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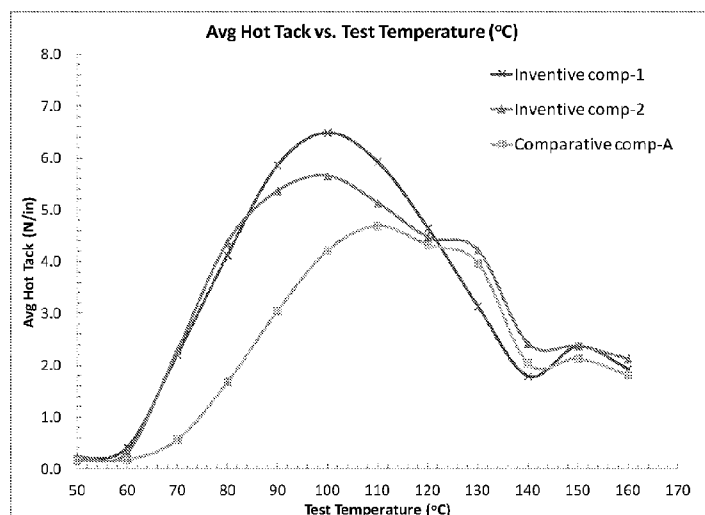


Figure 1

(57) Abstract: Polyethylene-based compositions are provided that can be used, for example, in the formation of film layers. In one aspect, a composition comprises (a) a first linear low density polyethylene having a density of 0.900 to 0.915 g/cm³ and a melt index (I₂) of 5.0 to 25 g/10 min, wherein the linear low density polyethylene is a blend of at least two components: (i) 20-40% by weight of a second linear low density polyethylene, wherein the second linear low density polyethylene is a homogeneously branched ethylene/α-olefin interpolymers having a density of 0.870-0.895 g/cm³ and a melt index (I₂) of 2.0-6.0 g/10 min; and (ii) 60-80% by weight of a third linear low density polyethylene, wherein the density of the third linear low density polyethylene is at least 0.02 g/cm³ greater than the density of the second linear low density polyethylene and wherein the melt index (I₂) of the third linear low density polyethylene is at least twice the melt index (I₂) of the second linear low density polyethylene.

RESIN COMPOSITIONS FOR EXTRUSION COATING

FIELD

The present invention relates generally to resin compositions and in some aspects, resin
5 compositions for extrusion coating that provide high hot tack performance.

INTRODUCTION

It is known that low density polyethylene (LDPE) made by high-pressure polymerization of
ethylene with free-radical initiators as well as homogeneous or heterogeneous linear low density
polyethylene (LLDPE) and ultra low density polyethylene (ULDPE) made by the copolymerization
10 of ethylene and α -olefins with metallocene or Ziegler coordination (transition metal) catalysts at low
to medium pressures can be used, for example, to extrusion coat substrates such as paper board,
paper, and/or polymeric substrates; to prepare extrusion cast film for applications such as disposable
diapers and food packaging; and to prepare extrusion profiles such as wire and cable jacketing.
However, although LDPE generally exhibits excellent extrusion processability and high extrusion
15 drawdown rates, LDPE extrusion compositions typically lack sufficient abuse resistance and
toughness for many applications. For extrusion coating and extrusion casting purposes, efforts to
improve abuse properties by providing LDPE compositions having high molecular weights (i.e.,
having melt index, I2, less than about 2 g/10min) are not generally effective since such compositions
have too much melt strength to be successfully drawn down at high line speeds.

20 While LLDPE and ULDPE extrusion compositions offer improved abuse resistance and
toughness properties, and MDPE (medium density polyethylene) extrusion compositions offer
improved barrier resistance (against, for example, moisture and grease permeation), these linear
ethylene polymers typically exhibit unacceptably high neck-in and draw instability; they also
typically exhibit relatively poor extrusion processability compared to pure LDPE. One proposal
25 commonly used in the industry is to blend LDPE with LLDPE. While the addition of LLDPE to
LDPE provides some improvement in functionality, additional improvements would be desirable.
One area of interest is improved sealant performance especially in hot tack strength for multi-layer
film structures that might be used, for example, in liquid packaging. While some existing resins
provide excellent sealant performance, such resins can be cost prohibitive for some applications or
30 for some film converters.

SUMMARY

The present invention utilizes ethylene-based polymers that can provide desirable sealing properties (e.g., hot tack strength) when incorporated in film structures. For example, in some embodiments, resin compositions of the present invention provide desirable hot tack strength across a broad range of temperatures, with a relatively low heat seal initiation temperature, and at a not very low density.

In one aspect, the present invention provides a composition comprising (a) a first linear low density polyethylene having a density of 0.900 to 0.915 grams per cubic centimeter (g/cm^3) and a melt index (I_2) of 5.0 to 25 grams/10 minutes (g/10 min), wherein the linear low density polyethylene is a blend of at least two components: (i) 20-40% by weight of a second linear low density polyethylene, wherein the second linear low density polyethylene is a homogeneously branched ethylene/ α -olefin interpolpolymer having a density of 0.870-0.895 g/cm^3 and a melt index of 2.0-6.0 g/10 min ; and (ii) 60-80% by weight of a third linear low density polyethylene, wherein the density of the third linear low density polyethylene is at least 0.02 g/cm^3 greater than the density of the second linear low density polyethylene and wherein the melt index (I_2) of the third linear low density polyethylene is at least twice the melt index (I_2) of the second linear low density polyethylene.

These and other embodiments are described in more detail in the Detailed Description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the results of hot tack testing described in the Examples.

DETAILED DESCRIPTION

Unless specified otherwise herein, percentages are weight percentages (wt%) and temperatures are in $^{\circ}\text{C}$.

The term “composition,” as used herein, includes material(s) which comprise the composition, as well as reaction products and decomposition products formed from the materials of the composition.

The term “comprising,” and derivatives thereof, is not intended to exclude the presence of any additional component, step or procedure, whether or not the same is disclosed herein. In order to avoid any doubt, all compositions claimed herein through use of the term “comprising” may

include any additional additive, adjuvant, or compound, whether polymeric or otherwise, unless stated to the contrary. In contrast, the term, “consisting essentially of” excludes from the scope of any succeeding recitation any other component, step or procedure, excepting those that are not essential to operability. The term “consisting of” excludes any component, step or procedure not specifically delineated or listed.

The term “polymer,” as used herein, refers to a polymeric compound prepared by polymerizing monomers, whether of the same or a different type. The generic term polymer thus embraces the term homopolymer (employed to refer to polymers prepared from only one type of monomer, with the understanding that trace amounts of impurities can be incorporated into the polymer structure), and the term interpolymer as defined hereinafter. Trace amounts of impurities may be incorporated into and/or within the polymer.

The term “interpolymer,” as used herein, refers to a polymer prepared by the polymerization of at least two different types of monomers. The generic term interpolymer thus includes copolymers (employed to refer to polymers prepared from two different types of monomers), and polymers prepared from more than two different types of monomers. The term “polymer”, as used herein, refers to a polymeric compound prepared by polymerizing monomers, whether of the same or a different type. The generic term polymer thus embraces the term “homopolymer”, usually employed to refer to polymers prepared from only one type of monomer as well as “copolymer” which refers to polymers prepared from two or more different monomers.

“Polyethylene” shall mean polymers comprising greater than 50% by weight of units which have been derived from ethylene monomer. This includes polyethylene homopolymers or copolymers (meaning units derived from two or more comonomers). Common forms of polyethylene known in the art include Low Density Polyethylene (LDPE); Linear Low Density Polyethylene (LLDPE); Ultra Low Density Polyethylene (ULDPE); Very Low Density Polyethylene (VLDPE); single site catalyzed Linear Low Density Polyethylene, including both linear and substantially linear low density resins (m-LLDPE); Medium Density Polyethylene (MDPE); and High Density Polyethylene (HDPE). These polyethylene materials are generally known in the art; however the following descriptions may be helpful in understanding the differences between some of these different polyethylene resins.

