instances at least about 0.75 wt.%, in other instances at least about 1 wt.%, in some situations at least about 1.25 wt.% and in other situations at least about 1.5 wt.% and can be up to about 25 wt.%, in some cases up to about 20 wt.% in other cases up to about 15 wt.% in some instances up to about 12.5 wt.%, in other instances up to about 10 wt.% and in some situations up to about 5 wt.% of the polymer composition. The amount of interpolymer resin particles in the polyethylene blend composition will vary depending on the particular polyethylenes used in the composition. The amount of interpolymer resin particles in the polymer composition can be any value or range between any of the values recited above.

In embodiments of the invention, the blend of interpolymer resin particles and one or more polyethylenes are combined using a blending step. Typically, the polyethylenes and interpolymer resin particles are intimately mixed by high shear mixing to form the polymer blend composition. The resulting composition often includes a continuous polyethylene phase and an interpolymer resin particulate dispersed phase. The dispersed interpolymer resin particles are suspended or dispersed throughout the polyethylene continuous phase. The manufacture of the dispersed interpolymer resin particulate phase within the polyethylene continuous phase can require substantial mechanical input. Such input can be achieved using a variety of mixing means including extruder mechanisms where the materials are mixed under conditions of high shear until the appropriate degree of wetting, intimate contact and dispersion are achieved.

In embodiments of the invention, the polyethylene blend composition provides improved film processing and film physical properties compared to multilayer films that use the polyethylenes alone as the first film. In many

embodiments of the invention, the blend improves physical properties such as, for example, characteristics of the film relative to strength, puncture resistance, rheology and deformation properties. Non-limiting examples of such film physical properties include processability, throughput, impact
5 properties, tensile properties, yield properties, creep properties, modulus values, tear properties, elongation properties, and flexural properties.

Particular embodiments of the invention are directed to multilayer films where the first film contains a polymer composition that includes interpolymer resin particles that include a styrenic polymer intercalated within a polyolefin
10 and at least one polyethylene, where the films show improved Dart impact properties as well as higher tensile yield strength and modulus values compared with similar multilayer films where the first layer does not include interpolymer resin particles.

As indicated above, the first layer in the multilayer film according to the
15 present invention contains a polyethylene blend composition that includes the above-described interpolymer resin particles and at least polyethylene.

In embodiments of the invention, the polyethylene of the polyethylene blend composition is one or more of homopolyethylene; copolymers of ethylene and one or more C₃-C₁₀ α -olefins, and combinations thereof.

20 In some embodiments of the invention, the polyethylene of the polyethylene blend composition can be a homopolymer of ethylene, ethylene copolymers that include at least 50 mole % and in some cases at least 70 mole %, of an ethylene unit and a minor proportion of a monomer copolymerizable with ethylene, HDPE, MDPE, LDPE, LLDPE, and
25 combinations thereof.

Non-limiting examples of monomers copolymerizable with ethylene include propylene, butene, hexene, octene, and combinations thereof.

In particular embodiments of the invention, the polyethylene of the polyethylene blend composition is one or more polymers selected from

HDPE, MDPE, LDPE, LLDPE, VLDPE, ethylene copolymers and combinations thereof.

In other particular embodiments of the invention, the polyethylene of the polyethylene blend composition can be a homopolymer of an α -olefin or a
5 copolymer of two or more α -olefins. In these particular embodiments, the polyolefin includes one or more polymers selected from polyethylene, and copolymers of ethylene and/or propylene with 1-butene, 1-hexene, 1-octene and combinations thereof.

Additional, non-limiting examples of polyethylenes that can be included
10 in the polyethylene blend composition include polyethylenes available under the trade names NOVAPOL[®] TD-9022-C, LA-0218-AF; SCLAIR[®] FG220-A and SCLAIR FP120-C, SURPASS[®] FPs117-C, SURPASS HPS900-C, SURPASS FPs016 and SURPASS FPs317 available from NOVA Chemicals.

The polyethylene is generally present in the polyethylene blend
15 composition at a level of at least about 95 wt.%, in some cases at least about 90 wt.%, in other cases at least about 87.5 wt.%, in some instances at least about 85 wt.%, and in other instances at least about 75 wt.% and can be up to about 99.9 wt.%, in some cases up to about 99.75 wt.%, in other cases up to about 99.5 wt.%, in some instances up to about 99.25 wt.%, in other
20 instances up to about 99 wt.%, in some situations up to about 98.75 wt.% and in other situations up to about 98.5 wt.% of the polyethylene blend composition. The amount of polyethylene in the polyethylene blend composition will vary depending on the particular interpolymer resin particles used in the composition as well as the particular properties desired in the final
25 film. The amount of polyethylene in the polymer blend composition can be any value or range between any of the values recited above.

The polymer blend compositions described herein can be used to make the first film of multilayer films using polymer processing techniques, such as sheet extrusion and cast film techniques.

In some embodiments of the invention the polymer blend composition of the first film can be made by preparing a first blend of the interpolymer resin particles with one or more polyethylenes and then blending the first blend into one or more polyethylenes that can be the same or different than
5 the polyethylene in the first blend.

In embodiments of the invention, the outer layers (second layer and third layer) include a thermoplastic resin. The second layer includes a first thermoplastic resin and the third layer includes a second thermoplastic resin. The first and second thermoplastic resins can be the same or different. The
10 outer layers can have differing compositions, but in some embodiments of the invention, the outer layers will be identical.

The thermoplastic resin in the outer layers can be selected from, as non-limiting examples, polyolefins, elastomers, polyvinylacetate, copolymers of ethylene and vinyl acetate, copolymers of ethylene and vinyl alcohol, and
15 combinations thereof.

In some embodiments of the invention, the outer layers include elastomers or elastomeric materials. In these embodiments, the elastomer or elastomeric material can be selected from copolymers of ethylene, propylene and a diene monomer (EPDM). In aspects of the invention, the diene
20 monomer used to make the elastomer or elastomeric material can be selected from butadiene, isoprene, chloroprene, 1,4-pentadiene, 1,4-hexadiene, 1,5-hexadiene, 2,5-dimethyl-1,5-hexadiene, 1,4-octadiene, cyclopentadiene, cyclohexadiene, cyclooctadiene, dicyclopentadiene, 1-vinyl-1-cyclopentene, 1-vinyl-1-cyclohexene, 3-methylbicyclo-(4,2,1)-nona-3,7-
25 diene, methyl tetrahydroindene, 5-ethylidene-2-norbornene, 5-butyldiene-2-norbornene, 2-methallyl-5-norbornene, 2-isopropenyl-5-norbornene, 5-(1,5-hexadienyl)-2-norbornene, 5-(3,7-octadienyl)-2-norbornene, 3-methyltricyclo (5,2,1,0²,6)-deca-3,8-diene and combinations thereof.

In other embodiments of the present multilayer film, the outer layers can include a polyolefin, non-limiting examples of which include copolymers formed from one or more monomers selected from ethylene, propylene, butene, pentene, methyl pentene, hexene, octene, and combination thereof.

5 In particular embodiments, the polyolefin of the outer layers includes one or more polymers selected from HDPE, MDPE, LDPE, LLDPE, VLDPE, ethylene propylene copolymers, ethylene butene copolymers, polypropylene, polybutene, polypentene, polymethylpentene, ethylene propylene rubber (EPR), ethylene - octene copolymer, and combinations thereof.

10 In embodiments of the invention, the outer layers can include at least 50 wt. % of a LLDPE component having a density of less than 0.940 g/cm^3 . In some embodiments, the outer layers include an LLDPE component and an LDPE component. In this embodiment, the LLDPE can be at least 75% by weight, in some cases at least 80% by weight, and in other cases at least
15 85% by weight of each outer layer and can be up to 99%, in some cases up to 95% and in other cases up to 90% by weight of each outer layer. The amount of LLDPE in the outer layers of this embodiment can be any value or range between any of the values recited above.

Non-limiting examples of suitable LLDPE materials, suitable as a
20 polyolefin in the outer layers, are those having a density of less than 0.945 g/cm^3 , in many cases less than 0.940 g/cm^3 , and can include LLDPE materials with a density ranging from 0.905 to 0.940 g/cm^3 , in some cases from 0.915 to 0.934 g/cm^3 , in other cases from 0.918 to 0.934 g/cm^3 , and in some instances from 0.920 to 0.930 g/cm^3 determined according to ISO
25 1183.

The MFR_2 (melt flow rate ISO 1133 at 190°C under a load of 2.16 kg) of the LLDPE can be in the range 0.5 to 10, in many cases 0.8 to 6.0, and in other cases 0.9 to 2.0 g/10 min.

