

POLYOLEFIN COMPOSITIONS WITH EXCELLENT IMPACT STRENGTH
AND LIGHT TRANSMITTANCE

BACKGROUND OF THE INVENTION

5 Ethylene/alpha-olefin elastomers have been used for several decades as impact modifiers to polypropylene. Such TPO compounds are prevalent in the automotive industry, where they are used to make interior and exterior car parts, such as bumper fascia, interior door panels, airbag covers, and many other components. Currently there is a new trend for translucent parts on electric vehicles, and particularly, the ability of the front grill and/or rear
10 bumper to transmit light. These translucent designed features are not realized with current TPO compositions. There is a need for new compositions that provide excellent mechanical properties (for example, toughness and stiffness) and excellent optical properties (for example, the percent transmittance of light). In addition, these features need to remain sufficient over a wide temperature range (for example, 0°C to 60°C).

15 U.S. Patent 8,921,491 discloses an impact modified composition comprising ethylene-alpha-olefin (block) interpolymers, characterized by an average block index, ABI, which is greater than zero and up to about 1.0, and a molecular weight distribution, MWD, greater than about 1.3. In addition, or alternatively, the block ethylene/alpha-olefin interpolymers is characterized by having at least one fraction obtained by Temperature Rising Elution
20 Fractionation (TREF), and wherein the fraction has a block index greater than about 0.3 and up to about 1.0, and the ethylene/alpha-olefin interpolymers has a molecular weight distribution, MWD, greater than about 1.4 (see abstract). The “soft segment T_m (°C) from the weighted DSC” of several of polymers are listed in Table 16 (see column 72, lines 6-29). See, for example, Table 27 (column 81) and Table 32 (column 85) for compositions
25 containing a propylene homopolymer.

 U.S. Patent 7,893,166 discloses a class of ethylene/alpha-olefin block interpolymers characterized by an average block index, ABI, which is greater than zero and up to about 1.0, and a molecular weight distribution, MWD, greater than about 1.3. Preferably, the block index is from about 0.2 to about 1. In addition, or alternatively, the block ethylene/alpha-
30 olefin interpolymers is characterized by having at least one fraction obtained by Temperature Rising Elution Fractionation (TREF), wherein the fraction has a block index greater than about 0.3 and up to about 1.0, and the ethylene/alpha-olefin interpolymers has a molecular weight distribution, MWD, greater than about 1.3 (see abstract). The “soft segment T_m (°C)

from the weighted DSC” of several polymers are listed in Table 16 (see column 60, lines 11-35). This patent discloses polymers for blending, which include polypropylene (see for example, column 25, lines 11-33). See also U.S. Patent 7,608,668.

U.S. Patent 10,557,005 discloses a painted article that includes a primer layer between
5 a substrate and a paint layer. The substrate is the product of a substrate forming composition including an olefin block copolymer and a polypropylene polymer having a density from 0.89 g/cc and 0.92 g/cc (see abstract). Such compositions, containing a majority amount of the olefin block copolymer, are shown in Tables 4 and 5.

Additional compositions and/or parts (such as automotive parts) are described in the
10 following references: U.S. Patent 7947793, U.S. Patent 8084537, U.S. Patent 7592397, U.S. Patent 7863379, U.S. Patent 8573665, U.S. Patent 5925703, U.S. Patent 8455087, U.S. Patent 7741397, U.S. Publication 2015/0291085, U.S. Publication 2012/0313392, International Publication WO2014/036292 and GB2552996A,

However, as discussed above, there remains a need for new compositions that provide
15 excellent mechanical properties and excellent optical properties, which remain sufficient over a wide temperature range. This need has met by the following invention.

SUMMARY OF THE INVENTION

A composition comprising a first composition that comprises at least the following
20 *components a and b*:

- a)* at least one ethylene/alpha-olefin multi-block interpolymers that comprises a density ≥ 0.870 g/cc and a soft segment melting temperature (SS-T_m) $\leq 35^{\circ}\text{C}$;
- b)* a polymer composition comprising at least one propylene homopolymer, and wherein the *component a* is present in an amount ≤ 50 wt%, based on the weight of
25 *components a and b*.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts the “Melt Enthalpy (J/g) versus Temperature ($^{\circ}\text{C}$)” for linear copolymers as described herein. Figure 2 depicts three test samples (ductile, semi-brittle and
30 brittle) from the Multiaxial Dart Impact (Dart Ductility) test. Figure 3 depicts pictures of two TPO plaques on a LED light source.

DETAILED DESCRIPTION OF THE INVENTION

Compositions have been discovered that have excellent mechanical properties (for example, toughness and stiffness) and excellent optical properties (for example, light transmittance and light diffusion). Moreover, these properties remain sufficient over a wide temperature range (for example, 0°C to 60°C).

As discussed above, a composition is provided, and which comprises a first composition that comprises at least the following *components a* and *b*: *a*) at least one ethylene/alpha-olefin multi-block interpolymers that comprises a density ≥ 0.870 g/cc and a soft segment melting temperature (SS-Tm) $\leq 35^\circ\text{C}$; *b*) a polymer composition comprising at least one propylene homopolymer, and wherein the *component a* is present in an amount ≤ 50 wt%, based on the weight of *components a* and *b*.

The above composition may comprise a combination of two or more embodiments, as described herein. The first composition may comprise a combination of two or more embodiments, as described herein. Each *component a* and *b* may independently comprise a combination of two or more embodiments, as described herein.

In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolymers (of *component a*) has a density ≥ 0.870 g/cc, or ≥ 0.871 g/cc, or ≥ 0.872 g/cc, or ≥ 0.873 g/cc, or ≥ 0.874 g/cc, or ≥ 0.875 g/cc, or ≥ 0.876 g/cc, or ≥ 0.877 g/cc, or ≥ 0.878 g/cc, or ≥ 0.879 g/cc, or ≥ 0.880 g/cc, or ≥ 0.881 g/cc, or ≥ 0.882 g/cc, or ≥ 0.883 g/cc, or ≥ 0.884 g/cc. In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolymers (of *component a*) has a density ≤ 0.910 g/cc, or ≤ 0.908 g/cc, or ≤ 0.906 g/cc, or ≤ 0.904 g/cc, or ≤ 0.902 g/cc, or ≤ 0.900 g/cc, or ≤ 0.898 g/cc, or ≤ 0.896 g/cc, or ≤ 0.894 g/cc, or ≤ 0.892 g/cc, or ≤ 0.890 g/cc, or ≤ 0.889 g/cc, or ≤ 0.888 g/cc, or ≤ 0.887 g/cc.