The term, “ethylene/ α -olefin interpolymer,” as used herein, refers to an interpolymer that comprises, in polymerized form, a majority amount of ethylene monomer (based on the weight of the interpolymer), and at least one α -olefin.

The term “LDPE” may also be referred to as “high pressure ethylene polymer” or “highly
5 branched polyethylene” and is defined to mean that the polymer is partly or entirely homopolymerized or copolymerized in autoclave or tubular reactors at pressures above 14,500 psi (100 MPa) with the use of free-radical initiators, such as peroxides (see for example US 4,599,392, which is hereby incorporated by reference). LDPE resins typically have a density in the range of 0.916 to 0.940 g/cm³.

10 The term “LLDPE”, includes both resin made using the traditional Ziegler-Natta catalyst systems as well as single-site catalysts such as metallocenes (sometimes referred to as “m-LLDPE”) and includes linear, substantially linear or heterogeneous polyethylene copolymers or homopolymers. LLDPEs contain less long chain branching than LDPEs and includes the substantially linear ethylene polymers which are further defined in U.S. Patent 5,272,236, U.S.
15 Patent 5,278,272, U.S. Patent 5,582,923 and US Patent 5,733,155; the homogeneously branched linear ethylene polymer compositions such as those in U.S. Patent No. 3,645,992; the heterogeneously branched ethylene polymers such as those prepared according to the process disclosed in U.S. Patent No. 4,076,698; and/or blends thereof (such as those disclosed in US 3,914,342 or US 5,854,045). The LLDPEs can be made via gas-phase, solution-phase or slurry
20 polymerization or any combination thereof, using any type of reactor or reactor configuration known in the art, with gas and slurry phase reactors being most preferred.

The term “MDPE” refers to polyethylenes having densities from 0.926 to 0.940 g/cm³. “MDPE” is typically made using chromium or Ziegler-Natta catalysts or using metallocene, constrained geometry, or single site catalysts, and typically have a molecular weight distribution
25 (“MWD”) greater than 2.5.

The term “HDPE” refers to polyethylenes having densities greater than about 0.940 g/cm³, which are generally prepared with Ziegler-Natta catalysts, chrome catalysts or even metallocene catalysts.

30 Compositions of the present invention can be provided as resins that can be used in various film structures (e.g., a film, a layer in a multi-layer film structure, etc.). Compositions of the present invention can, for example, provide relatively high hot tack when incorporated into a layer of a

multi-layer film structure without a significant reduction in overall density of the layer. One of the downsides of prior attempts to provide resin compositions with higher hot tack was that it required a significant reduction in density. Resin compositions of the present invention advantageously combine a relatively small fraction of a linear low density polyethylene with a very low density and a relatively low melt index (I_2) with a linear low density polyethylene having a higher density and a higher melt index (I_2). Resin compositions of the present invention can have an overall density and overall melt index that facilitate usage of the compositions in extrusion coating applications, extrusion lamination applications, cast film applications, and/or other applications.

As noted above, in some embodiments, the present invention provides a composition comprising (a) a first linear low density polyethylene having a density of 0.900 to 0.915 grams per cubic centimeter (g/cm^3) and a melt index (I_2) of 5.0 to 25 grams/10 minutes (g/10 min), wherein the linear low density polyethylene is a blend of at least two components: (i) 20-40% by weight of a second linear low density polyethylene, wherein the second linear low density polyethylene is a homogeneously branched ethylene/ α -olefin interpolymers having a density of 0.870-0.895 g/cm^3 and a melt index of 2.0-6.0 g/10 min ; and (ii) 60-80% by weight of a third linear low density polyethylene, wherein the density of the third linear low density polyethylene is at least 0.02 g/cm^3 greater than the density of the second linear low density polyethylene and wherein the melt index (I_2) of the third linear low density polyethylene is at least twice the melt index (I_2) of the second linear low density polyethylene.

The inventive composition may comprise a combination of two or more embodiments as described herein.

In some embodiments, the third linear low density polyethylene is a homogeneously branched ethylene/ α -olefin interpolymers, while in other embodiments, the third linear low density polyethylene is a heterogeneously branched ethylene/ α -olefin polymer.

In one embodiment, the first linear low density polyethylene has a melt index (I_2) of 10 to 20 g/10 mins .

In one embodiment, the second linear low density polyethylene has density of 0.890 g/cm^3 or less.

The second linear low density polyethylene, in one embodiment has a melt index of 3.0 to 5.0.

In one embodiment, the density of the third linear low density polyethylene is at least 0.024 g/cm³ greater than the density of the second linear low density polyethylene. The density of the third linear low density polyethylene, in one embodiment, is at least 0.026 g/cm³ greater than the density of the second linear low density polyethylene.

5 In one embodiment, a composition of the present invention further comprises 1 to 99 percent by weight of a high pressure low density polyethylene.

A composition of the present invention, in one embodiment, comprises 10 to 90 percent by weight of the first linear low density polyethylene.

10 In one embodiment, a composition of the present invention further comprises one more resin components in addition to the first linear low density polyethylene.

In one embodiment, a composition of the present invention further comprises one or more additives. In various embodiments, the one or more additives are selected from the group consisting of antioxidants, phosphites, cling additives, pigments, colorants, fillers, nucleators, clarifiers, or combinations thereof.

15 As noted above, in some embodiments, a composition of the present invention is suitable for use, or adapted for use, in extrusion coating applications, extrusion lamination applications, cast film applications, and/or other applications.

Some embodiments of the present invention relate to a film layer formed from any of the inventive compositions as described herein. Some embodiments of the present invention relate to a
20 film comprising at least one film layer formed from any of the inventive compositions as described herein. Some embodiments of the present invention related to an article comprising at least one film layer formed from any of the inventive compositions as described herein.

Compositions of the present invention comprise a first linear low density polyethylene (LLDPE) that is a blend of at least two components, a second linear low density polyethylene and a
25 third linear low density polyethylene. The preferred blends for making the first linear low density polyethylene used in compositions of the present invention can be prepared by any suitable means known in the art including tumble dry-blending, weigh feeding, solvent blending, melt blending via compound or side-arm extrusion, or the like as well as combinations thereof.

The first LLDPE can comprise up to 100 weight percent of the composition. As discussed
30 below, in some embodiments, the composition can comprise a second polyethylene and/or other components. In some embodiments where other components are used, the first LLDPE can

comprise at least 10 weight percent of the first LLDPE. All individual values and subranges from 10 to 100 percent by weight (wt%) are included herein and disclosed herein; for example the amount of the first linear low density polyethylene can be from a lower limit of 10, 20, 30, 40, 50, 60, 70, 80, or 90 wt% to an upper limit of 20, 30, 40, 50, 60, 70, 80, 90, or 100 wt%. For example, the amount of the first linear low density polyethylene can be from 10 to 100 wt%, or in the alternative, from 10 to 90 wt%, or in the alternative, from 20 to 80 wt%, or in the alternative from 30 to 70 wt%.

In some embodiments, the first LLDPE has a density in the range of 0.900 to 0.915 g/cm³. For example, the density can be from a lower limit of 0.900, 0.902, 0.904, 0.906, 0.908, or 0.910 g/cm³, to an upper limit of 0.908, 0.910, 0.912, 0.914, or 0.915 g/cm³.

In one embodiment, the first LLDPE has a melt index (I₂) from 5.0 to 25 g/10 minutes. In some embodiments, the first LLDPE has a melt index (I₂), from 10 to 20 g/10 minutes, or from 10 to 15 g/10 minutes. For example, the melt index (I₂) can be from a lower limit of 5.0, 10, 15, or 20 g/10 minutes, to an upper limit of 15, 20, or 25 g/10 minutes.

In some embodiments the first LLDPE has a composition distribution branching index (CDBI) of 50 to 80. The first LLDPE, in some embodiments, has a CDBI of 50 to 70.