In many embodiments of the invention, the LLDPE has a weight average molecular weight (Mw) of 100,000 to 250,000, in many cases 110,000 to 160,000. The Mw/Mn value can be from 1.5 to 20, in many cases from 1.5 to 4, and in other cases from 1.5 to 3.5.

5 It is within the scope of the invention for the polyolefin of the outer layers to be a blend of LLDPE materials, which will often be described as a bimodal or multimodal LLDPE.

Non-limiting examples of suitable blends that can be included in the polyolefin of the outer layers include the polyethylenes available under the
10 SURPASS trade name from NOVA Chemicals and those available under the ELITE trade name available from the Dow Chemical Company.

Non-limiting examples of suitable LLDPE's are available commercially under the trade names SCLAIR, NOVAPOL and SURPASS from NOVA Chemicals and BORSTAR from Borealis AG.

15 One or both outer layers of the multilayer film of the invention can contain an LDPE component. LDPE is prepared using a well-known high pressure radical process as will be known to the skilled individual and is a different polymer from an LLDPE.

According to embodiments of the invention, the outer layers can
20 include EVA, which is a copolymer of ethylene and vinyl acetate. In these embodiments, the content of vinyl acetate can be in the range of 10 to 30% by weight and in many cases 10 to 20% by weight having a melt flow rate (MFR), determined at 190°C under a load of 2.16 kg, in the range of 0.5 to 30 g/10 min, in many cases 1 to 10 g/10 min.

25 Each of the layers individually and the multilayer film as a whole can optionally include, depending on its intended use, additives and adjuvants, which can include, without limitation, anti-blocking agents, antioxidants, anti-static additives, anti-fogging agents, activators, cling additives, biodegradation enhancers, zinc oxide, chemical foaming agents, colorants, dyes, filler

materials, flame retardants, heat stabilizers, impact modifiers, light stabilizers, light absorbers, lubricants, nucleating agents, pigments, plasticizers, processing aids, slip agents, softening agents, and combinations thereof.

In embodiments of the invention, the additives and adjuvants can be
5 included in an of the first layer, second layer, or third layer by preparing a masterbatch using, for example, an extruder or kneader, whereupon a portion of the polymer in the particular layer and the additives and adjuvants are admixed to the masterbatch and the resulting mixture is blended mechanically on, for example, an extruder, kneader or the like. In other embodiments of
10 the invention, the masterbatch is formed by combining the components by melt blending. In further embodiments, the masterbatch can be prepared by feeding resins to a first extruder and then combining with the optional additives and adjuvants in a second extruder.

Suitable anti-blocking agents, slip agents and lubricants include
15 without limitation silicone oils, liquid paraffin, synthetic paraffin, mineral oils, petrolatum, petroleum wax, polyethylene wax, hydrogenated polybutene, higher fatty acids and the metal salts thereof, linear fatty alcohols, glycerine, sorbitol, propylene glycol, fatty acid esters of monohydroxy or polyhydroxy alcohols, phthalates, hydrogenated castor oil, beeswax, acetylated
20 monoglyceride, hydrogenated sperm oil, ethylenebis fatty acid esters, and higher fatty amides. Suitable lubricants include, but are not limited to, ester waxes such as the glycerol types, the polymeric complex esters, the oxidized polyethylene type ester waxes and the like, metallic stearates such as barium, calcium, magnesium, zinc and aluminum stearate, salts of 12-hydroxystearic
25 acid, amides of 12-hydroxystearic acid, stearic acid esters of polyethylene glycols, castor oil, ethylene-bis-stearamide, ethylene-bis-cocamide, ethylene-bis-lauramide, pentaerythritol adipate stearate and combinations thereof in an amount of from 0.1 to 2 wt.% of the film.

Suitable antioxidants include without limitation Vitamin E, citric acid, ascorbic acid, ascorbyl palmitate, butylated phenolic antioxidants, tert-butylhydroquinone (TBHQ) and propyl gallate (PG), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and hindered phenolics such as

5 IRGANOX® 1010 and IRGANOX 1076 available from Ciba Specialty Chemicals Corp., Tarrytown, NY.

Suitable anti-static agents include, without limitation, glycerine fatty acid, esters, sorbitan fatty acid esters, propylene glycol fatty acid esters, stearyl citrate, pentaerythritol fatty acid esters, polyglycerine fatty acid esters,

10 and polyoxethylene glycerine fatty acid esters in an amount of from 0.01 to 2 wt.% of the film.

Suitable colorants, dyes and pigments are those that do not adversely impact the desirable physical properties of the film include, without limitation, white or any colored pigment. In embodiments of the invention, suitable white

15 pigments contain titanium oxide, zinc oxide, magnesium oxide, cadmium oxide, zinc chloride, calcium carbonate, magnesium carbonate, kaolin clay and combinations thereof in an amount of 0.1 to 20 wt.% of the film. In embodiments of the invention, the colored pigment can include carbon black, phthalocyanine blue, Congo red, titanium yellow or any other colored pigment

20 typically used in the printing industry in an amount of 0.1 to 20 wt.% of the film. In embodiments of the invention, the colorants, dyes and pigments include inorganic pigments including, without limitation, titanium dioxide, iron oxide, zinc chromate, cadmium sulfides, chromium oxides and sodium aluminum silicate complexes. In embodiments of the invention, the colorants,

25 dyes and pigments include organic type pigments, which include without limitation, azo and diazo pigments, carbon black, phthalocyanines, quinacridone pigments, perylene pigments, isoindolinone, anthraquinones, thio-indigo and solvent dyes.

Suitable cling additives include, without limitation, hydrocarbon resins such as very low-density polyethylene resin (VLDPE), terpene resin, hydrogenated rosins, and rosin esters, polybutenes, polybutadienes, polyisobutylenes, and the like. Such agents are described, for example, in

5 U.S. Pat. Nos. 6,265,055 and 5,922,441. In many cases using a cling additive requires preblending or incorporating the additive into the resin material, and aging or the inclusion of auxiliary components (non-limiting examples including alkali metal stearates, monoesters of fatty acids and polyols, such as glycerol mono-oleate or a sorbitan ester) to convey the cling

10 additive to the film surface. Other disclosed cling additives include copolymers of ethylene and functional copolymers such as acrylates and vinyl acetate as described, for example, in U.S. Pat. Nos. 6,265,055 and 5,212,001.

Suitable fillers are those that do not adversely impact, and in some

15 cases enhance, the desirable physical properties of the film. Suitable fillers, include, without limitation, talc, silica, alumina, calcium carbonate in ground and precipitated form, barium sulfate, talc, metallic powder, glass spheres, barium stearate, calcium stearate, aluminum oxide, aluminum hydroxide, glass, clays such as kaolin and montmorolites, mica, silica, alumina, metallic

20 powder, glass spheres, titanium dioxide, diatomaceous earth, calcium stearate, aluminum oxide, aluminum hydroxide, carbon nanotubes and fiberglass, and combinations thereof can be incorporated into the polymer composition in order to reduce cost or to add desired properties to the film. The amount of filler is desirably less than 10% of the total weight of the film as

25 long as this amount does not alter the properties of the film.

Suitable flame retardants include, without limitation, brominated polystyrene, brominated polyphenylene oxide, red phosphorus, magnesium hydroxide, magnesium carbonate, antimony pentoxide, antimony trioxide,

sodium antimonite, zinc borate and combinations thereof in an amount of 0.1 to 2 wt.% of the film.

Suitable heat stabilizers include, without limitation, phosphite or phosphonite stabilizers and hindered phenols, non-limiting examples being the IRGANOX® stabilizers and antioxidants available from Ciba Specialty Chemicals. When used, the heat stabilizers are included in an amount of 0.1 to 2 wt.% of the film.

Suitable impact modifiers include, without limitation, high impact polystyrene (HIPS), SEEPS, ethylene – methacrylate resins (EMA), styrene/butadiene block copolymers, ABS, copolymers of C₁-C₁₂ linear, branched or cyclic olefins, C₁-C₁₂ linear, branched or cyclic alkyl esters of (meth)acrylic acid, styrenic monomers, styrene/ethylene/butadiene/styrene, block copolymers, styrene/ethylene copolymers. The amount of impact modifier used is typically in the range of 0.5 to 25 wt.% of the film.

Suitable ultra-violet light (UV) stabilizers include, without limitation, 2-hydroxy-4-(octyloxy)-benzophenone, 2-hydroxy-4-(octyl oxy)-phenyl phenyl-methanone, 2-(2'-hydroxy-3,5'-di-tetramethylphenyl) benzotriazole, and the family of UV hindered amine stabilizers available under the trade TINUVIN® from Ciba Specialty Chemicals Co., Tarrytown, NY, in an amount of 0.1 to 2 wt.% of the film.