In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolymers (of *component a*) has a SS-Tm $\leq 35^\circ\text{C}$, or $\leq 30^\circ\text{C}$, or $\leq 25^\circ\text{C}$, or $\leq 20^\circ\text{C}$, or $\leq 18^\circ\text{C}$, or $\leq 16^\circ\text{C}$, or $\leq 14^\circ\text{C}$, or $\leq 12^\circ\text{C}$, or $\leq 10^\circ\text{C}$, or $\leq 9^\circ\text{C}$, or $\leq 8^\circ\text{C}$, or $\leq 7^\circ\text{C}$, or $\leq 6^\circ\text{C}$. In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolymers (of *component a*) has a SS-Tm $\geq -20^\circ\text{C}$, or $\geq -18^\circ\text{C}$, or $\geq -16^\circ\text{C}$, or $\geq -14^\circ\text{C}$, or $\geq -12^\circ\text{C}$, or $\geq -10^\circ\text{C}$, or $\geq -8^\circ\text{C}$, or $\geq -6^\circ\text{C}$, or $\geq -4^\circ\text{C}$, or $\geq -2^\circ\text{C}$, or $\geq -1^\circ\text{C}$, or $\geq 0^\circ\text{C}$, or $\geq 1^\circ\text{C}$, or $\geq 2^\circ\text{C}$, or $\geq 3^\circ\text{C}$, or $\geq 4^\circ\text{C}$.

In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) is an ethylene/alpha-olefin multi-block copolymer.

5 In one embodiment, or a combination of two or more embodiments, each described herein, the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a melt index (MI or I2) ≥ 0.1 , or ≥ 0.2 , or ≥ 0.3 , or ≥ 0.4 , or ≥ 0.5 g/10 min and/or ≤ 50 , or ≤ 45 , or ≤ 40 , or ≤ 35 , or ≤ 30 , or ≤ 28 , or ≤ 26 , or ≤ 24 , or ≤ 22 , or ≤ 20 , or ≤ 18 , or ≤ 16 , or ≤ 14 , or ≤ 12 , or ≤ 10 , or ≤ 9.0 , or ≤ 8.0 , or ≤ 7.0 , or ≤ 6.0 , or ≤ 5.0 g/10 min.

10 In one embodiment, or a combination of two or more embodiments, each described herein, the propylene homopolymer (of *component b*) has a melt flow rate (MFR) ≥ 1.0 , or ≥ 2.0 , or ≥ 3.0 , or ≥ 4.0 , or ≥ 5.0 , or ≥ 10 , or ≥ 20 , or ≥ 25 g/10 min and/or ≤ 200 , or ≤ 150 , or ≤ 100 , or ≤ 90 , or ≤ 80 , or ≤ 75 , or ≤ 70 , or ≤ 68 , or ≤ 66 g/10 min.

In one embodiment, or a combination of two or more embodiments, each described herein, *component b* comprises at least two propylene homopolymers (first and second), and
15 wherein the melt flow rate of the first homopolymer (MFR_{hPP1}) is greater than the melt flow rate of the second homopolymer (MFR_{hPP2}).

In one embodiment, or a combination of two or more embodiments, each described herein, wherein the melt flow rate of the first homopolymer (MFR_{hPP1}) is ≥ 10 , or ≥ 20 , or ≥ 40 , or ≥ 60 , or ≥ 80 , or ≥ 100 g/10 min and/or ≤ 1000 , or ≤ 800 , or ≤ 600 , or ≤ 400 , or ≤ 300 ,
20 or ≤ 200 , or ≤ 150 , or ≤ 120 g/10 min.

In one embodiment, or a combination of two or more embodiments, each described herein, wherein the ratio of the MFR_{hPP1}/ MFR_{hPP2} is > 1.0 , or ≥ 2.0 , or ≥ 5.0 , or ≥ 7.0 , or ≥ 10 and/or ≤ 50 , or ≤ 45 , or ≤ 40 , or ≤ 35 , or ≤ 30 .

In one embodiment, or a combination of two or more embodiments, each described
25 herein, wherein the weight ratio of the first propylene homopolymer to the second propylene homopolymer is ≥ 0.10 , or ≥ 0.20 , or ≥ 0.40 , or ≥ 0.50 , or ≥ 0.60 , or ≥ 0.80 , or ≥ 1.0 , or ≥ 1.2 , or ≥ 1.4 , or ≥ 1.5 and/or ≤ 10 , or ≤ 8.0 , or ≤ 6.0 , or ≤ 4.0 , or ≤ 2.0 , or ≤ 1.8 , or ≤ 1.6 .

In one embodiment, or a combination of two or more embodiments, each described herein, the weight ratio of *component b* to *component a* is ≥ 1.0 , or ≥ 1.2 , or ≥ 1.4 , or ≥ 1.6 , or
30 ≥ 1.8 and/or ≤ 10 , or ≤ 9.0 , or ≤ 8.0 , or ≤ 7.0 , or ≤ 6.0 , or ≤ 5.5 , or ≤ 5.0 , or ≤ 4.5 , or ≤ 4.0 , or ≤ 3.5 , or ≤ 3.0 .

In one embodiment, or a combination of two or more embodiments, each described herein, the first composition comprises ≥ 80 wt%, or ≥ 85 wt%, or ≥ 90 wt%, or ≥ 92 wt%, or

≥ 94 wt%, or ≥ 96 wt%, or ≥ 98 wt% of the sum of *components a and b*, based on the weight of the first composition. In one embodiment, or a combination of two or more embodiments, each described herein, the first composition comprises ≤ 100 wt%, or ≤ 99 wt% of the sum of *components a and b*, based on the weight of the first composition.