The first LLDPE can be a physical blend of dry materials, with subsequent melt blending, or the first LLDPE can be made in-situ, as described and claimed in U.S. Pat. No. 5,844,045, the disclosure of which is incorporated herein by reference.

A second LLDPE is a first component of the first LLDPE. The second LLDPE can comprise up to 40 weight percent of the first LLDPE. In some embodiments, the second LLDPE can comprise at least 20 weight percent of the composition. All individual values and subranges from 20 to 40 percent by weight (wt%) are included herein and disclosed herein; for example the amount of the second linear low density polyethylene can be from a lower limit of 20, 22, 24, 26, 28, or 30 to an upper limit of 30, 32, 34, 36, 38, or 40 wt%. For example, the amount of the second linear low density polyethylene can be from 22 to 38 wt%, or in the alternative, from 26 to 34 wt%.

The second LLDPE is preferably a homogeneously branched ethylene/ α -olefin interpolpolymer. In one embodiment, the α -olefin has less than, or equal to, 20 carbon atoms. For example, the α -olefin comonomers may preferably have 3 to 10 carbon atoms, and more preferably 3 to 8 carbon atoms. Exemplary α -olefin comonomers include, but are not limited to, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, and 4-methyl-1-pentene. The one or more α -olefin comonomers may, for example, be selected from the group consisting of propylene, 1-

butene, 1-hexene, and 1-octene; or in the alternative, from the group consisting of 1-butene, 1-hexene and 1-octene, and further 1-hexene and 1-octene.

Homogeneous ethylene-based polymers (e.g., ethylene/ α -olefin interpolymers) have a uniform branching distribution, that is, substantially all the polymer molecules have the same amount of comonomer incorporated in each. Composition distribution branching indices (CDBI) have been used to characterize branching distributions (or homogeneity or heterogeneity) and can be determined in accordance with U.S. Pat. No. 5,246,783 using the device described in U.S. Pat. No. 5,008,204, the disclosures of each of which are incorporated herein by reference. CDBI for heterogeneous polymers is between 30 and 70, while the CDBI for homogeneous polymers is between 80 and can be as high as 100.

In some embodiments, the second LLDPE has a density in the range of 0.870 to 0.895 g/cm³. The second LLDPE, in some embodiments, has a density of 0.890 g/cm³ or less. For example, the density can be from a lower limit of 0.870, 0.875, 0.880, or 0.885 g/cm³, to an upper limit of 0.890 or 0.895 g/cm³.

In one embodiment, the second LLDPE has a melt index (I₂) from 2.0 to 6.0 g/10 minutes. In some embodiments, the second LLDPE has a melt index (I₂), from 3.0 to 5.0 g/10 minutes. For example, the melt index (I₂) can be from a lower limit of 2.0, 2.5, 3.0, or 3.5 g/10 minutes, to an upper limit of 4.5, 5.0, 5.5, or 6.0 g/10 minutes.

As set forth above, the second LLDPE combines a very low density with a relatively low melt index. The second LLDPE preferably has a density of 0.870 to 0.895 g/cm³ and a melt index (I₂) of 2.0 to 6.0 g/10 minutes, more preferably a density 0.870 to 0.890 g/cm³ and a melt index of 3.0 to 5.0 g/cm³.

A second component of the first LLDPE is a third LLDPE. The third LLDPE has a higher density and higher melt index than the second LLDPE and is a larger part of the first LLDPE on the basis of weight percentage as set forth below.

The third LLDPE can comprise up to 80 weight percent of the first LLDPE. In some embodiments, the third LLDPE can comprise at least 60 weight percent of the first LLDPE. The third LLDPE preferably comprises 60 to 80 percent by weight of first LLDPE. All individual values and subranges from 60 to 80 percent by weight (wt%) are included herein and disclosed herein; for example the amount of the third linear low density polyethylene can be from a lower limit of 60, 62, 64, 66, 68, or 70 to an upper limit of 70, 72, 74, 76, 78, or 80 wt%. For example, the amount of the

third linear low density polyethylene can be from 62 to 78 wt%, or in the alternative, from 66 to 74 wt%.

The third LLDPE is an ethylene/ α -olefin interpolymers. In one embodiment, the α -olefin has less than, or equal to, 20 carbon atoms. For example, the α -olefin comonomers may preferably have 3 to 10 carbon atoms, and more preferably 3 to 8 carbon atoms. Exemplary α -olefin comonomers include, but are not limited to, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, and 4-methyl-1-pentene. The one or more α -olefin comonomers may, for example, be selected from the group consisting of propylene, 1-butene, 1-hexene, and 1-octene; or in the alternative, from the group consisting of 1-butene, 1-hexene and 1-octene, and further 1-hexene and 1-octene.

The third LLDPE can be heterogeneously branched or homogeneously branched, but is preferably homogeneously branched. Homogeneous ethylene-based polymers have a uniform branching distribution, that is, substantially all the polymer molecules have the same amount of comonomer incorporated in each. Heterogeneously branched ethylene-based polymers (e.g., ethylene/ α -olefin interpolymers) are typically produced using Ziegler/Natta type catalyst system, and have more comonomer distributed in the lower molecular weight molecules of the polymer. Composition distribution branching indices (CDBI) have been used to characterize branching distributions (or homogeneity or heterogeneity) and can be determined in accordance with U.S. Pat. No. 5,246,783 using the device described in U.S. Pat. No. 5,008,204, the disclosures of each of which are incorporated herein by reference. CDBI for heterogeneous polymers is between 30 and 70, while the CDBI for homogeneous polymers is between 80 and can be as high as 100.

In some embodiments, the third LLDPE has a density that is at least 0.02 g/cm³ greater than the density of the second LLDPE. The third LLDPE, in some embodiments, has a density that is at least 0.024 g/cm³ greater than the density of the second LLDPE. In some embodiments, the third LLDPE has a density that is at least 0.026 g/cm³ greater than the density of the second LLDPE. In some embodiments, the density of the third LLDPE is in the range of 0.900 to 0.930 g/cm³. The third LLDPE, in some embodiments, has a density of 0.890 g/cm³ or more, preferably 0.900 g/cm³ or more, more preferably 0.910 g/cm³ or more. The density of the third LLDPE is in the range of 0.910 to 0.920 g/cm³ in some embodiments. For example, the density can be from a lower limit of 0.900, 0.905, 0.910, 0.915 or 0.920 g/cm³, to an upper limit of 0.910, 0.915, 0.920, 0.925, or 0.930 g/cm³.

In some embodiments, the third LLDPE has a melt index (I_2) that is at least twice the melt index of the second LLDPE. The third LLDPE, in some embodiments, has a melt index (I_2) that is at least three times the melt index of the second LLDPE. In some embodiments, the third LLDPE has a melt index (I_2) that is at least four times the melt index of the second LLDPE. In some
5 embodiments, the third LLDPE has a melt index (I_2) from 10 to 30 g/10 minutes. In some
embodiments, the third LLDPE has a melt index (I_2), from 15 to 25 g/10 minutes. For example, the
melt index (I_2) can be from a lower limit of 10, 12.5, 15, 17.5, 20, 22.5, or 25 g/10 minutes, to an
upper limit of 20, 22.5, 25, 27.5, or 30 g/10 minutes.

As set forth above, the third LLDPE combines a density that is at least 0.020 g/cm³ higher
10 than the second LLDPE with a melt index (I_2) the melt index (I_2) of the second LLDPE.

The first LLDPE can comprise other components in some embodiments.

In addition to the first LLDPE, compositions of the present invention can comprise other
components in some embodiments. In some embodiments, compositions of the present invention
can further comprise a second polyethylene resin, such as another ethylene/ α -olefin interpolymers.
15 For example, compositions of the present invention, in some embodiments, can comprise a LDPE
(i.e., a high pressure, low density polyethylene). The LDPE can comprise 1 to 99 percent by weight
of the total composition, alternatively from 3 to 50 percent by weight of the total composition,
alternatively from 10 to 40 percent, more preferably from 15 to 35 percent. In general the more of
the LDPE resin which can be included, the less of the first LLDPE may be needed to achieve good
20 neck-in properties. Such LDPE materials are well known in the art and include resins made in
autoclave or tubular reactors. The preferred LDPE for use as the second polyethylene resin has a
density in the range of from 0.915 to 0.930 g/cm³, preferably from 0.916 to 0.925 g/cm³, more
preferably from 0.917 to 0.920 g/cm³.