Suitable ultraviolet light absorbers, include without limitation, 2-(2-hydroxyphenyl)-2H-benzotriazoles, for example, known commercial hydroxyphenyl-2H-benzotriazoles and benzotriazoles hydroxybenzophenones, acrylates, malonates, sterically hindered amine stabilizers, sterically hindered amines substituted on the N-atom by a hydroxy-substituted alkoxy group, oxamides, tris-aryl-o-hydroxyphenyl-s-triazines, esters of substituted and unsubstituted benzoic acids, nickel compounds, and combinations thereof, in an amount of 0.1 to 2 wt.% of the film.

Suitable softening agents and plasticizers include, without limitation, cumarone-indene resin, d-limonene, terpene resins, and oils in an amount of about 2 parts by weight or less based on 100 parts by weight of the film.

In embodiments of the invention, the components of the polymer blend
5 composition of the first layer are combined into a homogenous mixture by any suitable technique, which can include without limitation, mixing extrusion (compounding) and milling. The polymer blend composition components are then blended in the form of granules or in powder form, according to the types of components, in a blender before plastification and homogenization.
10 Blending may be effected in a discontinuous process working with batches or in a continuous process.

In embodiments of the invention, the components can be mixed, for example, in an internal mixer of Banbury type, in a single or twin-screw co-rotary or counter-rotary extruder, or in any other mixer capable of supplying
15 sufficient energy to melt and fully homogenize the mixture.

In particular embodiments of the invention, production of the mixture resulting from the composition can be done by mixing extrusion (compounding) in a twin-screw extruder. Such a mixture must be a uniform and homogenous mixture.

20 In embodiments of the invention, the mixed polymer blend composition is extruded into pellets obtained by cutting under cooling water; the pellets, which will be stored for subsequent conversion into items and parts. The conversion techniques used are those of plastics processing such as, in particular, injection if a cover is involved, and having very different wall
25 thicknesses between the tear start zone and the support and fitting structural zone.

The multilayer films of the present invention can be produced by a variety of methods known to those skilled in the art. Non-limiting examples of suitable methods include coextrusion, lamination by joining the various layers

together with adhesives or with heat. More particularly, suitable film processes include cast film techniques.

When the polymer composition of the first layer is used in extrusion processing, particles of the polymer composition can be fed into an extruder, and then extruded as a single layer or co-extruded into multi-layer structures, e.g., sheet or film.

In embodiments of the invention, the multilayer film is made by extruding directly into sheet, or film, or any article.

As non-limiting examples, extruded multilayer films that include the interpolymer resin particle – polyethylene blend as a core layer, compared to the polyethylene alone as a core layer, demonstrate improved throughput and processability, improved Dart impact properties, improved modulus, improved tensile properties and improved elongation properties.

In embodiments of the invention, the multilayer film can be characterized as the first layer making up from about 20% to about 50% by volume of the multi-layer film, the second layer making up from about 20% to about 60% by volume of the multi-layer film, and the third layer making up from about 20% to about 50% by volume of the multi-layer film.

Referring to FIG. 1, in embodiments of the invention, the multilayer film can have an overall thickness X of at least about 0.5 mils (12.5 μm), in some cases at least about 1 mil (25.4 μm), in other cases at least about 1.5 mils (38.1 μm), in some instances at least about 2 mils (50.8 μm) and in other instances at least about 2.5 mils (63.5 μm). In particular embodiments, the multilayer film can have an overall thickness X of up to about 15 mils (381 μm), in some cases up to about 12 mil (305 μm), in other cases up to about 11 mils (279.4 μm), in some instances up to about 10 mils (254 μm), in other instances up to about 9 mils (228.6 μm) and in some situations up to about 8 mils (203.2 μm). The particular overall thickness X of the multilayer film will vary depending on the composition of each layer, the technique used to form

the multilayer film, and the intended end use. The overall thickness X of the multilayer film can be any value or range between any of the values recited above.

In embodiments of the invention, the core layer 14 or first layer, will
5 have a thickness that is less than the overall thickness X of the multilayer film. The thickness of core layer 14 or first layer can be most conveniently expressed as a percentage of the overall thickness X of the multilayer film. The thickness of core layer 14 or first layer can be at least about 10%, in some cases at least about 15%, in other cases at least about 20% and in
10 some instances at least about 25% of the overall thickness X of the multilayer film. Further, the thickness of core layer 14 or first layer can be up to about 90%, in some cases up to about 80%, in other cases up to about 75%, in some instances up to about 70%, in other instances up to about 60%, and in some situations up to about 50% of the overall thickness X of the multilayer
15 film. The particular thickness of core layer 14 or first layer will vary depending on the composition of each layer, the technique used to form the multilayer film, and the intended end use. The thickness of core layer 14 or first layer can be any value or range between any of the values recited above.

In particular embodiments of the invention, the first film can make up
20 from about 20% to about 50% by volume of the multi-layer film, the second film layer can make up from about 20% to about 60% by volume of the multi-layer film, and the third film layer can make up from about 20% to about 50% by volume of the multi-layer film.

In other embodiments of the invention, the outer layers second layer
25 12 and third layer 16, will independently have a thickness that is less than the overall thickness X of the multilayer film. The thickness of outer layers second layer 12 and third layer 16 can be most conveniently expressed as a percentage of the overall thickness X of the multilayer film. The thickness of outer layers second layer 12 and third layer 16, can independently be at least

about 5%, in some cases at least about 10%, in other cases at least about 15% and in some instances at least about 20% of the overall thickness X of the multilayer film. Further, the thickness of outer layers second layer 12 and third layer 16, can independently be up to about 50%, in some cases up to about 45%, in other cases up to about 40%, in some instances up to about 35%, in other instances up to about 30%, and in some situations up to about 25% of the overall thickness X of the multilayer film. The particular thickness of outer layers second layer 12 and third layer 16, will vary depending on the composition of each layer, the technique used to form the multilayer film, and the intended end use. Additionally, the thickness of outer layers second layer 12 and third layer 16 will vary independently so as to respond effectively to the requirements of packaging machines. In many cases, the outer layer which has to face a product can have a greater thickness in respect of the outer layer facing the environment, and often the product facing outer layer will be from 30 to 50% more thick than the environment facing outer layer. The thickness of outer layers second layer 12 and third layer 16, can independently be any value or range between any of the values recited above.

The methods according to the invention provide mono- and multi-layer films having impact properties, 1% secant modulus, 2% secant modulus, tensile yield, tensile elongation, and increased creep resistance greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

The improvements provided in the present method generally provide a converter more flexibility to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particles.

Compared to using polyethylenes alone, the films containing the polymer blend composition demonstrate a property known in the art as "good

lock up" (maintains shape after stretching) and do not demonstrate ultimate failure, which represents a safety factor for both machine and hand wrap techniques.

More particularly, when films are made according to the methods
5 described herein, the films demonstrate an ultimate break of at least 10%, in some cases at least 20%, in other cases at least 25% and in many instances at least 30% compared with films using the same polyethylenes with no interpolymer resin particles.

The following examples are intended to aid in understanding the
10 present invention, however, in no way, should these examples be interpreted as limiting the scope thereof. Unless noted to the contrary, all percentages are expressed in weight percent.

EXAMPLES

Example 1

This Example 1 relates to styrene-polyethylene interpolymer resin particles comprised of 60% by weight polystyrene and 40% by weight of low-density polyethylene, based on the weight of the interpolymer resin particles.

A mixture of 520 pounds of de-ionized water, 9.6 pounds of tri-calcium
20 phosphate as a suspending agent, and 27 grams of a strong anionic surfactant were charged to a polymerization reactor with the agitator running at 88 rpm to prepare an aqueous medium. The surfactant was Nacconol[®] 90 (Stephan Chemical Co.), which is sodium n-dodecyl benzene sulfonate. The aqueous medium was heated to about 91°C and held for about 10 minutes.
25 Then 112 pounds of low density polyethylene (LDPE) pellets (LA-0218-AF from NOVA Chemicals Inc.), each weighing about 20 milligrams, having a melt index of 2.1 g/10 minutes(190°C/2.16 kg), and a VICAT softening point of about 93°C were added to the aqueous medium. This suspension of beads and water continued to be stirred at 88 rpm. The low temperature polystyrene

initiators, i.e., 373 grams of peroxide (BPO) (75% active) and 70 grams of tertiary butyl perbenzoate (TBP) were dissolved in 84 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 200 minutes. A second batch of 84 pounds of pure styrene
5 was then added to the reactor over 100 minutes at a temperature of 91°C. The reactor contents were held at 91°C for an additional 90 minutes to allow the styrene to soak into and react within the polyethylene. Then the reactor contents were heated to 140°C over 2 hours and held for an additional 4 hours to polymerize the remaining styrene into polystyrene within the
10 polyethylene matrix.