- 5 In one embodiment, or a combination of two or more embodiments, each described herein, the first composition comprises at least two crystallization peaks (first peak and second peak), and wherein the second peak and the first peak are the peaks with highest and second highest crystallization temperatures, respectively, and wherein the second and first peaks each, independently, has a crystallization temperature ≥ 100 °C.
- 10 In one embodiment, or a combination of two or more embodiments, each described herein, the first crystallization peak has a crystallization temperature $\geq 100^{\circ}\text{C}$, or $\geq 102^{\circ}\text{C}$, or $\geq 104^{\circ}\text{C}$, or $\geq 106^{\circ}\text{C}$, or $\geq 108^{\circ}\text{C}$, or $\geq 110^{\circ}\text{C}$, or $\geq 116^{\circ}\text{C}$ or $\geq 112^{\circ}\text{C}$, or $\geq 114^{\circ}\text{C}$, or $\geq 116^{\circ}\text{C}$ and/or $\leq 140^{\circ}\text{C}$, or $\leq 138^{\circ}\text{C}$, or $\leq 138^{\circ}\text{C} \leq 134^{\circ}\text{C}$, or $\leq 132^{\circ}\text{C}$, or $\leq 130^{\circ}\text{C}$, or $\leq 128^{\circ}\text{C}$, or $\leq 126^{\circ}\text{C}$, or $\leq 124^{\circ}\text{C}$.
- 15 In one embodiment, or a combination of two or more embodiments, each described herein, the second crystallization peak has a crystallization temperature $\geq 5^{\circ}\text{C}$, or $\geq 7^{\circ}\text{C}$, or $\geq 10^{\circ}\text{C}$, or $\geq 12^{\circ}\text{C}$, or $\geq 14^{\circ}\text{C}$, or $\geq 16^{\circ}\text{C}$, or $\geq 18^{\circ}\text{C}$ or $\geq 20^{\circ}\text{C}$, or $\geq 22^{\circ}\text{C}$, or $\geq 25^{\circ}\text{C}$, or $\geq 27^{\circ}\text{C}$, or $\geq 30^{\circ}\text{C}$, or $\geq 32^{\circ}\text{C}$, or $\geq 35^{\circ}\text{C}$, or $\geq 37^{\circ}\text{C}$, or $\geq 40^{\circ}\text{C}$, or $\geq 42^{\circ}\text{C}$ or $\geq 45^{\circ}\text{C}$, or $\geq 47^{\circ}\text{C}$, or $\geq 50^{\circ}\text{C}$ higher than the crystallization temperature of the first crystallization peak.
- 20 In one embodiment, or a combination of two or more embodiments, each described herein, the intensity (in watts/g) of each of the first crystallization peak and the second crystallization peak, independently, meets the following relationship: [(Peak Intensity) – (average baseline intensity)] ≤ -0.05 , further ≤ -0.10 , further ≤ -0.15 , further ≤ -0.20 , further ≤ -0.25 , further ≤ -0.30 watts/g, further ≤ -0.35 . The “average baseline intensity (in watts/g)” =
25 [(heat flow (watts/g) at 160°C) – (heat flow (watts/g) at -40°C)] / 2.
In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a MFR ≥ 5.0 , or ≥ 7.0 , or ≥ 10 , or ≥ 12 , or ≥ 15 , or ≥ 18 , or ≥ 20 g/10 min and/or ≤ 50 , or ≤ 45 , or ≤ 40 , or ≤ 35 , or ≤ 30 , or ≤ 25 g/10 min.
In one embodiment, or a combination of two or more embodiments, each described
30 herein, the composition has a Light Transmittance (3.2 mm thickness), at RT (23°C), $\geq 30\%$, or $\geq 35\%$, or $\geq 40\%$, or $\geq 45\%$, or $\geq 50\%$, or $\geq 55\%$, or $\geq 60\%$ and/or $\leq 100\%$, or $\leq 95\%$.
In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a % change in Light Transmittance that meets the following

relationship: [(Light Transmittance (3.2 mm thickness), at RT (23°C)) - (Light Transmittance (3.2 mm thickness), at 60°C)] ≤ 15% or ≤ 14%, or ≤ 13%, or ≤ 12%, or ≤ 11%, or ≤ 10%, or ≤ 9.0%, or ≤ 8.0%, or ≤ 7.0%, or ≤ 6.0%, or ≤ 5.0%.

In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a Dart Ductility, at -10°C (2.2 m/s), ≥ 90%, or ≥ 95%, or 100%. In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a Dart Ductility, at -30°C (2.2 m/s), ≥ 90%, or ≥ 95%, or 100%.

In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a Notched Izod, at -30°C, ≥ 3, or ≥ 4, or ≥ 5, or ≥ 6, or ≥ 7 ≥ 8, or ≥ 9, or ≥ 10 kJ/m². In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a Notched Izod, at 23°C ≥ 10, or ≥ 15, or ≥ 20, or ≥ 25, or ≥ 30, or ≥ 35, or ≥ 40, or ≥ 45, or ≥ 50 kJ/m².

In one embodiment, or a combination of two or more embodiments, each described herein, the composition has a Flexural Modulus ≥ 800, or ≥ 900, or ≥ 1000 MPa. In one embodiment, or a combination of two or more embodiments, each described herein, the composition has the following properties a) through g): a) a MFR ≥ 10 g/min, b) a Light Transmittance (3.2 mm thickness), at RT (23°C), ≥ 30%, c) a Dart Ductility, at -10°C (2.2 m/s), ≥ 90%, d) a Notched Izod, at -30°C, ≥ 4 kJ/m², e) a Notched Izod, at 23°C, ≥ 35 kJ/m², f) a Flexural Modulus ≥ 800 MPa, and g) a [(Light Transmittance (3.2 mm thickness) at RT (23°C)) - (Light Transmittance (3.2 mm thickness) at 60°C)] ≤ 10%.

Also provided is an article comprising at least one component formed from the composition of an embodiment or a combination of two or more embodiments described herein. In a further embodiment, the article is an automotive part.

Also provided is a method of forming an automotive part, said method comprising mixing the composition of an embodiment or a combination of two or more embodiments described herein.

Ethylene/Alpha-Olefin Multi-Block Interpolymers

Ethylene/alpha-olefin multi-block interpolymers and copolymers comprises, in polymerize form, ethylene, and an alpha-olefin. Alpha-olefins include, but are not limited to, a C3-C20 alpha-olefins, further C3-C10 alpha-olefins, further C3-C8 alpha-olefins, such as propylene, 1-butene, 1-pentene, 1-hexene, and 1-octene.

Ethylene/alpha-olefin multi-block interpolymers are characterized by multiple blocks or segments of two or more polymerized monomer units, differing in chemical or physical

properties. In some embodiments, the multi-block interpolymers, and further copolymers, can be represented by the following formula: $(AB)_n$, where n is at least 1, preferably an integer greater than 1, such as 2, 3, 4, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, or higher. Here, "A" represents a hard block or segment, and "B" represents a soft block or segment.

- 5 Preferably the A segments and the B segments are linked (or covalently bonded) in a substantially linear fashion, as opposed to a substantially branched or substantially star-shaped fashion. In other embodiments, the A segments and the B segments are randomly distributed along the polymer chain. In other words, for example, the block interpolymers usually do not have a structure as follows: AAA-AA-BBB-BB. In still other embodiments,
- 10 the block interpolymers do not usually have a third type of block or segment, which comprises different comonomer(s). In yet other embodiments, each of block A and block B has monomers or comonomers substantially randomly distributed within the block. In other words, neither block A nor block B comprises two or more sub-segments (or sub-blocks) of distinct composition, such as a tip segment, which has a substantially different composition
- 15 than the rest of the block.

The term "hard segments (HS)," as used herein, refer to blocks of polymerized monomer units, in which ethylene is present in an amount, for example, > 90 mol%, or ≥ 92 mol%, or ≥ 95 mol%, or ≥ 98 mol%, or ≥ 99 mol%, based on the total number of moles of polymerized monomers in the blocks. In one embodiment, ethylene is present in an amount $\leq$

20 99.8 mol%, or ≤ 99.6 mol%, or ≤ 99.4 mol%, or ≤ 99.3 mol%, based on the total number of moles of polymerized monomers in the blocks.

The term "soft segments (SS)," as used herein, refer to blocks of polymerized monomer units, in which ethylene is present in an amount, for example, ≤ 90 mol%, or ≤ 88 mol%, or ≤ 86 mol%, or ≤ 84 mol%, or ≤ 82 mol%, based on the total number of moles of

25 polymerized monomers in the blocks. In one embodiment, ethylene is present in an amount ≥ 60 mol%, or ≥ 65 mol%, or ≥ 70 mol%, or ≥ 75 mol%, or ≥ 80 mol%, based on the total number of moles of polymerized monomers in the blocks.