Additives such as antioxidants (e.g., hindered phenolics such as Irganox® 1010 or Irganox®
25 1076 supplied by Ciba Geigy), phosphites (e.g., Irgafos® 168 also supplied by Ciba Geigy), cling
additives (e.g., PIB), Standostab PEPQ™ (supplied by Sandoz), pigments, colorants, fillers,
nucleators, clarifiers, and the like can also be included in the compositions of the present invention,
to the extent that they do not substantially interfere with the performance of the composition (e.g., in
extrusion coating applications, extrusion lamination applications, and/or cast film applications).
30 These compositions preferably contain no or only limited amounts of antioxidants as these
compounds may interfere with adhesion to a substrate in some applications. The article made from

or using the inventive composition may also contain additives to enhance antiblocking and coefficient of friction characteristics including, but not limited to, untreated and treated silicon dioxide, talc, calcium carbonate, and clay, as well as primary, secondary and substituted fatty acid amides, chill roll release agents, silicone coatings, etc. Other additives may also be added to
5 enhance the anti-fogging characteristics of, for example, transparent cast films, as described, for example, by Niemann in U.S. Pat. No. 4,486,552, the disclosure of which is incorporated herein by reference. Still other additives, such as quaternary ammonium compounds alone or in combination with ethylene-acrylic acid (EAA) copolymers or other functional polymers, may also be added to enhance the antistatic characteristics of coatings, profiles and films of this invention and allow, for
10 example, the packaging or making of electronically sensitive goods. Other functional polymers such as maleic anhydride grafted polyethylene may also be added to enhance adhesion, especially to polar substrates.

The preferred blends for making the polymer extrusion compositions of this invention can be prepared by any suitable means known in the art including tumble dry-blending, weigh feeding,
15 solvent blending, melt blending via compound or side-arm extrusion, or the like as well as combinations thereof.

The compositions of this invention, whether used in monolayer or multilayered constructions, can be used to make extrusion coatings, extrusion profiles, and extrusion cast films as is generally known in the art. When the inventive composition is used for coating purposes or in
20 multilayered constructions, substrates or adjacent material layers can be polar or nonpolar including for example, but not limited to, paper products, metals, ceramics, glass and various polymers, particularly other polyolefins, and combinations thereof. For extrusion profiling, various articles can potentially be fabricated including, but not limited to, refrigerator gaskets, wire and cable jacketing, wire coating, medical tubing and water piping, where the physical properties of the composition are
25 suitable for the purpose. Extrusion cast film made from or with the inventive composition can also potentially be used in food packaging and industrial stretch wrap applications.

Unless otherwise indicated herein, the following analytical methods are used in the describing aspects of the present invention:

Melt index

30 Melt indices I_2 (or $I2$) and I_{10} (or $I10$) were measured according to ASTM D-1238 at 190°C and at 2.16 kg and 10 kg load, respectively. Their values are reported in g/10 min.

Density

Samples for density measurement were prepared according to ASTM D4703. Measurements were made, according to ASTM D792, Method B, within one hour of sample pressing.

Dynamic Shear Rheology

5 Each sample was compression-molded into “3 mm thick x 25 mm diameter” circular plaque, at 177°C, for 5 minutes, under 10 MPa pressure, in air. The sample was then taken out of the press and placed on a counter top to cool.

Constant temperature, frequency sweep measurements were performed on an ARES strain controlled rheometer (TA Instruments), equipped with 25 mm parallel plates, under a nitrogen purge. 10 For each measurement, the rheometer was thermally equilibrated for at least 30 minutes prior to zeroing the gap. The sample disk was placed on the plate, and allowed to melt for five minutes at 190°C. The plates were then closed to 2 mm, the sample trimmed, and then the test was started. The method had an additional five minute delay built in, to allow for temperature equilibrium. The experiments were performed at 190°C, over a frequency range from 0.1 to 100 rad/s, at five points 15 per decade interval. The strain amplitude was constant at 10%. The stress response was analyzed in terms of amplitude and phase, from which the storage modulus (G'), loss modulus (G''), complex modulus (G^*), dynamic viscosity (η^* or Eta^*), and $\tan \delta$ (or $\tan \delta$) were calculated.

DSC

Differential Scanning Calorimetry (DSC) was measured by a TA Q1000 DSC (TA 20 Instruments; New Castle, DE) equipped with an RCS (Refrigerated Cooling System) cooling accessory and an autosampler module is used to perform the tests. During testing, a nitrogen purge gas flow of 50 ml/minute is used. Each sample is pressed into a thin film and melted in the press at about 175 °C; the melted sample is then air-cooled to room temperature (~25 °C). A 3-10 mg sample of the cooled material is cut into a 6 mm diameter disk, weighed, placed in a light aluminum 25 pan (ca 50 mg), and crimped shut. The sample is then tested for its thermal behavior.

The thermal behavior of the sample is determined by changing the sample temperature upwards and downwards to create a response versus temperature profile. The sample is first rapidly heated to 180 °C and held at an isothermal state for 3 minutes in order to remove any previous thermal history. Next, the sample is then cooled to -40 °C at a 10 °C/minute cooling rate and held at 30 -40 °C for 3 minutes. The sample is then heated to 150 °C at 10 °C/minute heating rate. The cooling and second heating curves are recorded. The values determined are peak melting

temperature (T_m), peak crystallization temperature (T_c), the heat of fusion (H_f). The heat of fusion (H_f) and the peak melting temperature are reported from the second heat curve. The peak crystallization temperature is determined from the cooling curve.

Conventional Gel Permeation Chromatography (conv. GPC)

5 A GPC-IR high temperature chromatographic system from, PolymerChar (Valencia, Spain), was equipped with a Precision Detectors (Amherst, MA), 2-angle laser light scattering detector Model 2040, an IR5 infra-red detector and a 4-capillary viscometer, both from PolymerChar. Data collection was performed using PolymerChAR InstrumentControl software and data collection interface. The system was equipped with an on-line, solvent degas device and pumping system from
10 Agilent Technologies (Santa Clara, CA).

Injection temperature was controlled at 150 degrees Celsius. The columns used were three 10-micron "Mixed-B" columns from Polymer Laboratories (Shropshire, UK). The solvent used was 1,2,4 trichlorobenzene. The samples were prepared at a concentration of "0.1 grams of polymer in 50 milliliters of solvent." The chromatographic solvent and the sample preparation solvent each
15 contained "200 ppm of butylated hydroxytoluene (BHT)." Both solvent sources were nitrogen sparged. Ethylene-based polymer samples were stirred gently at 160 degrees Celsius for three hours. The injection volume was 200 microliters, and the flow rate was 1 milliliters/minute. The GPC column set was calibrated by running 21 "narrow molecular weight distribution" polystyrene standards. The molecular weight (MW) of the standards ranges from 580 to 8,400,000 g/mole, and
20 the standards were contained in six "cocktail" mixtures. Each standard mixture had at least a decade of separation between individual molecular weights. The standard mixtures were purchased from Polymer Laboratories. The polystyrene standards were prepared at "0.025 g in 50 mL of solvent" for molecular weights equal to, or greater than, 1,000,000 g/mole, and at "0.050 g in 50 mL of solvent" for molecular weights less than 1,000,000 g/mole.

25 The polystyrene standards were dissolved at 80°C, with gentle agitation, for 30 minutes. The narrow standards mixtures were run first, and in order of decreasing "highest molecular weight component," to minimize degradation. The polystyrene standard peak molecular weights were converted to polyethylene molecular weight using Equation 1 (as described in Williams and Ward, *J. Polym. Sci., Polym. Letters*, 6, 621 (1968)):

$$30 \quad M_{\text{polyethylene}} = A \times (M_{\text{polystyrene}})^B \quad (\text{Eqn. 1}),$$

where M is the molecular weight, A is equal to 0.4316 and B is equal to 1.0.