After polymerization, the reactive mixture was cooled and hydrochloric acid was added to dissolve the suspending agents. The resin particles were then washed and dried.

The average gel content for two samples of the resin particles was
15 0.65 weight % based on the weight of the formed interpolymer resin particles. The melt index was 1.046 g/10 minutes (230°C/5.0 kg).

Example 2

This Example 2 relates to interpolymer styrene-polyethylene
20 interpolymer resin particles comprised of 70% by weight polystyrene and 30% by weight low-density polyethylene, based on the weight of the interpolymer resin particles. A mixture of 520 pounds of deionized water, 9.6 pounds of tri-calcium phosphate as a suspending agent, and 27 grams of a strong anionic surfactant (Nacconol® 90) were charged to a polymerization reactor with the
25 agitator running at about 88 rpm to prepare an aqueous medium. The aqueous medium was heated to about 91°C and held for about 10 minutes. Then 84 pounds of low-density polyethylene pellets (LA-0218-AF) were suspended in the aqueous medium. The suspension continued to be stirred at 88 rpm. The low temperature polystyrene initiators, i.e., 356 grams of benzoyl

peroxide (BPO) and 66.8 grams of tertiary butyl perbenzoate (TBP) were dissolved in 98 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 200 minutes. A second batch of 98 pounds of pure styrene was then added to the reactor over 100
5 minutes at a temperature of 91°C. The reactor contents were held at 91°C for an additional 90 minutes to allow the styrene to soak into and react within the polyethylene. Then the reactor contents were heated to 140°C over 2 hours and held at this temperature for an additional 4 hours to polymerize the remaining styrene into polystyrene within the polyethylene matrix.

10 After polymerization, the reactive mixture was cooled and hydrochloric acid was added to dissolve the suspending agents. The resin particles were then washed and dried.

The average gel content for two samples of resin particles was 0.45% by weight based on the weight of the particles. The melt index was 0.501 g/10
15 minutes at (230°/5.0 kg).

Example 3

This Example 3 relates to styrene-polyethylene interpolymer resin particles comprised of 50% by weight polystyrene and 50% by weight low-
20 density polyethylene, based on the weight of the interpolymer resin particles.

A mixture of 520 pounds of de-ionized water, 9.6 pounds of tri-calcium phosphate as a suspending agent, and 27 grams of a strong anionic surfactant (Nacconol[®] 90) were charged to a polymerization reactor with the agitator running at about 88 rpm to prepare an aqueous medium. The
25 aqueous medium was heated to about 91°C and held for about 10 minutes. Then 140 pounds of low-density polyethylene pellets (LA-0218-AF) were suspended in the aqueous medium. The suspension continued to be stirred at 88 rpm. The low temperature polystyrene initiators, i.e., 350 grams of benzoyl peroxide (BPO) and 65.63 grams of tertiary butyl perbenzoate (TBP), were

dissolved in 70 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 200 minutes. A second batch of 70 pounds of pure styrene was then added to the reactor over 100 minutes at a temperature of 91°C. The reactor contents were held at 91°C for
5 an additional 90 minutes to allow the styrene to soak into and react within the polyethylene. Then the reactor contents were heated to 140°C over 2 hours and held for an additional 4 hours to polymerize the remaining styrene into polystyrene within the polyethylene matrix. After polymerization, the reactive mixture was cooled and hydrochloric acid was added to dissolve the
10 suspending agents. The resin particles were then washed and dried.

The average gel content for two samples of resin particles was 0.69% by weight based on the weight of the formed interpolymer resin particles. The melt index was 1.022 g/10 minutes (230°/5.0 kg).

15 Example 4

This Example 4 is similar to Example 1 in that a styrene-polyethylene interpolymer with 60% by to weight polystyrene and 40% by weight low density polyethylene based on the weight of the interpolymer particles was produced. In this Example 4, however, a chain transfer agent was used in an
20 attempt to increase the melt flow rate of the interpolymer resin.

Alpha-methyl styrene dimer (a chain transfer agent) in an amount of 163 grams, i.e., about 0.20 parts per hundred of styrene was added to the suspension with the benzoyl peroxide (BPO) and the tertiary butyl perbenzoate (TBP).

25 The average gel content for two samples of the resin particles was 1.01% by weight based on the weight of the formed interpolymer resin particles. The melt index was 2.688 g/10 minutes (230°/5.0 kg). These results demonstrate that when using a chain transfer agent without a cross-linking agent the melt index was increased compared to Example 1.

Example 5

In this Example 5, interpolymer resin particles were produced containing 60% by weight polystyrene and 40% by weight ethylene vinyl acetate copolymer (EVA), based on the weight of the resin particles. No high temperature cross-linking agent, i.e., dicumyl peroxide initiator was added.

A mixture of 380 pounds of de-ionized water, 13 pounds of tri-calcium phosphate as a suspending agent, and 8.6 grams of Nacconol[®] 90 anionic surfactant were charged to a polymerization reactor with the agitator running at about 102 rpm to prepare an aqueous medium.

The aqueous medium was heated to about 60°C and held for about 30 minutes. Then 125 pounds of a low-density polyethylene vinyl acetate (EVA) pellets containing 4.5% by weight vinyl acetate and 95.5% by weight ethylene (NA 480 from Equistar Chemicals, LP, Houston, Tex.) and having a density of about 0.923 g/cc and a melt index of 0.25 g/10 minutes (190°C/2.16 kg) were suspended in the aqueous medium. The reactor temperature was increased to 85°C. The low temperature polystyrene initiators, i.e., 246 grams of benzoyl peroxide (BPO) and 30 grams of tertiary butyl perbenzoate (TBP), were dissolved in 22.6 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 96 minutes. A second batch of 146 pounds of pure styrene and 5.0 lbs of butyl acrylate was then added to the reactor over 215 minutes. Then the reactor contents were heated and held at 140°C. for over 8 hours to finish the polymerization of styrene within the polyethylene matrix.

After polymerization was completed, the reactive mixture was cooled and removed to a wash kettle where muriatic acid (HCl) was added to dissolve the suspending agents from the pellet surfaces. The pellets were then washed and dried.

The average gel content for two samples of the resin pellets was 0.46 weight % based on the weight of the formed interpolymer resin particles. The melt index of the pellets was 0.21 g/10 minutes (230°C/5.0 kg).

5 Example 6

This Example 6 relates to interpolymer resin particles containing 70% by weight polystyrene based on the weight of the interpolymer resin particles, and 30% by weight of ethylene vinyl acetate copolymer (EVA). The process for making the particles was similar to that for Example 5. The low-density polyethylene vinyl acetate (EVA) used in Example 5 was the same as used in
10 Example 6.

A mixture of 411 pounds of de-ionized water, 9.8 pounds of tri-calcium phosphate as a suspending agent, and 6.5 grams of anionic surfactant (Nacconol® 90) were charged to a polymerization reactor with the agitator
15 running at about 102 rpm to prepare an aqueous medium. The aqueous medium was heated to about 60°C and held for about 30 minutes. Then 87 pounds of the low-density ethylene vinyl acetate pellets were suspended in the aqueous medium. The reactor temperature was increased to 85°C. The low temperature polystyrene initiators, i.e., 246 grams of benzoyl peroxide
20 (BPO) and 30 grams of tertiary butyl perbenzoate (TBP), were dissolved in 22.6 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 96 minutes. A second batch of 146 pounds of pure styrene and 5.0 lbs of butyl acrylate was then added to the reactor over a period of 215 minutes. Then the reactor contents were heated
25 and held at 140°C for over 8 hours to finish the polymerization of styrene within the polyethylene matrix.

After polymerization was completed, the reactive mixture was cooled and removed to a wash kettle where muriatic acid (HCl) was added to

dissolve the suspending agents from the pellet surfaces. The pellets were then washed and dried.

The average gel content for two samples of the resin pellets was 0.32% by weight based on the weight of the formed interpolymer resin particles. The melt index of the pellets was 0.25 g/10 minutes (230°C/5.0 kg).

Examples 7 and 8 below show that the use of dicumyl peroxide for viscbreaking purposes increases the melt index of the resin.

Example 7

This Example 7 relates to interpolymer resin particles containing 60% by weight polystyrene based on the weight of the interpolymer resin particles, and 40% by weight of polypropylene. Dicumyl peroxide was added to viscbreak the polypropylene.