The soft segments can be present in the ethylene/octene multi-block interpolymers from 1 wt%, or 5 wt%, or 10 wt%, or 15 wt%, or 20 wt%, or 25 wt%, or 30 wt%, or 35 wt%,

30 or 40 wt%, or 45 wt% to 50 wt%, or 55 wt%, or 60 wt%, or 65 wt%, or 70 wt%, or 75 wt%, or 80 wt%, or 85 wt%, or 90 wt%, or 95 wt%, or 99 wt% of the total weight of the ethylene/octene multi-block interpolymers. Conversely, the hard segments can be present in similar ranges. The soft segment weight percentage and the hard segment weight percentage

can be calculated based on data obtained from DSC or NMR. Such methods and calculations are disclosed in, for example, USP 7,608,668, the disclosure of which is incorporated by reference herein, in its entirety. For example, the hard segment and the soft segment weight percentages may be determined as described in column 57 to column 63 of U.S. Patent
5 7,608,668, incorporated herein by reference.

Typically, ethylene comprises 50 mole percent or a majority mole percent of the whole multi-block interpolmer; that is, ethylene comprises at least 50 mole percent of the whole interpolmer. More preferably ethylene comprises at least 60 mole percent, or at least 70 mole percent, or at least 80 mole percent, or at least 90 mole percent, with the substantial
10 remainder of the whole polymer comprising at least one other comonomer that is preferably an alpha-olefin having three or more carbon atoms.

As discussed, the ethylene/alpha-olefin multi-block interpolymers comprise two or more chemically distinct regions or segments (referred to as "blocks"), preferably joined in a linear manner. In an embodiment, the blocks differ in the amount or type of incorporated
15 comonomer, density, amount of crystallinity, crystallite size attributable to a polymer of such composition, type or degree of tacticity (isotactic or syndiotactic), region-regularity or regio-irregularity, amount of branching (including long chain branching or hyper-branching), homogeneity or any other chemical or physical property. Compared to block interpolymers of the prior art, including interpolymers produced by sequential monomer addition, fluxional
20 catalysts, or anionic polymerization techniques, the present ethylene/alpha-olefin multi-block interpolmer is characterized by unique distributions of both polymer polydispersity (PDI or Mw/Mn or MWD), polydisperse block length distribution, and/or polydisperse block number distribution, due, in an embodiment, to the effect of the shuttling agent(s) in combination with multiple catalysts used in their preparation.

The ethylene/alpha-olefin multi-block interpolymers, and further copolymers, in general, are produced via a chain shuttling process, such as, for example, described in U.S. Patent 7,858,706, which is herein incorporated by reference. Some chain shuttling agents and related information are listed in column 16, line 39, through column 19, line 44. Some catalysts are described in column 19, line 45, through column 46, line 19, and some co-
30 catalysts in column 46, line 20, through column 51, line 28. Some process features are described in column 51, line 29, through column 54, line 56. See also the following: U.S. Patent 7,608,668; U.S. Patent 7,893,166; and U.S. Patent 7,947,793 as well as US Patent 8,476,393. See also U.S. Patent 9,243,173.

In an embodiment, the ethylene/alpha-olefin multi-block interpolpolymer (for example, an ethylene/octene multi-block interpolpolymer) is produced in a continuous process and possesses a polydispersity index (M_w/M_n) from 1.7 to 3.5, or from 1.8 to 3, or from 1.8 to 2.5, or from 1.8 to 2.2. When produced in a batch or semi-batch process, the ethylene/alpha-olefin multi-block interpolpolymer (for example, an ethylene/octene multi-block interpolpolymer) usually has M_w/M_n from 1.0 to 3.5, or from 1.3 to 3.0, or from 1.4 to 2.5, or from 1.4 to 2.0.

In addition, the ethylene/alpha-olefin multi-block interpolpolymer (for example, an ethylene/octene multi-block interpolpolymer) typically possesses a PDI (or M_w/M_n) fitting a Schultz-Flory distribution rather than a Poisson distribution. In one embodiment, the ethylene/alpha-olefin multi-block interpolpolymer (for example, an ethylene/octene multi-block interpolpolymer) has both a polydisperse block distribution as well as a polydisperse distribution of block sizes. This results in the formation of polymer products having improved and distinguishable physical properties. The theoretical benefits of a polydisperse block distribution have been previously modeled and discussed in Potemkin, Physical Review E (1998) 57 (6), pp. 6902–6912, and Dobrynin, J. Chem. Phys. (1997) 107 (21), pp. 9234–9238. In an embodiment, the ethylene/alpha-olefin multi-block interpolpolymer (i.e., an ethylene/octene multi-block interpolpolymer) has a most probable distribution of block lengths.

DEFINITIONS

Unless stated to the contrary, implicit from the context, or customary in the art, all parts and percentages are based on weight, and all test methods are current as of the filing date of this disclosure.

The term “composition,” as used herein, includes a mixture of materials, which comprise the composition, as well as reaction products and decomposition products formed from the materials of the composition. Any reaction product or decomposition product is typically present in trace or residual amounts.

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 includes 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 interpolpolymer as defined hereinafter. Trace amounts of impurities, such as catalyst residues, can be incorporated into and/or within

the polymer. Typically, a polymer is stabilized with very low amounts (“ppm” amounts) of one or more stabilizers, such as one or more antioxidants.

The term “interpolymer,” as used herein, refers to a polymer prepared by the polymerization of at least two different types of monomers. The term interpolymer thus
5 includes the term copolymer (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 “olefin-based polymer,” as used herein, refers to a polymer that comprises, in polymerized form, 50 wt% or a majority weight percent of an olefin, such as ethylene or propylene (based on the weight of the polymer), and optionally may comprise one or more
10 comonomers.

The term “propylene-based polymer,” as used herein, refers to a polymer that comprises, in polymerized form, a majority weight percent of propylene (based on the weight of the polymer), and optionally may comprise one or more comonomers.

The term “ethylene-based polymer,” as used herein, refers to a polymer that
15 comprises, in polymerized form, 50 wt% or a majority weight percent of ethylene (based on the weight of the polymer), and optionally may comprise one or more comonomers.

The term “ethylene/alpha-olefin interpolymer,” as used herein, refers to an interpolymer that comprises, in polymerized form, 50 wt% or a majority weight percent of ethylene (based on the weight of the interpolymer), and an alpha-olefin. The alpha-olefin is
20 randomly distributed within the interpolymer. The term, “ethylene/alpha-olefin copolymer,” as used herein, refers to a copolymer that comprises, in polymerized form, 50 wt% or a majority amount of ethylene monomer (based on the weight of the copolymer), and an alpha-olefin, as the only two monomer types. The alpha-olefin is randomly distributed within the copolymer.