Number-average molecular weight ($M_n(\text{conv gpc})$), weight average molecular weight ($M_w(\text{conv gpc})$), and z-average molecular weight ($M_z(\text{conv gpc})$) were calculated according to Equations 2-4 below.

$$M_n(\text{conv gpc}) = \frac{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} (IR_{\text{measurement channel}_i})}{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} \left(IR_{\text{measurement channel}_i} / \text{Log} M_{PE_i} \right)} \quad (\text{Eqn. 2}).$$

$$M_w(\text{conv gpc}) = \frac{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} (\text{Log} M_{PE_i} IR_{\text{measurement channel}_i})}{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} (IR_{\text{measurement channel}_i})} \quad (\text{Eqn. 3}).$$

$$M_z(\text{conv gpc}) = \frac{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} (\text{Log} M_{PE_i}^2 IR_{\text{measurement channel}_i})}{\sum_{i=RV \text{ integration start}}^{i=RV \text{ integration end}} (\text{Log} M_{PE_i} IR_{\text{measurement channel}_i})} \quad (\text{Eqn. 4}).$$

In Equations 2-4, the RV is column retention volume (linearly-spaced), collected at “1 point per second,” the IR is the baseline-subtracted IR detector signal, in Volts, from the IR5 measurement channel of the GPC instrument, and $\text{Log} M_{PE}$ is the polyethylene-equivalent MW determined from Equation 1. Data calculation were performed using “GPC One software (version 2.013H)” from PolymerChar.

Crystallization Elution Fractionation (CEF)

Comonomer distribution analysis is performed with Crystallization Elution Fractionation (CEF) (PolymerChar, Spain) (Monrabal et al, Macromol. Symp. 257, 71-79 (2007)) equipped with IR-4 detector (PolymerChar, Spain) and two angle light scattering detector Model 2040 (Precision Detectors, currently Agilent Technologies). IR-4 detector operates at compositional mode with the two filters of C006 and B057. A 10 micron guard column of 50X4.6 mm (PolymerLab, currently Agilent Technologies) was installed just before IR-4 detector in the detector oven. Ortho-dichlorobenzene (ODCB, 99% anhydrous grade) and 2,5-di-tert-butyl-4-methylphenol (BHT) were purchased from Sigma-Aldrich. Silica gel 40 (particle size 0.2~0.5 mm) was purchased from EMD Chemicals. The silica gel was dried in a vacuum oven at 160°C for about two hours before use. Eight hundred milligrams of BHT and five grams of silica gel were added to two liters of ODCB. ODCB containing BHT and silica gel is now referred to as “ODCB.” This ODCB was sparged with dried nitrogen (N_2) for one hour before use. Dried nitrogen is such that is obtained by passing nitrogen at <90 psig over $CaCO_3$ and 5Å molecular sieves. The resulting nitrogen should have a dew point of approximately -73°C. Sample preparation is done with an autosampler at 4 mg/ml (unless otherwise specified) under shaking at 160°C for 2 hours. The injection volume is 300

ml. The temperature profile of CEF is: crystallization at 3°C/min from 110°C to 30°C, the thermal equilibrium at 30°C for 5 minutes (including Soluble Fraction Elution Time being set as 2 minutes), elution at 3°C/min from 30°C to 140°C. The flow rate during crystallization is 0.052 ml/min. The flow rate during elution is 0.50 ml/min. The data is collected at one data point/second.

- 5 CEF column is packed by the Dow Chemical Company with glass beads at 125 $\mu\text{m} \pm 6\%$ (MO-SCI Specialty Products) with 1/8 inch stainless tubing according to US 2011/0015346 A1. The internal liquid volume of CEF column is between 2.1 and 2.3 mL. Column temperature calibration is performed by using a mixture of NIST Standard Reference Material Linear polyethylene 1475a (1.0mg/ml) and Eicosane (2mg/ml) in ODCB. CEF temperature calibration consists of four steps: ⁽¹⁾
- 10 Calculating the delay volume defined as the temperature offset between the measured peak elution temperature of Eicosane minus 30.00°C; ⁽²⁾ Subtracting the temperature offset of the elution temperature from CEF raw temperature data. It is noted that this temperature offset is a function of experimental conditions, such as elution temperature, elution flow rate, etc.; ⁽³⁾ Creating a linear calibration line transforming the elution temperature across a range of 30.00°C and 140.00°C such
- 15 that NIST linear polyethylene 1475a has a peak temperature at 101.0°C, and Eicosane has a peak temperature of 30.0°C; ⁽⁴⁾ For the soluble fraction measured isothermally at 30°C, the elution temperature is extrapolated linearly by using the elution heating rate of 3°C/min. The reported elution peak temperatures are obtained such that the observed comonomer content calibration curve agrees with those previously reported in US 2011/0015346 A1. The data from this analysis is used
- 20 in the calculation of CDBI as set forth herein.

Hot Tack

- Hot tack measurements on the film are performed using an Enepay commercial testing machines according to ASTM F-1921 (Method B). Prior to testing the samples are conditioned for a minimum of 40hrs at 23°C and 50% R.H. per ASTM D-618 (Procedure A). The hot tack test
- 25 simulates the filling of material into a pouch or bag before the seal has had a chance to cool completely.

- Sheets of dimensions 8.5" by 14" are cut from the three-layer coextruded laminated film, with the longest dimension in the machine direction. Strips 1" wide and 14" long are cut from the film [samples need only be of sufficient length for clamping]. Tests are performed on these samples
- 30 over a range of temperatures and the results reported as the maximum load as a function of

temperature. Typical temperature steps are 5°C or 10°C with 6 replicates performed at each temperature. The parameters used in the test are as follows:

Specimen Width: 25.4 mm (1.0 in)

Sealing Pressure: 0.275 N/mm²

5 Sealing Dwell Time: 1.0 s

Delay time: 0.18s

Peel speed: 200 mm/s

The Enepay machines make 0.5 inch seals. The data are reported as a hot tack curve where Average Hot Tack Force (N) is plotted as a function of Temperature, as for example shown in Figure 1. The
10 Hot Tack Initiation temperature is the temperature required to achieve a pre-defined Minimum Hot Tack Force. This force is typically in the 1-2N range, but will vary depending on the specific application. The ultimate Hot Tack Strength is the peak in the hot tack curve. The Hot Tack Range is the range in temperature at which the seal strength exceeds the Minimum Hot Tack Force.

Comonomer Distribution Branching Index (CDBI)

15 CDBI is determined in accordance with U.S. Pat. No. 5,246,783 using the device described in U.S. Pat. No. 5,008,204, the disclosures of each of which are incorporated herein by reference, relying on data from the Crystallization Elution Fractionation (CEF) analysis set forth above.

EXAMPLES

20 The following examples illustrate the present invention, but are not intended to limit the scope of the invention.

Preparation of Blend Components and Comparative Composition A

Blend Components A and B for use in compositions of the present invention and Comparative Composition A are prepared as follows. All raw materials (monomer and comonomer)
25 and the process solvent (a narrow boiling range high-purity isoparaffinic solvent) are purified with molecular sieves before introduction into the reaction environment. Hydrogen is supplied in pressurized cylinders as a high purity grade and is not further purified. The reactor monomer feed stream is pressurized via a mechanical compressor to above reaction pressure. The solvent and comonomer feed is pressurized via a pump to above reaction pressure. The individual catalyst
30 components are manually batch diluted to specified component concentrations with purified solvent

and pressured to above reaction pressure. All reaction feed flows are measured with mass flow meters and independently controlled with computer automated valve control systems.