A mixture of 520 pounds of deionized water, 9.6 pounds of tri-calcium phosphate as a suspending agent, and 27 grams of Nacconol 90 were charged to a polymerization reactor with the agitator running at about 88 rpm to prepare an aqueous medium. The aqueous medium was heated to about 91°C and held for about 10 minutes. Then 112 pounds of polypropylene pellets (Huntsman P5M4K-046), each weighing about 20 milligrams and having a MI of 25.5 g/10 minutes (230°C/5.0 kg) were suspended in the aqueous medium. The suspension continued to be stirred at 88 rpm. The low temperature polystyrene initiators, i.e., 473 grams of benzoyl peroxide (BPO) and 145 grams of tertiary butyl perbenzoate (TBP), and 173 grams of dicumyl peroxide (for viscbreaking the polypropylene) were dissolved in 84 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 200 minutes. A second batch of 84 pounds of pure styrene was then added to the reactor over 100 minutes at a temperature of 91°C. The reactor contents were held at 91°C for an additional 90 minutes to allow the styrene to soak into and react with the polypropylene.

Then the reactor contents were heated to 140°C for over 2 hours and held for an additional 4 hours to polymerize the styrene into polystyrene within the matrix of the polyethylene.

After polymerization, the reactive mixture was cooled and removed,
5 and an acid was added to dissolve the suspending agents.

The average gel content for two samples of the resin particles was 0.47% by weight based on the weight of the formed interpolymer resin particles. The melt index was 32.61 g/10 minutes (230°C/5.0 kg).

10 Example 8

This Example 8 relates to interpolymer resin particles containing 70% by weight polystyrene based on the weight of the interpolymer resin particles, and 30% by weight of polypropylene. Dicumyl peroxide was added to the formulation to viscbreak the polypropylene. The process for producing the
15 interpolymer resins is similar to Example 7.

A mixture of 520 pounds of de-ionized water, 9.6 pounds of tri-calcium phosphate as a suspending agent, and 27 grams of an anionic surfactant (Nacconol 90) were charged to a polymerization reactor with the agitator running at about 88 rpm to prepare an aqueous medium. The aqueous
20 medium was heated to about 91°C and held for about 10 minutes. Then 112 pounds of polypropylene pellets (Huntsman P5M4K-046) each weighing about 20 milligrams and having a MI of 25.5 g/10 minutes (230°C/5.0 kg) were suspended in the aqueous medium. The suspension continued to be stirred at 88 rpm. The low temperature polystyrene initiators, i.e., 475 grams
25 of benzoyl peroxide (BPO) (for improved grafting) and 145 grams of tertiary butyl perbenzoate (TBP) (for reducing the styrene residuals), and 173 grams of dicumyl peroxide for viscbreaking the polypropylene were dissolved in 98 pounds of styrene monomer to prepare a monomer solution, and this mixture was pumped into the reactor over 200 minutes. A second batch of 98 pounds

of pure styrene was then added to the reactor over 100 minutes at a temperature of 91°C. The reactor contents were held at 91°C for an additional 90 minutes to allow the styrene to soak into and react within the polypropylene. Then the reactor contents were heated to 140°C for over 2
5 hours and held for an additional 4 hours to polymerize the styrene into polystyrene within the matrix of the polypropylene.

After polymerization was completed, the reactive mixture was cooled and removed, and an acid was added to dissolve the suspending agents.

The average gel content for two samples was 0.41% by weight based
10 on the weight of the formed interpolymer resin particles. The melt index was 21.92 g/10 minutes (230°C/5.0 kg).

The particles produced in Examples 1 to 8 were oven dried at 49°C. and then molded into plaques using an Engel Model 80 injection-molding machine. The mechanical and physical properties were measured and tested
15 according to the standards set up by ASTM. These properties are shown in the table below.

As stated herein above, the flexural and tensile properties of the articles formed from the interpolymer resin particles of the invention have values that range between those values for articles made solely from
20 polystyrene and those values for articles made solely from low-density polyethylene, while the thermal and impact properties of the articles made from the interpolymer resin particles approach that of pure polystyrene.

Property	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Comp. Example 7	Comp. Example 8
Flex Modulus (KSI)	200.52	256.47	170.46	222.63	211.19	269.25	303.89	348.76
Flex Stress@<5% (KSI)	6.67	8.34	5.63	7.55	6.78	NA	9.14	9.08
Strain at Break(Auto)%	2.14	4.43	3.00	5.48	3.17	3.30	2.51	2.07
Stress at Break(Auto)(KSI)	3.69	5.09	3.32	4.54	4.97	4.91	4.88	5.43
YOUNGS Modulus (Auto)(KSI)	NA	281.92	NA	242.02	279.95	281.52	325.65	366.07
IZOD Impact Mean	0.404	0.233	0.490	0.446	0.430	0.338	0.174	0.150
DYNATUP-Total Energy (ft-lbs)	0.43	0.47	0.55	0.50	NA	NA	0.53	0.42
MI (230°C/ 5.0 kg)	1.046	0.501	1.022	2.688	0.21	0.25	32.61	21.92
VICAT-Mean (°C)	101.00	104.8	99.00	101.6	NA	NA	110.2	108.7
Gel wt%(Average)	0.65	0.45	0.69	1.01	0.46	0.32	0.47	0.41

Example 9

A blend containing 98 wt.% FPs 117C (linear low density polyethylene available from NOVA Chemicals) and 2 wt.% of an interpolymer resin particle of 70 wt.% ethylene-vinyl acetate copolymer (EVA)/30 wt.% polystyrene (prepared as described in Example 6) was prepared by compounding on a Leistritz twin screw extruder (co-rotating, inter-meshing, 35/1 – L/D). The blend was processed at temperatures between 190 and 230°C. Vacuum was pulled from one or more of the ports to extract unnecessary volatiles or by-products from the mixtures. The blend was strand cut/pelletized after being cooled with flowing tap water.

The films of the polyethylene alone (PE) and blend (Blend) were produced using a Macro Engineering and Technology blown film line under the following conditions:

Blow Up Ratio (BUR) = 2.5:1

Die Gap: 50 mil

Dual lip air ring

Film Gauge = 1 mil

Melt Temperature = 211°C

Line Speed = 71.8 ft/min.

Resin	Max Output (lb/hr)	Melt Temp (°C)	Current (amps)	Screw Speed (rpm)	Air Ring Pressure (inches of water)
PE	398	234	16.3	58	12.5
Blend	439	233	16.2	64	16

The processing improvement using the blend according to the invention provided a nine percent improved output compared with the polyethylene alone. Qualitative antiblock properties were also observed for the blend.

Example 10

A blend of 90 wt.% SCLAIR FP120-C (linear low density polyethylene available from NOVA Chemicals) and 10 wt.% of the interpolymer resin particle used in Example 9 was prepared as described in Example 9 (90/10 blend). Film samples of the polyethylene (PE) alone and the blend were prepared as described in Example 9. Comparative physical properties of the sheets are shown in the table below.

	PE	90/10 Blend	Improvement (%)
Dart Impact (g/ml)	282	421	49
1% Sec Modulus – MD (MPa)	176	278	58
1% Sec Modulus – TD (MPa)	209	306	46
Tensile Break Str – MD (MPa)	34.4	45.6	33
Tensile Break Str – TD (MPa)	33.0	40.2	22
Elongation at Break – MD (%)	445	588	32
Elongation at Break – TD (%)	693	774	12
Tensile Yield Str – MD (MPa)	10.7	12.8	20
Tensile Yield Str – TD (MPa)	9.9	11.4	15
Tensile Elongation at Yield – MD (%)	16	16	0
Tensile Elongation at Yield – TD (%)	20	15	-25

The blend film demonstrated a 50% modulus increase in both the machine and transverse directions, almost 50% increase in Dart impact, and 30% improvement in tensile and elongation properties over the film that was 100% polyethylene.

Example 11

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5" extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line
5 speed were set at 20 mils and 800 feet per minute, respectively. The (A) layers was SCLAIR® FG220-A (220) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of 2.3 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.920 g/cm³ (ASTM D 792). The core layer (B) was as described in the table below using the interpolymer resin particle
10 described in Example 6 (ex-int). All percentages are expressed in wt.%.

Core Layer (B)	100% 220	90% 220 10% ex-int	80% 220 20% ex-int	60% 220 40% ex-int
Density Column (g/cm ³)	0.9151	0.9201	0.9230	0.9337
Dart Impact (g/mil)	129	183	186	125
1% Secant Modulus MD (MPa)	131	280	380	672
2% Secant Modulus MD (MPa)	122	257	359	626
1% Secant Modulus TD (MPa)	158	185	217	279
2% Secant Modulus TD (MPa)	135	171	194	253
Tensile Elongation MD (%)	396	506	250	108
Tensile Elongation TD (%)	687	647	578	461
Tensile Yield Strength MD (MPa)	10	12	16	20
Tensile Yield Strength TD (MPa)	9	11	11	13
Elmendorf Tear MD (G)	247	91	54	14
Elmendorf Tear TD (G)	484	356	271	23
Highlight Ultimate Strength Test (%)	360	538	126	55

As indicated in the table, the density of the interpolymer resin particle containing films increased with increased interpolymer resin particle loadings. Increases in modulus are also observed with increased interpolymer resin particle loadings. Films with greater moduli offer the advantage of increased stiffness.