The term “ethylene/alpha-olefin multi-block interpolymer,” as used herein, refers to a
25 multi-block interpolymer that comprises, in polymerized form, 45 wt%, and further 50 wt%, or a majority weight percent of ethylene (based on the weight of the interpolymer), and an alpha-olefin. The term “ethylene/alpha-olefin multi-block copolymer,” as used herein, refers to a multi-block copolymer that comprises, in polymerized form, 45 wt%, and further 50
30 wt%, or a majority weight percent of ethylene (based on the weight of the copolymer), and an alpha-olefin, as the only two monomer types. See also prior discussion.

The term “propylene homopolymer or polypropylene homopolymer,” as used herein, refers to a homopolymer that comprises, in polymerized form, propylene as the monomer type.

5 The phrase “a majority weight percent,” as used herein, in reference to a polymer (or interpolymers or copolymer), refers to the amount of monomer present in the greatest amount in the polymer.

The terms “thermally treating,” “thermally treated,” “thermal treatment,” and similar terms, as used herein, in reference to an inventive composition as discussed herein, refer to increasing the temperature of the composition by the application of heat. As an example,
10 heat may be applied by electrical means (for example, a heating coil) and/or by radiation and/or by hot oil and/or by mechanical shearing. Note, the temperature at which the thermal treatment takes place, refers to the temperature of the “heat-applying” device, or, if the device contains an enclosed or semi-enclosed atmosphere, the temperature of the atmosphere within the device, such as, for example, the atmosphere within an oven or a tunnel (for example, the
15 air temperature in an hot air oven or a hot air tunnel).

The terms “comprising,” “including,” “having,” and their derivatives, are not intended to exclude the presence of any additional component, step or procedure, whether the same is specifically disclosed. In order to avoid any doubt, all compositions claimed through use of the term “comprising” may include any additional additive, adjuvant, or compound, whether
20 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.

25 Listing of Some Composition Features

A] A composition comprising a first composition that comprises at least the following components *a* and *b*:

- 30 a) at least one ethylene/alpha-olefin multi-block interpolymers that comprises a density ≥ 0.870 g/cc and a soft segment melting temperature (SS-T_m) $\leq 35^\circ\text{C}$;
b) a polymer composition comprising at least one propylene homopolymer, and wherein the component *a* is present in an amount ≤ 50 wt%, based on the weight of components *a* and *b*.

B] The composition of A] above, wherein the ethylene/alpha-olefin multi-block interpolymers (of component *a*) has a density ≥ 0.870 g/cc, or ≥ 0.871 g/cc, or ≥ 0.872 g/cc, or

≥ 0.873 g/cc, or ≥ 0.874 g/cc, or ≥ 0.875 g/cc, or ≥ 0.876 g/cc, or ≥ 0.877 g/cc, or ≥ 0.878 g/cc, or ≥ 0.879 g/cc, or ≥ 0.880 g/cc, or ≥ 0.881 g/cc, or ≥ 0.882 g/cc, or ≥ 0.883 g/cc, or ≥ 0.884 g/cc.

C] The composition of A] or B] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a density ≤ 0.910 g/cc, or ≤ 0.908 g/cc, or ≤ 0.906 g/cc, or ≤ 0.904 g/cc, or ≤ 0.902 g/cc, or ≤ 0.900 g/cc, or ≤ 0.898 g/cc, or ≤ 0.896 g/cc, or ≤ 0.894 g/cc, or ≤ 0.892 g/cc, or ≤ 0.890 g/cc, or ≤ 0.889 g/cc, or ≤ 0.888 g/cc, or ≤ 0.887 g/cc.

D] The composition of any one of A]-C] (A] through C]) above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a SS-Tm $\leq 35^{\circ}\text{C}$, or $\leq 30^{\circ}\text{C}$, or $\leq 25^{\circ}\text{C}$, or $\leq 20^{\circ}\text{C}$, or $\leq 18^{\circ}\text{C}$, or $\leq 16^{\circ}\text{C}$, or $\leq 14^{\circ}\text{C}$, or $\leq 12^{\circ}\text{C}$, or $\leq 10^{\circ}\text{C}$, or $\leq 9^{\circ}\text{C}$, or $\leq 8^{\circ}\text{C}$, or $\leq 7^{\circ}\text{C}$, or $\leq 6^{\circ}\text{C}$.

E] The composition of any one of A]-D] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a SS-Tm $\geq -20^{\circ}\text{C}$, or $\geq -18^{\circ}\text{C}$, or $\geq -16^{\circ}\text{C}$, or $\geq -14^{\circ}\text{C}$, or $\geq -12^{\circ}\text{C}$, or $\geq -10^{\circ}\text{C}$, or $\geq -8^{\circ}\text{C}$, or $\geq -6^{\circ}\text{C}$, or $\geq -4^{\circ}\text{C}$, or $\geq -2^{\circ}\text{C}$, or $\geq -1^{\circ}\text{C}$, or $\geq 0^{\circ}\text{C}$, or $\geq 1^{\circ}\text{C}$, or $\geq 2^{\circ}\text{C}$, or $\geq 3^{\circ}\text{C}$, or $\geq 4^{\circ}\text{C}$.

F] The composition of any one of A]-E] above, wherein *component a* has a density ≥ 0.870 g/cc, or ≥ 0.871 g/cc, or ≥ 0.872 g/cc, or ≥ 0.873 g/cc, or ≥ 0.874 g/cc, or ≥ 0.875 g/cc, or ≥ 0.876 g/cc, or ≥ 0.877 g/cc, or ≥ 0.878 g/cc, or ≥ 0.879 g/cc, or ≥ 0.880 g/cc, or ≥ 0.881 g/cc, or ≥ 0.882 g/cc, or ≥ 0.883 g/cc, or ≥ 0.884 g/cc.

G] The composition of any one of A]-F] above, wherein *component a* has a density or ≤ 0.910 g/cc, or ≤ 0.908 g/cc, or ≤ 0.906 g/cc, or ≤ 0.904 g/cc, or ≤ 0.902 g/cc, or ≤ 0.900 g/cc, or ≤ 0.898 g/cc, or ≤ 0.896 g/cc, or ≤ 0.894 g/cc, or ≤ 0.892 g/cc, or ≤ 0.890 g/cc, or ≤ 0.889 g/cc, or ≤ 0.888 g/cc, or ≤ 0.887 g/cc.

H] The composition of any one of A]-G] above, wherein *component a* has a SS-Tm $\leq 35^{\circ}\text{C}$, or $\leq 30^{\circ}\text{C}$, or $\leq 25^{\circ}\text{C}$, or $\leq 20^{\circ}\text{C}$, or $\leq 18^{\circ}\text{C}$, or $\leq 16^{\circ}\text{C}$, or $\leq 14^{\circ}\text{C}$, or $\leq 12^{\circ}\text{C}$, or $\leq 10^{\circ}\text{C}$, or $\leq 9^{\circ}\text{C}$, or $\leq 8^{\circ}\text{C}$, or $\leq 7^{\circ}\text{C}$, or $\leq 6^{\circ}\text{C}$.