The fresh comonomer feed is mechanically pressurized and can be injected into the process at several potential locations depending on reactor configuration which include: only the feed stream for the first reactor, only the feed stream for the second reactor, both the first and second reactor feed streams independently, or into a common stream prior to the solvent split to the two reactors. Some comonomer injection combinations are only possible when running dual reactor configuration.

Reactor configuration options include single reactor operation (for Blend Component A and Blend Component B) and dual series reactor operation (for Comparative Composition A).

The continuous solution polymerization reactor consists of a liquid full, non-adiabatic, isothermal, circulating, loop reactor which mimics a continuously stirred tank reactor (CSTR) with heat removal. Independent control of all fresh solvent, monomer, comonomer, hydrogen, and catalyst component feeds is possible. The total fresh feed stream to the reactor (solvent, monomer, comonomer, and hydrogen) is temperature controlled by passing the feed stream through a heat exchanger. The total fresh feed to the polymerization reactor is injected into the reactor at two locations with approximately equal reactor volumes between each injection location. The fresh feed is controlled with each injector receiving half of the total fresh feed mass flow. The catalyst components are injected into the polymerization reactor through a specially designed injection stinger and are combined into one mixed catalyst/cocatalyst feed stream prior to injection into the reactor. The primary catalyst component feed is computer controlled to maintain the reactor monomer conversion at a specified target. The cocatalyst component(s) is/are fed based on calculated specified molar ratios to the primary catalyst component. Immediately following each fresh injection location (either feed or catalyst), the feed streams are mixed with the circulating polymerization reactor contents with static mixing elements. The contents of the reactor are continuously circulated through heat exchangers responsible for removing much of the heat of reaction and with the temperature of the coolant side responsible for maintaining an isothermal reaction environment at the specified temperature. Circulation around the reactor loop is provided by a pump.

In the dual series reactor configuration (for Comparative Composition A), the effluent from the first polymerization reactor (containing solvent, monomer, comonomer, hydrogen, catalyst

components, and polymer) exits the first reactor loop and is added to the second reactor loop downstream of the second reactor lower pressure fresh feed injection.

In all reactor configurations the final reactor effluent (second reactor effluent for dual series or the single reactor effluent) enters a zone where it is deactivated with the addition of and reaction
 5 with a suitable reagent (typically water). At this same reactor exit location other additives may also be added.

Following catalyst deactivation and additive addition, the reactor effluent enters a devolatilization system where the polymer is removed from the non-polymer stream. The isolated polymer melt is pelletized and collected. The non-polymer stream passes through various pieces of
 10 equipment which separate most of the ethylene which is removed from the system. Most of the solvent and unreacted comonomer is recycled back to the reactor after passing through a purification system. A small amount of solvent and comonomer is purged from the process.

The polymerization conditions for Blend Components A and B are reported in Table 1. The First Reactor Catalyst (CatA) is (tert-butyl(dimethyl(3-(pyrrolidin-1-yl)-1H-inden-1-
 15 yl)silyl)amino)dimethyltitanium. The First Reactor Cocatalyst (CatB) is bis(hydrogenated tallow alkyl)methyl, tetrakis(pentafluorophenyl)borate(1-) amine. The First Reactor Scavenger (CatC) is modified methyl aluminoxane (MMAO).

Table 1

	Units	Blend component A	Blend component B
Reactor Configuration		Single Reactor	Single Reactor
Comonomer		1-octene	1-octene
REACTOR FEEDS			
First Reactor Total Solvent Flow	lb/hr	1999	1123
First Reactor Total Ethylene Flow	lb/hr	297	387
First Reactor Total Comonomer Flow	lb/hr	397	171
First Reactor Hydrogen Feed Flow	SCCM	6466	7761
REACTION			
First Reactor Control Temperature	°C	110	170
First Reactor Ethylene Conversion	%	85.3	90.1
First Reactor Viscosity	cP	213	152

First Reactor Catalyst	type	CatA	CatA
First Reactor Cocatalyst	type	CatB	CatB
First Reactor Scavenger	type	CatC	CatC
First Reactor Catalyst Efficiency	g Polymer/ g catalyst metal	7,431,000	1,329,775
First Reactor Cocatalyst to Catalyst Metal Molar Ratio	Ratio	1.3	1.1
First Reactor Scavenger to Catalyst Metal Molar Ratio	Ratio	8.0	5.0

The polymerization conditions for Comparative Composition A which is made in the dual series reactor configuration are reported in Table 2. The First Reactor Catalyst (CatD) is [N-(1,1-dimethylethyl)-1,1-dimethyl-1-[(1,2,3,4,5-eta.)-2,3,4,5-tetramethyl-2,4-cyclopentadien-1-yl]silanaminato(2-)-.kappa.N][(1,2,3,4-eta.)-1,3-pentadiene]-Titanium. The First Reactor Cocatalyst (CatE) is tris (2,3,4,5,6-pentafluorophenyl) borane. The First Reactor Scavenger (CatC) is modified methyl aluminoxane (MMAO). The Second Reactor Catalyst is a Ziegler-Natta premix. The Second Reactor Cocatalyst (CatF) is triethylaluminum (TEA). Comparative Composition A is comprised of 58% of the First Reactor Component which is a homogeneously branched LLDPE component that has a melt index I₂ of 15 g/10 minutes and a density of 0.9016 g/cm³, and 42% of the Second Reactor Component which is heterogeneously branched LLDPE component that has a melt index of 15 g/10 minutes and a density 0.9219 g/cm³.

Table 2

	Units	Comparative composition A
Reactor Configuration		Dual Series
Comonomer		1-octene
REACTOR FEEDS		
First Reactor Total Solvent Flow	lb/hr	938
First Reactor Total Ethylene Flow	lb/hr	207
First Reactor Total Comonomer Flow	lb/hr	155
First Reactor Hydrogen Feed Flow	SCCM	1,345
Second Reactor Total Solvent Flow	lb/hr	280
Second Reactor Total Ethylene Flow	lb/hr	92
Second Reactor Total Comonomer Flow	lb/hr	96
Second Reactor Hydrogen Feed Flow	SCCM	5,711

REACTION		
First Reactor Control Temperature	°C	135
First Reactor Ethylene Conversion	%	76.0
Second Reactor Control Temperature	°C	190
Second Reactor Ethylene Conversion	%	86.0
First Reactor Catalyst	type	CatD
First Reactor Cocatalyst	type	CatE
First Reactor Cocatalyst2	type	CatC
First Reactor Catalyst Efficiency	g Polymer/ g catalyst metal	800,000
First Reactor Cocatalyst to Catalyst Metal Molar Ratio	Ratio	3.0
First Reactor Cocatalyst2 to Catalyst Metal Molar Ratio	Ratio	5.0
Second Reactor Catalyst	type	Ziegler-Natta premix
Second Reactor CoCatalyst	type	CatF
Second Reactor Catalyst Efficiency	g Polymer/ g catalyst metal	219,000
Second Reactor Al to Ti Molar Ratio	Ratio	4.0

Various properties of Blend Components A and B are measured and reported in Table 3. Blend components A and B are homogeneously branched LLDPEs that can be used to form inventive compositions of the present invention. Blend Component C is a heterogeneously branched LLDPE commercially available from The Dow Chemical Company as DOWLEX™ 2517, and its properties are also measured and reported in Table 2. Blend Component C can be used with Blend Component A to also form inventive compositions of the present invention.

Table 3

	Unit	Blend component A	Blend component B	Blend component C
Type		homo	home	hetero
Density	g/cc	0.887	0.916	0.917
I ₂	g/10 min	4.3	21.6	25.6
I ₁₀ /I ₂		6.1	6.1	6.9
Mn (conv.)	g/mol	36,968	21,390	15,713
Mw (conv.)	g/mol	76,919	48,121	50,639
Mz (conv.)	g/mol	125,250	80,015	127,379
Mw/Mn		2.08	2.25	3.22
Mz/Mw		1.63	1.66	2.52

Eta* (0.1 rad/s)	Pa.s	1,518	329	403
Eta* (1.0 rad/s)	Pa.s	1,496	328	395
Eta* (10 rad/s)	Pa.s	1,330	317	353
Eta* (100 rad/s)	Pa.s	835	252	250
Eta* 0.1/Eta* 100		1.82	1.30	1.61
Tm1	°C	82.6	108.9	123.9
Tm2	°C			117.3
Tm3	°C			107.2
Tc1	°C	63.4	91.3	103.4
CDBI		99.4	82.9	54.6

Preparation of Inventive Compositions

Inventive Compositions 1 and 2 are prepared from Blend Components A, B, & C. Inventive Composition 1 is made using 30% of Blend Component A and 70% of Blend Component B.