Dart impact properties increased up to 20% interpolymer resin particle loading and were lower at 40% interpolymer resin particle loading. Film stiffness doubled with 10% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

The interpolymer resin particle containing films showed lower tear properties. This indicates that films containing the interpolymer resin particles may have increased peelability properties.

In general, The results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particle.

Compared to the pure polyethylene film control, the interpolymer resin particle containing films demonstrated a property known in the art as "good lock up" (maintains shape after stretching) and did not demonstrate ultimate failure, which represents a safety factor for both machine and hand wrap. This property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 330 to 380%. When the in the sample containing 10% interpolymer resin particle core layer (B) was pulled on the Highlight apparatus, the film showed an ultimate break of 510 to 550%.

Example 12

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5" extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line

- speed were set at 20 mils and 800 feet per minute, respectively. The (A) layers was SCLAIR® FG120-A (120) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of 1.0 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.920 g/cm³ (ASTM D 792). The core layer (B) was as described in the table below using the interpolymer resin particle described in Example 6 (ex-int). All percentages are expressed in wt. %.

Core Layer (B)	100% 120	90% 120 10% ex-int	80% 120 20% ex-int
Density Column (g/cm ³)	0.9147	0.9210	0.9225
Dart Impact (g/mil)	246	328	221
1% Secant Modulus MD (MPa)	117	260	399
2% Secant Modulus MD (MPa)	110	248	376
1% Secant Modulus TD (MPa)	148	185	226
2% Secant Modulus TD (MPa)	131	167	201
Tensile Elongation MD (%)	340	353	239
Tensile Elongation TD (%)	669	626	606
Tensile Yield Strength MD (MPa)	8	12	15
Tensile Yield Strength TD (MPa)	8	10	11
Elmendorf Tear MD (G)	349	64	38
Elmendorf Tear TD (G)	589	463	435
Highlight Ultimate Strength Test (%)	249	366	Not measured

- As indicated in the table, the density of the interpolymer resin particle containing films increased with increased interpolymer resin particle loadings. Increases in modulus are also observed with increased interpolymer resin particle loadings. Films with greater moduli offer the advantage of increased stiffness.

Dart impact properties increased up to 10% interpolymer resin particle loading. Film stiffness doubled with 10% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

- 5 The interpolymer resin particle containing films showed lower tear properties. This indicates that films containing the interpolymer resin particles may have increased peelability properties.

In general, the results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by
10 incorporating specific amounts of the present interpolymer resin particles.

Compared to the pure polyethylene film control, the interpolymer resin particle containing films demonstrated a property known in the art as “good lock up” (maintains shape after stretching) and did not demonstrate ultimate failure, which represents a safety factor for both machine and hand wrap. This
15 property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 249%. When the in the sample containing 10% interpolymer resin particle core layer (B) was pulled on the Highlight apparatus, the film showed an ultimate break of 366%.

20 Example 13

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5” extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line
25 speed were set at 20 mils and 800 feet per minute, respectively. Extruder output temperature was between 243°C and 249°C was passed into an extrusion die head to form a continuous multi-layer sheet structure.

The (A) layers were SCLAIR® FG220-A resin (NOVA Chemicals) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of 2.3 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.920 g/cm³

(ASTM D 792). The core layer (B) was as described in the table below using the interpolymers resin particle described in Example 2 (70% polyethylene – 30% polystyrene) [ex-100]. All percentages are expressed in wt.%.

Core Layer (B)	100% FG220	98% FG220 2% ex-100	95% FG220 5% ex-100	90% FG220 10% ex- 100	80% FG220 20% ex- 100	60% FG220 40% ex- 100
Dart Impact (g/mil)	137	238	208	192	186	125
1% Secant Modulus MD (MPa)	128.5	170.0	181.9	259.9	379.9	671.8
2% Secant Modulus MD (MPa)	120.5	161.0	169.0	239.9	358.9	625.8
1% Secant Modulus TD (MPa)	156.5	181.9	196.9	194.9	216.9	278.9
2% Secant Modulus TD (MPa)	135.5	162.0	175.9	178.4	193.9	252.9
Elmendorf Tear MD (g/mil)	250	311	306	158	68	18
Elmendorf Tear TD (g/mil)	545	546	500	431	339	29
Tensile Elongation MD (%)	416	495	495	476	250	108
Tensile Elongation TD (%)	697	734	734	664	578	461
Tensile Yield Strength MD (MPa)	9.75	9.90	10.4	11.6	18.1	20.0
Tensile Yield Strength TD (MPa)	8.90	10.6	10.6	11.0	11.0	13.0
Highlight Ultimate Strength Test (%)	360	531	569	537	126	55

As indicated in the table, increases in modulus are observed with increased interpolymer resin particle loadings. Films with greater moduli offer the advantage of increased stiffness.

Dart impact properties increased, compared to the control, at up to 20% interpolymer resin particle loading. Film stiffness doubled with 10% interpolymer resin particle loading. Elmendorf Tear remained relatively constant up to about 10% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

In general, the results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particles.

Compared to the pure polyethylene film control, films containing up to 10% interpolymer resin particle demonstrated good lock up properties and did not demonstrate ultimate failure, which represents a safety factor for both machine and hand wrap. This property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 360%. For Samples containing up to 10% interpolymer resin particle core layer (B) that were pulled on the Highlight apparatus, the film showed an ultimate break of 530% to 570%.

20

Example 14

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5" extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line speed were set at 20 mils and 800 feet per minute, respectively. Extruder output temperature was between 243°C and 249°C was passed into an extrusion die head to form a continuous multi-layer sheet structure.

The (A) layers were SCLAIR® FG220-A resin (NOVA Chemicals) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of 2.3 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.920 g/cm³

30

(ASTM D 792). The core layer (B) was as described in the table below using the interpolymers resin particle described in Example 6 (70% polyethylene – 30% 96.7%/3.3% styrene-butyl acrylate copolymer) [ex-97/3]. All percentages are expressed in wt. %.

5

Core Layer (B)	100% FG220	98% FG220 2% ex- 97/3	95% FG220 5% ex- 97/3	92% FG220 8% ex- 97/3	90% FG220 10% ex- 97/3	88% FG220 12% 97/3
Dart Impact (g/mil)	137	201	202	240	187	184
1% Secant Modulus MD (MPa)	128.5	166.0	223.9	219.9	249.9	272.9
2% Secant Modulus MD (MPa)	120.5	153.0	207.9	206.9	235.9	251.9
1% Secant Modulus TD (MPa)	156.5	192.9	178.9	202.9	201.4	202.9
2% Secant Modulus TD (MPa)	135.5	172.9	165.0	175.9	176.4	183.9
Elmendorf Tear MD (g/mil)	250	318	285	349	275	225
Elmendorf Tear TD (g/mil)	545	521	525	531	486	440
Tensile Elongation MD (%)	416	538	527	521	494	424
Tensile Elongation TD (%)	697	713	658	712	700	704
Tensile Yield Strength MD (MPa)	9.75	11.2	11.6	11.2	11.6	12.0
Tensile Yield Strength TD (MPa)	8.90	10.4	11.1	10.2	10.0	11.0
Highlight Ultimate Strength Test (%)	360	451	476	464	450	443

As indicated in the table, increases in modulus are observed with increased interpolymer resin particle loadings. Films with greater moduli offer the advantage of increased stiffness.

5 Dart impact properties increased, compared to the control through 12% interpolymer resin particle loading. Film stiffness significantly increased from 2% to 12% interpolymer resin particle loading. Elmendorf Tear remained relatively constant up to 12% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

10 In general, the results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particles.

Compared to the pure polyethylene film control, films containing up to 12% interpolymer resin particle demonstrated good lock up properties and did not demonstrate ultimate failure, which represents a safety factor for both
15 machine and hand wrap. This property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 360%. For Samples containing up to 10% interpolymer resin particle core layer (B) that were pulled on the Highlight apparatus, the film showed an ultimate break of about 450%.

20

Example 15

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5" extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line
25 speed were set at 20 mils and 800 feet per minute, respectively. Extruder output temperature was between 243°C and 249°C was passed into an extrusion die head to form a continuous multi-layer sheet structure.