I] The composition of any one of A]-H] above, wherein *component a* has a SS-Tm $\geq -20^{\circ}\text{C}$, or $\geq -18^{\circ}\text{C}$, or $\geq -16^{\circ}\text{C}$, or $\geq -14^{\circ}\text{C}$, or $\geq -12^{\circ}\text{C}$, or $\geq -10^{\circ}\text{C}$, or $\geq -8^{\circ}\text{C}$, or $\geq -6^{\circ}\text{C}$, or $\geq -4^{\circ}\text{C}$, or $\geq -2^{\circ}\text{C}$, or $\geq -1^{\circ}\text{C}$, or $\geq 0^{\circ}\text{C}$, or $\geq 1^{\circ}\text{C}$, or $\geq 2^{\circ}\text{C}$, or $\geq 3^{\circ}\text{C}$, or $\geq 4^{\circ}\text{C}$.

J] The composition of any one of A]-I] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) is an ethylene/alpha-olefin multi-block copolymer.

K] The composition of any one of A]-J] above, wherein the alpha-olefin of the ethylene/alpha-olefin multi-block interpolpolymer, and further copolymer, is a C3-C20 alpha-olefin, and further a C3-C10 alpha-olefin, and further a C3-C8 alpha-olefin.

L] The composition of any one of A]-K] above, wherein the alpha-olefin of the ethylene/alpha-olefin multi-block interpolpolymer, and further copolymer, is selected from propylene, 1-butene, 1-pentene, 1-hexene or 1-octene, and further propylene, 1-butene or 1-octene, and further propylene or 1-octene, and further 1-octene.

M] The composition any one of A]-L] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a melt index (MI or I2) ≥ 0.1 , or ≥ 0.2 , or ≥ 0.3 , or ≥ 0.4 , or ≥ 0.5 g/10 min and/or ≤ 50 , or ≤ 45 , or ≤ 40 , or ≤ 35 , or ≤ 30 , or ≤ 28 , or ≤ 26 , or ≤ 24 , or ≤ 22 , or ≤ 20 , or ≤ 18 , or ≤ 16 , or ≤ 14 , or ≤ 12 , or ≤ 10 , or ≤ 9.0 , or ≤ 8.0 , or ≤ 7.0 , or ≤ 6.0 , or ≤ 5.0 g/10 min.

N] The composition of any one of A]-M] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a molecular weight distribution (MWD = M_w/M_n) ≥ 1.5 , or ≥ 1.6 , or ≥ 1.7 , or ≥ 1.8 , or ≥ 1.9 , or ≥ 2.0 and/or ≤ 4.0 , or ≤ 3.5 , or ≤ 3.0 , or ≤ 2.8 , or ≤ 2.6 , or ≤ 2.4 .

O] The composition of any one of A]-N] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a number average molecular weight (M_n) $\geq 10,000$, or $\geq 15,000$, or $\geq 20,000$, or $\geq 25,000$, or $\geq 30,000$, or $\geq 32,000$, or $\geq 35,000$ g/mol and/or $\leq 100,000$, or $\leq 90,000$, or $\leq 80,000$, or $\leq 75,000$, or $\leq 70,000$, or $\leq 65,000$, or $\leq 60,000$ g/mol.

P] The composition of any one of A]-O] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has melting point (T_m) $\geq 90^\circ\text{C}$, or $\geq 100^\circ\text{C}$, or $\geq 105^\circ\text{C}$, or $\geq 110^\circ\text{C}$, or $\geq 112^\circ\text{C}$, or $\geq 114^\circ\text{C}$, or $\geq 116^\circ\text{C}$, or $\geq 118^\circ\text{C}$ and/or $\leq 140^\circ\text{C}$, or $\leq 135^\circ\text{C}$, or $\leq 130^\circ\text{C}$, or $\leq 128^\circ\text{C}$, or $\leq 126^\circ\text{C}$, or $\leq 124^\circ\text{C}$, or $\leq 123^\circ\text{C}$, as determined by DSC.

Q] The composition of any one of A]-P] above, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a glass transition temperature (T_g) $\geq -75.0^\circ\text{C}$, or $\geq -72.0^\circ\text{C}$, or $\geq -70.0^\circ\text{C}$, or $\geq -68.0^\circ\text{C}$, or $\geq -66.0^\circ\text{C}$, or $\geq -65.0^\circ\text{C}$ and/or $\leq -40.0^\circ\text{C}$, $\leq -50.0^\circ\text{C}$, or $\leq -55.0^\circ\text{C}$, or $\leq -60.0^\circ\text{C}$, as determined by DSC.

R] The composition of any one of A]-Q] above, wherein *component a* comprises only one ethylene/alpha-olefin multi-block interpolpolymer, and further one ethylene/alpha-olefin multi-block copolymer.

S] The composition of any one of A]-Q] above, wherein *component a* comprises two ethylene/alpha-olefin multi-block interpolymers (first and second), and further one two ethylene/alpha-olefin multi-block copolymers.

T] The composition of S] above, wherein the melt index of the first interpolymer (MI₁),
 5 and further copolymer, is greater than the melt index of the second interpolymer (MI₂), further copolymer.

U] The composition of S] or T] above, wherein the ratio MI₁/ MI₂ is ≥ 2.0 , or ≥ 3.0 , or ≥ 3.5 , or ≥ 4.0 , or ≥ 4.5 , or ≥ 5.0 g/10 min and/or ≤ 20 , or ≤ 15 , or ≤ 10 , or ≤ 6.0 g/10 min.

V] The composition of any one of S]-U] above, wherein the ratio of the density of first
 10 interpolymer, further copolymer, to the density of the second interpolymer, further copolymer, is ≥ 0.850 , or ≥ 0.900 , or ≥ 0.950 , or ≥ 1.00 and/or ≤ 1.20 , or ≤ 1.15 , or ≤ 1.10 , or ≤ 1.05 .

W] The composition of any one of S]-V] above, wherein the weight ratio of the first interpolymer, further copolymer, to the second interpolymer, further copolymer, is ≥ 0.40 , or
 15 ≥ 0.60 , or ≥ 0.80 , or ≥ 1.0 and/or ≤ 3.0 , or ≤ 2.0 , or ≤ 1.8 , or ≤ 1.6 , or ≤ 1.4 , or ≤ 1.2 .

X] The composition of any one of S]-W] above, wherein the alpha-olefin of each ethylene/alpha-olefin multi-block interpolymer, and further copolymer, is independently a C3-C20 alpha-olefin, and further a C3-C10 alpha-olefin, and further a C3-C8 alpha-olefin.

Y] The composition of any one of S]-X] above, wherein the alpha-olefin of each
 20 ethylene/alpha-olefin multi-block interpolymer, and further copolymer, is independently selected from propylene, 1-butene, 1-pentene, 1-hexene or 1-octene, and further propylene, 1-butene or 1-octene, and further propylene or 1-octene, and further 1-octene.