- 5 Inventive Composition 2 is made using 30% of Blend Component A and 70% of Blend Component C. Various properties of Inventive Compositions 1 and 2 and of Comparative Composition A compositions are measured and reported in Table 4.

Table 4

	Unit	Inventive Comp. 1 (30% A + 70% B)	Inventive Comp. 2 (30% A + 70% C)	Compar. Comp. A
Type		homo+homo	homo+hetero	homo+hetero
Density	g/cc	0.908	0.910	0.911
I ₂	g/10 min	12.0	14.2	14.5
I ₁₀ /I ₂		6.4	6.7	6.7
Mn (conv.)	g/mol	23,797	18,004	19,288
Mw (conv.)	g/mol	57,200	59,081	51,596
Mz (conv.)	g/mol	102,620	136,899	121,489
Mw/Mn		2.40	3.28	2.68
Mz/Mw		1.79	2.32	2.35
Eta* (0.1 rad/s)	Pa.s	614	555	539
Eta* (1.0 rad/s)	Pa.s	612	545	526
Eta* (10 rad/s)	Pa.s	571	501	480
Eta* (100 rad/s)	Pa.s	414	354	348
Eta* 0.1/Eta* 100		1.49	1.57	1.55
Tm1	°C	107.2	123.2	124.1

Tm2	°C		117.9	115.4
Tm3	°C		105.6	98.6
Tc1	°C	93.7	106.3	99.5
CDBI		67.0	54.1	73.3

Preparation of Coextruded Cast Films

3-layer coextruded cast films are prepared via a Collin cast film line. The cast line consists of two 20mm and one 30mm 25:1 L/D Dr. Collin extruders which have air cooled barrels and water cooled inlet feed zones. All extruders have Xaloy / Nordson barrier type screws. The barrels, the
 5 cooled inlet feed zones. All extruders have Xaloy / Nordson barrier type screws. The barrels, the internals of the die and the feed block are all coated with corrosion resistant coating. The control system consists of the proprietary FECON Dr. Collin software which controls operations. The extrusion process is monitored by pressure transducers located before the breaker plates as well as four heater zones on the 30mm barrel and three heater zones on the 20mm barrels, one each at the
 10 adapters, two on the feedblock, and two zones on the die. The software also tracks the extruder RPM, amps, kg/hr rate, melt pressure (bar), line speed, and melt temperature for each extruder.

Equipment specifications include a Dr Collin three / five layer feed block and a Dr. Collin 250 mm flex lip cast die. The three chill rolls have a polished chrome finish, with the primary 144mm O.D. x 350mm long, and two additional chill rolls 72mm O.D. x 350mm long. The surface
 15 of these rolls is finished to um 5-6. All three chill rolls have chilled water circulating through them to provide quenching, with the addition of a GWK TECO microprocessor controlled temperature control unit for heating the rolls to a maximum of 90° C. Rate is measured by three iNOEX weigh
 20 hoppers with load cells on each hopper for gravimetric control. Film or sheet rolls are wound on a Dr. Collin two position winder on 3" I.D. cores. The takeoff film and sheet slitter station is located before the nip roll with the trim collected below the station on two tension adjustable take-up
 spools. The maximum throughput rate for the line is 12 kg/hr with three extruders, and maximum line speed is 65 m/min.

The cast film consists of 3 layers with a total film thickness of 3.5 mils. The ratio of the three layers is 25% sealant layer, 50% tie layer and 25% back layer. The sealant layer is formed
 25 from 100% of either Inventive Composition 1, Inventive Composition 2, or Comparative Composition A. Inventive Compositions 1 and 2 are formed by weighing the blend components (as indicated in Tables 2 and 3 above), and then tumble blending them for at least 30 minutes before they are fed into the extruder for forming the sealant layer. The tie layer is comprised of a blend of

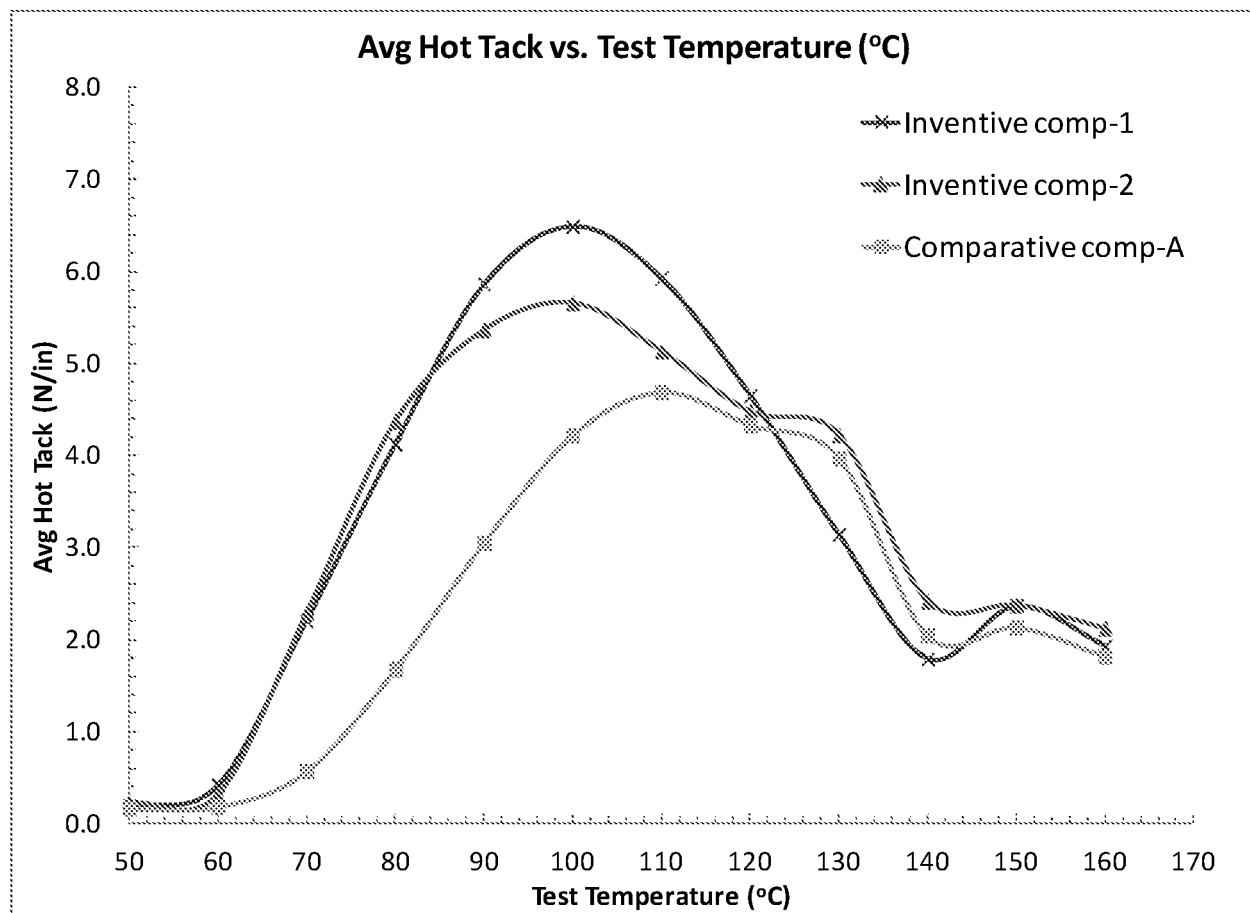
90% ATTANE™ 4202 ULLDPE and 10% AMPLIFY GR 205 Functional Polymer, both of which are commercial resins supplied by The Dow Chemical Company. The two components are weighed and then tumble blended for at least 30 minutes before they are fed into the extruder for forming the tie layer. The back layer is comprised of Ultramid Nylon B36 LN supplied by BASF.