The (A) layers were SCLAIR® FG220-A resin (NOVA Chemicals) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of
30 2.3 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.920 g/cm³

(ASTM D 792). The core layer (B) was as described in the table below using the interpolymer resin particle described in Example 6, except that the weight ratio of styrene to butyl acrylate used to make the interpolymer resin particles was 90/10 (70% polyethylene – 30% 90%/10% styrene-butyl acrylate copolymer) [ex-90/10]. All percentages at expressed in wt.%.
5

Core Layer (B)	100% FG220	98% FG220 2% ex-90/10	95% FG220 5% ex-90/10	92% FG220 8% ex-90/10	88% FG220 12% ex- 90/10
Dart Impact (g/mil)	137	148	190	251	212
1% Secant Modulus MD (MPa)	128.5	170.0	201.9	206.9	231.9
2% Secant Modulus MD (MPa)	120.5	155.0	186.9	191.9	216.9
1% Secant Modulus TD (MPa)	156.5	158.0	178.9	177.9	184.9
2% Secant Modulus TD (MPa)	135.5	141.0	157.0	157.0	165.0
Elmendorf Tear MD (g/mil)	250	280	302	368	346
Elmendorf Tear TD (g/mil)	545	570	528	516	531
Tensile Elongation MD (%)	416	480	471	492	492
Tensile Elongation TD (%)	697	674	672	688	649
Tensile Yield Strength MD (MPa)	9.75	9.80	10.8	10.4	11.0
Tensile Yield Strength TD (MPa)	8.90	8.7	8.8	9.4	9.8
Highlight Ultimate Strength Test (%)	360	411	424	430	437

As indicated in the table, increases in modulus are observed with increased interpolymer resin particle loadings. Films with greater moduli offer the advantage of increased stiffness.

5 Dart impact properties increased, compared to the control through 12% interpolymer resin particle loading. Film stiffness significantly increased from 2% to 12% interpolymer resin particle loading. Elmendorf Tear remained relatively constant up to 12% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

10 In general, the results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particles.

Compared to the pure polyethylene film control, films containing up to 12% interpolymer resin particle demonstrated good lock up properties and did not demonstrate ultimate failure, which represents a safety factor for both
15 machine and hand wrap. This property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 360%. For Samples containing up to 10% interpolymer resin particle core layer (B) that were pulled on the Highlight apparatus, the film showed an ultimate break of 410% to 440%.

20

Example 16

A/B/A film structures were produced on a Gloucester cast film line equipped with 2.5" extruders. The core layer (B) comprised of 80% of the overall film composition, while film thickness was 0.8 mil. Die lips gap and line
25 speed were set at 20 mils and 800 feet per minute, respectively. Extruder output temperature was between 243°C and 249°C was passed into an extrusion die head to form a continuous multi-layer sheet structure.

The (A) layers were SURPASS® FPs317-A resin (NOVA Chemicals) polyethylene resin (ethylene – octene copolymer), which had a Melt Index of
30 4.0 g/10 min. (ASTM D1238, 190°C/2.16 Kg) and density of 0.917 g/cm³

(ASTM D 792). The core layer (B) was as described in the table below using the interpolymer resin particle described in Example 2 (70% polyethylene – 30% polystyrene) [ex-100] with one exception. A master batch was prepared by mixing interpolymer resin particles ex-100 was into SURPASS FPs317-A

- 5 resin at an 80/20 FPs317/ex-90/10 weight ratio and then mixed into additional SURPASS FPs317-A resin to arrive at the core layer (B) composition in the table below where all percentages at expressed in wt.%.

Core Layer (B)	100% FPs317	90% FPs317 10% ex-100	80% FPs317 20% ex-100
Dart Impact (g/mil)	183	305	296
1% Secant Modulus MD (MPa)	134.0	146.0	163.0
2% Secant Modulus MD (MPa)	125.0	134.0	153.0
1% Secant Modulus TD (MPa)	146.0	143.0	153.0
2% Secant Modulus TD (MPa)	132.0	129.0	141.0
Elmendorf Tear MD (g/mil)	371	428	377
Elmendorf Tear TD (g/mil)	502	510	467
Tensile Elongation MD (%)	577	589	538
Tensile Elongation TD (%)	708	699	742
Tensile Yield Strength MD (MPa)	8.6	9.0	9.6
Tensile Yield Strength TD (MPa)	8.4	8.3	9.5
Highlight Ultimate Strength Test (%)	395	431	410

- As indicated in the table, increases in modulus are observed with increased interpolymer resin particle loadings up to 20%. Films with greater moduli offer the advantage of increased stiffness.

- Dart impact properties increased, compared to the control, when interpolymer resin particles were included in the core (B) layer. Elmendorf Tear remained relatively constant up to about 10% to 20% interpolymer resin particle loading. Films with greater impact properties offer the advantage of increased toughness.

In general, the results indicate that a converter would be able to tailor the tensile and elongational properties of polyethylene-based cast films by incorporating specific amounts of the present interpolymer resin particles.

5 Compared to the pure polyethylene film control, films containing up to 10% interpolymer resin particle demonstrated good lock up properties and did not demonstrate ultimate failure, which represents a safety factor for both machine and hand wrap. This property was simulated on a Highlight stretch apparatus. The pure polyethylene control displayed an ultimate break of 395%. For Samples containing 10% interpolymer resin particle core layer (B)
10 that were pulled on the Highlight apparatus, the film showed an ultimate break of about 430%.

While the present invention has been particularly set forth in terms of specific embodiments thereof, it will be understood in view of the instant disclosure that numerous variations upon the invention are now enabled yet
15 reside within the scope of the invention. Accordingly, the invention is to be broadly construed and limited only by the scope and spirit of the claims now appended hereto.

WHAT IS CLAIMED IS:

1. A method of improving polyethylene stretch film comprising:
providing interpolymer resin particles comprising a styrenic polymer
intercalated within a first polyolefin, wherein the first polyolefin is present at
5 from about 20% to about 80% by weight based on the weight of the particles,
and the styrenic polymer is present at from about 20% to about 80% by
weight based on the weight of the particles;
forming a polyethylene blend composition by blending from about 0.1
to about 25 percent by weight based on the weight of the blend composition
10 of interpolymer resin particles into one or more polyethylene resins; and
forming a first film from the polyethylene blend composition.
2. The method according to Claim 1, wherein the film is formed
using cast film techniques.
15
3. The method according to Claim 1, wherein the film is formed
using extrusion techniques.
4. The method according to any of Claims 1 through 3, wherein the
20 polyethylene blend composition film comprises a first layer of a multilayer film
comprising layers of one or more thermoplastic resins.
5. The method according to any of Claims 1 through 4, wherein the
polyethylene resins of the polyethylene blend composition are selected from
25 the group consisting of high density polyethylene (HDPE), medium density
polyethylene (MDPE), low density polyethylene (LDPE), linear low density
polyethylene (LLDPE), ethylene vinyl acetate, ethylene propylene copolymer,
ethylene butene copolymer, ethylene hexene copolymer, ethylene octene
copolymer, and combinations thereof.

6. The method according to Claim 4, comprising placing one or more second film layers directly contacting the first film, wherein the second film layers independently comprise one or more thermoplastic resins.

5

7. The method according to Claim 4, comprising placing a second film layer over a first surface of the first film and placing a third film layer over a second surface of the first film.

10

8. The method according to Claim 7, wherein the first film comprises from about 20% to about 50% by volume of the multi-layer film, the second film layer comprises from about 20% to about 60% by volume of the multi-layer film, and the third film layer comprises from about 20% to about 50% by volume of the multi-layer film.

15

9. The method according to any of Claims 4 through 8, wherein the second film layer and third film layer are applied using coextrusion techniques.

20

10. The method according to any of Claims 1 through 9, wherein the first polyolefin of the interpolymer resin particles has a VICAT softening temperature greater than 60°C and a melt index of from about 0.3 to about 15 g/10 minutes (230°C/2.16 kg).

25

11. The method according to any of Claims 1 through 10, wherein the interpolymer resin particles have a gel content ranging from about 0 to about 5.0% by weight based on the weight of said interpolymer resin particles, a VICAT softening temperature ranging from about 85°C to about

115°C, and a melt index value ranging from about 0.1 to about 4.0 (230°C/2.16 kg).

12. The method according to any of Claims 1 through 11, wherein
5 the interpolymer resin particles of the polyethylene blend composition are formed by polymerizing polystyrene in the first polyolefin resin particles to form an interpenetrating network of polyolefin resin and polystyrene.

13. The method according to any of Claims 4 through 9, wherein the
10 thermoplastic resins are independently selected from polyolefins, elastomers, polyvinylacetate, copolymers of ethylene and vinyl acetate, copolymers of ethylene and vinyl alcohol, and combinations thereof.