Z] The composition of any one of S]-Y] above, wherein the alpha-olefin of the first interpolymer, and further copolymer, is the same as the alpha-olefin of the second
 25 interpolymer, and further copolymer.

A2] The composition of any one of S]-Z] above, wherein *component a* comprises from ≥ 95 wt%, or ≥ 98 wt%, or ≥ 99 wt% to ≤ 100 wt% of the first and second interpolymers, and further the first and second copolymers.

B2] The composition of any one of A]-A2] above, wherein *component a* has a % change
 30 in cumulative crystallinity that meets the following relationship: $[(\% \text{ Cumulative Crystallinity at RT (23}^\circ\text{C)}) - (\% \text{ Cumulative Crystallinity at 60}^\circ\text{C})] \leq 10\%$, or $\leq 8.0\%$, or $\leq 6.0\%$, or $\leq 5.0\%$, or $\leq 4.0\%$, or $\leq 3.0\%$, or $\leq 2.0\%$. The % Cumulative Crystallinity is determined by DSC as described herein.

- C2]** The composition of any one of A]-B2] above, wherein the propylene homopolymer (of *component b*) has a melt flow rate (MFR) ≥ 1.0 , or ≥ 2.0 , or ≥ 3.0 , or ≥ 4.0 , or ≥ 5.0 , or ≥ 10 , or ≥ 20 , or ≥ 25 g/10 min and/or ≤ 200 , or ≤ 150 , or ≤ 100 , or ≤ 90 , or ≤ 80 , or ≤ 75 , or ≤ 70 , or ≤ 68 , or ≤ 66 g/10 min.
- 5 **D2]** The composition of any one of A]-C2] above, wherein the propylene homopolymer (of *component b*) has a density ≥ 0.875 g/cc, or ≥ 0.880 g/cc, or ≥ 0.885 g/cc, or ≥ 0.890 g/cc, or ≥ 0.895 g/cc, or ≥ 0.900 g/cc and/or ≤ 0.935 g/cc, or ≤ 0.930 g/cc, or ≤ 0.925 g/cc, or ≤ 0.920 g/cc, or ≤ 0.915 g/cc, or ≤ 0.910 g/cc.
- E2]** The composition of any one of A]-D2] above, wherein *component b* has a melt flow rate (MFR) ≥ 1.0 , or ≥ 2.0 , or ≥ 3.0 , or ≥ 4.0 , or ≥ 5.0 , or ≥ 10 , or ≥ 20 , or ≥ 25 g/10 min and/or ≤ 200 , or ≤ 150 , or ≤ 100 , or ≤ 90 , or ≤ 80 , or ≤ 75 , or ≤ 70 , or ≤ 68 , or ≤ 66 g/10 min.
- 10 **F2]** The composition of any one of A]-E2] above, wherein *component b* has a density ≥ 0.875 g/cc, or ≥ 0.880 g/cc, or ≥ 0.885 g/cc, or ≥ 0.890 g/cc, or ≥ 0.895 g/cc, or ≥ 0.900 g/cc and/or ≤ 0.935 g/cc, or ≤ 0.930 g/cc, or ≤ 0.925 g/cc, or ≤ 0.920 g/cc, or ≤ 0.915 g/cc, or ≤ 0.910 g/cc.
- 15 **G2]** The composition of any one of A]-F2] above, wherein *component b* comprises at least two propylene homopolymers (first and second), and further two propylene homopolymers (first and second).
- H2]** The composition of G2] above, wherein the melt flow rate of the first homopolymer (MFR_{hPP1}) is greater than the melt flow rate of the second homopolymer (MFR_{hPP2}).
- 20 **I2]** The composition of G2] or H2] above, wherein the melt flow rate of the first homopolymer (MFR_{hPP1}) is ≥ 10 , or ≥ 20 , or ≥ 40 , or ≥ 60 , or ≥ 80 , or ≥ 100 g/10 min and/or ≤ 1000 , or ≤ 800 , or ≤ 600 , or ≤ 400 , or ≤ 300 , or ≤ 200 , or ≤ 150 , or ≤ 120 g/10 min.
- J2]** The composition of any one of G2]-I2] above, wherein the ratio of the MFR_{hPP1}/MFR_{hPP2} is > 1.0 , or ≥ 2.0 , or ≥ 5.0 , or ≥ 7.0 , or ≥ 10 and/or ≤ 50 , or ≤ 45 , or ≤ 40 , or ≤ 35 , or ≤ 30 .
- 25 **K2]** The composition of any one of G2]-J2] above, wherein the ratio of the density of first propylene homopolymer to the density of the second propylene homopolymer is ≥ 0.800 , or ≥ 0.850 , or ≥ 0.900 , or ≥ 0.950 , or ≥ 1.00 and/or ≤ 1.30 , or ≤ 1.25 , or ≤ 1.20 , or ≤ 1.15 , or ≤ 1.10 , or ≤ 1.05 .
- 30 **L2]** The composition of any one of G2]-K2] above, wherein the weight ratio of the first propylene homopolymer to the second propylene homopolymer is ≥ 0.10 , or ≥ 0.20 , or $\geq$

0.40, or ≥ 0.50 , or ≥ 0.60 , or ≥ 0.80 , or ≥ 1.0 , or ≥ 1.2 , or ≥ 1.4 , or ≥ 1.5 and/or ≤ 10 , or ≤ 8.0 , or ≤ 6.0 , or ≤ 4.0 , or ≤ 2.0 , or ≤ 1.8 , or ≤ 1.6 .