5 The Hot Tack of each of the films is measured as described above, and the results are shown in Figure 1. As shown in Figure 1, Inventive Compositions 1 and 2 each show a substantially higher hot tack strength across a broader range of temperatures than Comparative Composition A. Inventive Compositions 1 and 2 also show a substantial decrease in heat seal initiation temperature relative to Comparative Composition A.

10

CLAIMS

1. A composition comprising:
 - (a) a first linear low density polyethylene having a density of 0.900 to 0.915 g/cm³ and a melt index (I₂) of 5.0 to 25 g/10 min, wherein the linear low density polyethylene is a blend of at least two components:
 - (i) 20-40% by weight of a second linear low density polyethylene, wherein the second linear low density polyethylene is a homogeneously branched ethylene/α-olefin interpolpolymer having a density of 0.870-0.895 g/cm³ and a melt index (I₂) of 2.0-6.0 g/10 min; and
 - (ii) 60-80% by weight of a third linear low density polyethylene, wherein the density of the third linear low density polyethylene is at least 0.02 g/cm³ greater than the density of the second linear low density polyethylene and wherein the melt index (I₂) of the third linear low density polyethylene is at least twice the melt index (I₂) of the second linear low density polyethylene.
2. The composition of claim 1, wherein the third linear low density polyethylene is a homogeneously branched ethylene/α-olefin interpolpolymer.
3. The composition of claim 1, wherein the third linear low density polyethylene is a heterogeneously branched ethylene/α-olefin interpolpolymer.
4. The composition of any of the preceding claims, wherein the first linear low density polyethylene has a melt index of 10 to 20 g/10 minutes.
5. The composition of any of the preceding claims, wherein the second linear low density polyethylene has a density of 0.890 g/cm³ or less.
6. The composition of any of the preceding claims, wherein the second linear low density has a melt index of 3.0 to 5.0.
7. The composition of any of the preceding claims, wherein the density of the third linear low density polyethylene is at least 0.024 g/cm³ greater than the density of the second linear low density polyethylene.
8. The composition of any of the preceding claims, wherein the composition further comprises 1 to 99 percent by weight of a high pressure low density polyethylene.
9. A film comprising at least one layer made from the composition of any of the preceding claims.
10. An article comprising at least one film layer according to claim 9.

**Figure 1**

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/029344

A. CLASSIFICATION OF SUBJECT MATTER

INV. C08L23/08

ADD.

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)

C08L

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 747 594 A (DEGROOT JACQUELYN A [US] ET AL) 5 May 1998 (1998-05-05) abstract column 9, line 33 - line 65 example 27; table 6 column 22, line 15 - line 59 column 32, line 50 - line 62 -----	1-10
A	WO 2009/139957 A2 (EXXONMOBIL OIL CORP [US]; LU PANG-CHIA [US]) 19 November 2009 (2009-11-19) claim 1 paragraph [0040] -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* 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

17 June 2016

Date of mailing of the international search report

29/06/2016

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/029344

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

see form PCT/ISA/220

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/US2016/029344

International filing date (day/month/year)
26.04.2016

Priority date (day/month/year)
13.05.2015

International Patent Classification (IPC) or both national classification and IPC
INV. C08L23/08

Applicant
DOW GLOBAL TECHNOLOGIES LLC

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



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Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer

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Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - ☒ the international application in the language in which it was filed.
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed:
 - ☐ in the form of an Annex C/ST.25 text file.
 - ☐ on paper or in the form of an image file.
 - b. ☐ furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
 - ☐ in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
 - ☐ on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>2, 8-10</u>
	No: Claims	<u>1, 3-7</u>
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-10</u>
Industrial applicability (IA)	Yes: Claims	<u>1-10</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reference is made to the following documents:

- D1 US 5 747 594 A (DEGROOT JACQUELYN A [US] ET AL) 5 May 1998
 (1998-05-05)
- D2 WO 2009/139957 A2 (EXXONMOBIL OIL CORP [US]; LU PANG-CHIA
 [US]) 19 November 2009 (2009-11-19)

1. Novelty (Art. 33(2) PCT)

1.1 D1 relates to polyolefin compositions having high heat resistivity and which can be fabricated into films and which are suitable for use in multilayer film structures as a sealant layer (abstract).

D1 discloses a composition comprising 37 wt% of a substantially linear ethylene polymer having a density of 0.870 g/cm³ and an MFR of 3.0 g/10 min, and 63 wt% of a heterogeneously branched linear ethylene polymer having a density of 0.941 g/cm³ and an MFR of 58 g/10 min. The density of the blend is 0.9135 g/cm³ and the MFR is 19.48 g/10 min (table 6, example 27). It can be assumed that the polyethylene of example is produced from ethylene and octene (column 32, lines 50-62; column 22, lines 15-59). It can also be assumed that the first polyethylene, the substantially linear polyethylene, is also homogeneously branched (column 9, lines 33-65; see also item VIII 1.).

Hence, D1 discloses all the technical features of claims 1 and 3-7. The subject matter of these claims is therefore not novel over D1.

1.2 D2 discloses a composition comprising a first linear LLDPE having a density within the range of from 0.890 to 0.920 g/cm³ and an I₂ within the range of from 0.1 to 4.0 g/10 min; and from 80 to 20 wt%, by weight of the core layer, of a second LLDPE having a density within the range of from 0.900 to 0.935 g/cm³ and an I₂ within the range of from 0.5 to 10.0 g/min; wherein the density of the second LLDPE is greater than the density of the first LLDPE by at least 0.002 g/cm³; and/or the I₂ of the second LLDPE is greater than the I₂ of the first LLDPE by at least 0.5 g/10 min (claim 1).

D2 is silent about the density and the MFR of the whole composition. In none of the examples, an ethylene polymer with a density of 0.870-0.895 g/cm³ as required in claim 1 of the present application has been used (paragraph 40).

The subject matter of claims 1-10 is therefore novel over D2.

2. Inventive step (Art. 33(3) PCT)

2.1 D1 may be considered as closest prior art to the subject matter of claim 1 (see 1.1).

D1 already anticipates the subject matter of claims 1 and 3-7 (see 1.1). The subject matter of these claims is therefore not inventive.

Dependent claims 2 and 8 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, unless a surprising advantageous technical effect associated with any of the additional effects can be shown. The second ethylene polymer of D1 (corresponding to the third polyethylene of present claim 1) can also be a homogeneously branched ethylene polymer (claim 1 of D1). The addition of further polymers like high pressure low density polyethylene does not appear inventive either.

Since D1 already points to the production of films from the claimed compositions (see e.g. abstract), the subject matter of claims 9 and 10 is not inventive either. Even if novelty was established by a more precise definition of "homogeneously branched", this would not render claim 1 inventive over D1 in the absence of a surprising advantageous technical effect.

Re Item VII

1. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1 is not mentioned in the description, nor is this document identified therein.

Re Item VIII

1. Claim 1 is unclear (Art. 6 PCT) because the expression "homogeneously branched" is unclear. The description contains a more precise definition (page 8, lines 8-10) which should be contained in the claim. The same applies to claim 2 and to claim 3 (with regard to "heterogeneously branched").
2. The expression "incorporated herein by reference" or expressions similar to this used on pages 4, 7-9, 11 and 16 are not allowable (see PCT-Guidelines 4.26).
3. The units ", inch, lb/hr and mils employed on pages 15, 18, 19 (table 2) and 22 are not additionally expressed in /terms of the units stipulated by Rule 10.1/(a)/and/(b) PCT.