14. The method according to Claim 13, wherein the polyolefins are
15 selected from the group consisting of high density polyethylene (HDPE), medium density polyethylene (MDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), ethylene propylene copolymer, ethylene butene copolymer, ethylene hexene copolymer, ethylene octene copolymer, polypropylene (PP), polybutene, polypentene,
20 polymethylpentene, ethylene propylene rubber (EPR), and combinations thereof.

15. The method to any of Claims 4 through 9, wherein the
25 thermoplastic resins are selected from polyethylene and polypropylene.

16. The method according to Claim 15, wherein the polyethylene is selected from the group consisting of homopolyethylene; copolymers of ethylene and one or more C₃-C₁₀ α-olefins, copolymers ethylene and vinyl

acetate; copolymers of ethylene and butadiene; copolymers ethylene and isoprene; and combinations thereof.

17. The method according to Claim 15, wherein the polypropylene
5 is selected from the group consisting of homopolypropylene; copolymers of propylene and one or more C₂-C₁₀ α-olefins, copolymers propylene and vinyl acetate; copolymers of propylene and butadiene; copolymers propylene and isoprene; and combinations thereof.

10 18. The method according to any of Claims 1 through 17 comprising blending one or more additives into the polyethylene blend composition or thermoplastic resins.

15 19. The method according to Claim 18, wherein the additives are selected from the group consisting of anti-blocking agents, antioxidants, anti-static additives, activators, biodegradation enhancers, cling additives, zinc oxide, chemical foaming agents, colorants, dyes, filler materials, flame retardants, heat stabilizers, impact modifiers, light stabilizers, light absorbers, lubricants, nucleating agents, pigments, plasticizers, processing aids, slip
20 agents, softening agents, and combinations thereof.

20. The method according to Claim 19, wherein the fillers are selected from calcium carbonate, clays, and talc.

25 21. The method according to Claim 19, wherein the cling additives are selected from polybutene, polyisobutylene, polybutadienes, very low-density polyethylene resin (VLDPE), terpene resins, hydrogenated rosins, rosin esters, and combinations thereof.

22. The method according to any of Claims 1 through 21, wherein the film has impact properties greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

5

23. The method according to any of Claims 1 through 21, wherein the film has a 1% secant modulus greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

10

24. The method according to any of Claims 1 through 21, wherein the film has a 2% secant modulus greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

15

25. The method according to any of Claims 1 through 21, wherein the film has a tensile yield strength greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

20

26. The method according to any of Claims 1 through 21, wherein the film has tensile elongation properties greater than the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

25

27. The method according to any of Claims 1 through 21, wherein the film has increased creep resistance compared with the same film where the polyethylene blend composition layer contains the polyethylenes alone with no interpolymer resin particles.

28. A film made according to the method of any one of Claims 1 through 27.

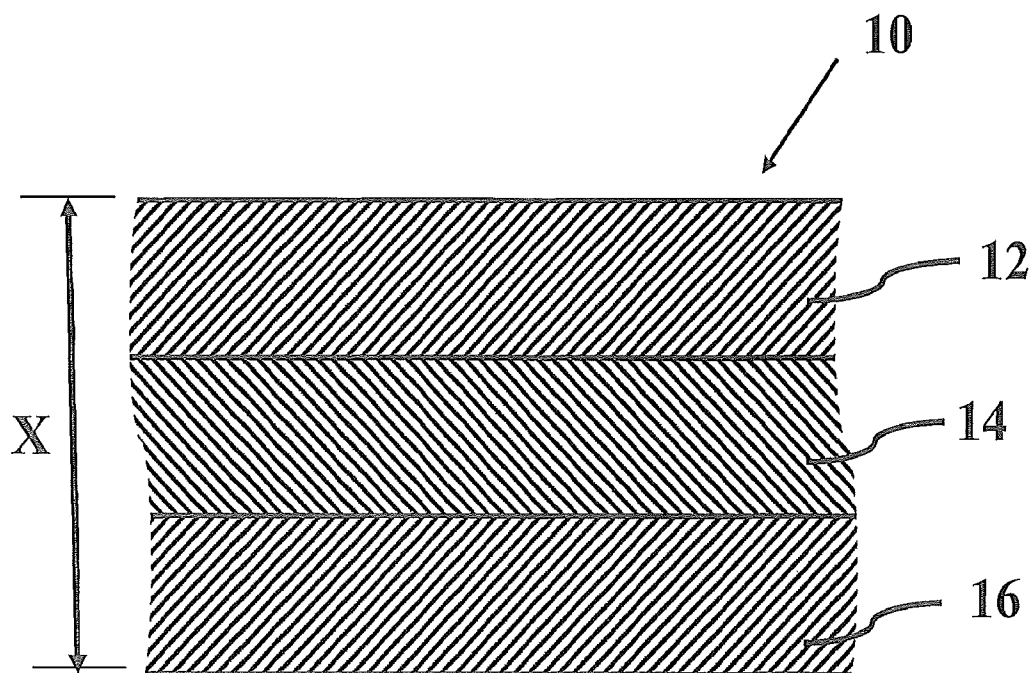


FIG. 1

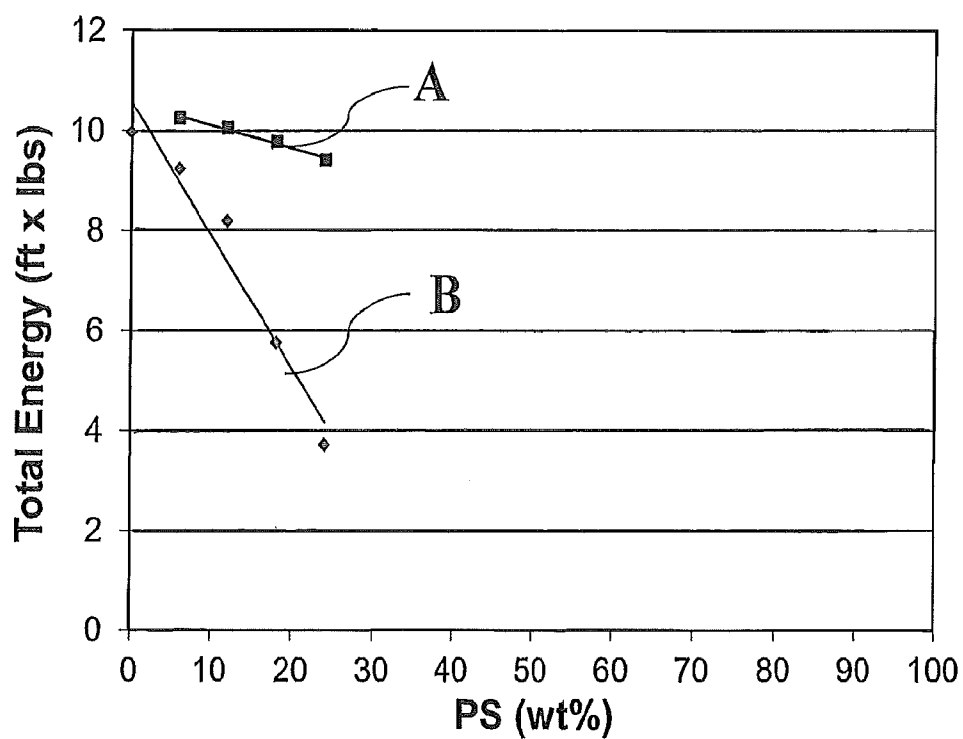


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/25360

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C08L 23/00 (2012.01)

USPC - 428/515

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (8) - C08L 23/00 (2012.01)

USPC - 428/515

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST (PGPB,USPT,USOC,EPAB,JPAB) Terms - intercalated interpolymers polystyrene styrene polypropylene polyolefin olefin butadiene polyethylene mix particles stretch cling film cast extruded masterbatch

Google - (styrene polyolefin interpolymers)-particles polyethylene stretch film extruded cast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2010/0331474 A1 (VIGNOLA) 30 December 2010 (30.12.2010), para [0032], [0038], [0051], [0070], [0087], [0106], [0110], [0146]-[0147]	1-3 ----- 4, 6-8
Y	US 7,411,024 B2 (KRUPINSKI) 12 August 2008 (12.08.2008), col 4, ln 51-54; col 8, ln 66 to col 9, ln 11	4, 6-8
A	US 2005/0282028 A1 (HUBER) 22 December 2005 (22.12.2005), entire document	1-4, 6-8
A	US 5,756,577 A (GUTIERREZ-VILLARREAL) 26 May 1998 (26.05.1998), entire document	1-4, 6-8

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 June 2012 (14.06.2012)

Date of mailing of the international search report

22 JUN 2012

Name and mailing address of the ISA/US

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Facsimile No. 571-273-3201

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/25360

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5, 9-28
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.