- M2]** The composition of any one of G2]-L2] above, wherein *component b* comprises from ≥ 95 wt%, or ≥ 98 wt%, or ≥ 99 wt% to ≤ 100 wt% of the first and second propylene homopolymers.
- N2]** The composition of any one of A]-M2] above, wherein the weight ratio of *component b* to *component a* is ≥ 1.0 , or ≥ 1.2 , or ≥ 1.4 , or ≥ 1.6 , or ≥ 1.8 and/or ≤ 10 , or ≤ 9.0 , or $\leq 8.0 \leq 7.0$, or ≤ 6.0 , or ≤ 5.5 , or ≤ 5.0 , or ≤ 4.5 , or ≤ 4.0 , or ≤ 3.5 , or ≤ 3.0 .
- O2]** The composition of any one of A]-N2] above, wherein the ratio of the MFR of *component b* to the I2 of *component a* is ≥ 0.4 , or ≥ 1.0 , or ≥ 1.5 , or ≥ 2.0 , or ≥ 3.0 and/or ≤ 230 , or ≤ 200 , or ≤ 100 , or ≤ 50 , or ≤ 20 , or ≤ 10 .
- P2]** The composition of any one of A]-O2] above, wherein the ratio of the density of *component b* to the density of *component a* is ≥ 0.98 , or ≥ 0.99 , or ≥ 1.00 , or ≥ 1.01 and/or ≤ 1.20 , or ≤ 1.15 , or ≤ 1.10 , or ≤ 1.08 , or ≤ 1.06 , or ≤ 1.05 .
- Q2]** The composition of any one of A]-P2] above, wherein the first composition comprises ≥ 10 wt%, or ≥ 15 wt%, or ≥ 20 wt%, or ≥ 22 wt%, or ≥ 25 wt% of *component a* and/or ≤ 50 wt%, or ≤ 40 wt%, or ≤ 38 wt%, or ≤ 32 wt%, or ≤ 30 wt%, or ≤ 28 wt% of *component a*, based on the sum weight of *components a* and *b*.
- R2]** The composition of any one of A]-Q2] above, wherein the first composition comprises ≥ 15 wt%, or ≥ 20 wt%, or ≥ 30 wt%, or ≥ 40 wt%, or ≥ 50 wt%, or ≥ 55 wt%, or ≥ 60 wt%, or ≥ 62 wt%, or ≥ 65 wt%, or ≥ 68 wt% of *component b* and/or ≤ 80 wt%, or ≤ 78 wt%, or ≤ 75 wt% of *component b*, based on the sum weight of *components a* and *b*.
- S2]** The composition of any one of A]-R2] above, wherein the first composition comprises ≥ 80 wt%, or ≥ 85 wt%, or ≥ 90 wt%, or ≥ 92 wt%, or ≥ 94 wt%, or ≥ 96 wt%, or ≥ 98 wt% of the sum of *components a* and *b*, based on the weight of the first composition.
- T2]** The composition of any one of A]-S2] above, wherein the first composition comprises ≤ 100 wt%, or ≤ 99 wt% of the sum of *components a* and *b*, based on the weight of the first composition.
- U2]** The composition of any one of A]-T2] above, wherein the first composition comprises at least two crystallization peaks (first peak and second peak), and wherein the second peak and the first peak are the peaks with highest and second highest crystallization temperatures, respectively.

V2] The composition of U2] above, wherein the second peak and the first peak each independently has a crystallization temperature $\geq 100^{\circ}\text{C}$.

W2] The composition of U2] or V2] above, wherein the first crystallization peak has a crystallization temperature (peak temp.) $\geq 100^{\circ}\text{C}$, or $\geq 102^{\circ}\text{C}$, or $\geq 104^{\circ}\text{C}$, or $\geq 106^{\circ}\text{C}$, or $\geq 108^{\circ}\text{C}$, or $\geq 110^{\circ}\text{C}$, or $\geq 116^{\circ}\text{C}$ or $\geq 112^{\circ}\text{C}$, or $\geq 114^{\circ}\text{C}$, or $\geq 116^{\circ}\text{C}$ and/or $\leq 140^{\circ}\text{C}$, or $\leq 138^{\circ}\text{C}$, or $\leq 138^{\circ}\text{C} \leq 134^{\circ}\text{C}$, or $\leq 132^{\circ}\text{C}$, or $\leq 130^{\circ}\text{C}$, or $\leq 128^{\circ}\text{C}$, or $\leq 126^{\circ}\text{C}$, or $\leq 124^{\circ}\text{C}$.

X2] The composition of any one of U2]-W2] above, wherein the second crystallization peak has a crystallization temperature (peak temp.) $\geq 106^{\circ}\text{C}$, or $\geq 108^{\circ}\text{C}$, or $\geq 110^{\circ}\text{C}$, or $\geq 112^{\circ}\text{C}$, or $\geq 114^{\circ}\text{C}$, or $\geq 116^{\circ}\text{C}$, or $\geq 118^{\circ}\text{C}$ or $\geq 120^{\circ}\text{C}$, or $\geq 122^{\circ}\text{C}$, or $\geq 124^{\circ}\text{C}$, or $\geq 126^{\circ}\text{C}$, or $\geq 128^{\circ}\text{C}$, or $\geq 130^{\circ}\text{C}$ and/or $\leq 160^{\circ}\text{C}$, or $\leq 155^{\circ}\text{C}$, or $\leq 150^{\circ}\text{C} \leq 148^{\circ}\text{C}$, or $\leq 146^{\circ}\text{C}$, or $\leq 144^{\circ}\text{C}$, or $\leq 142^{\circ}\text{C}$, or $\leq 140^{\circ}\text{C}$, or $\leq 138^{\circ}\text{C}$, or $\geq 136^{\circ}\text{C}$, or $\geq 134^{\circ}\text{C}$.

Y2] The composition of any one of U2]-X2] above, wherein the second crystallization peak has a crystallization temp. $\geq 5^{\circ}\text{C}$, or $\geq 7^{\circ}\text{C}$, or $\geq 10^{\circ}\text{C}$, or $\geq 12^{\circ}\text{C}$, or $\geq 14^{\circ}\text{C}$, or $\geq 16^{\circ}\text{C}$, or $\geq 18^{\circ}\text{C}$ or $\geq 20^{\circ}\text{C}$, or $\geq 22^{\circ}\text{C}$, or $\geq 25^{\circ}\text{C}$, or $\geq 27^{\circ}\text{C}$, or $\geq 30^{\circ}\text{C}$, or $\geq 32^{\circ}\text{C}$, or $\geq 35^{\circ}\text{C}$, or $\geq 37^{\circ}\text{C}$, or $\geq 40^{\circ}\text{C}$, or $\geq 42^{\circ}\text{C}$ or $\geq 45^{\circ}\text{C}$, or $\geq 47^{\circ}\text{C}$, or $\geq 50^{\circ}\text{C}$ and/or $\leq 90^{\circ}\text{C}$, or $\leq 80^{\circ}\text{C}$, or $\leq 70^{\circ}\text{C}$, higher than the crystallization temperature of the first crystallization peak.

Z2] The composition of any one of U2]-Y2] above, wherein the first crystallization peak and the second crystallization peak appear as two separate peaks on the DSC profile, with no overlap of these two peaks.

A3] The composition of any one of U2]-Z2] above, wherein the intensity (in watts/g) of each of the first crystallization peak and the second crystallization peak, independently, meets the following relationship: $[(\text{Peak Intensity}) - (\text{average baseline intensity})] \leq -0.05$, further ≤ -0.10 , further ≤ -0.15 , further ≤ -0.20 , further ≤ -0.25 , further ≤ -0.30 watts/g, further ≤ -0.35 . The "average baseline intensity (in watts/g)" = $[(\text{heat flow (watts/g) at } 160^{\circ}\text{C}) - (\text{heat flow (watts/g) at } -40^{\circ}\text{C})] / 2$.

B3] The composition of any one of A]-A3] above, wherein the first composition comprises *components a and b* as the only polymer components of the first composition.

C3] The composition of any one of A]-B3] above, wherein the composition comprises ≥ 55 wt%, or ≥ 60 wt%, or ≥ 65 wt%, or ≥ 70 wt%, or ≥ 75 wt% of *component b*, based on the weight of the composition, and/or ≤ 90 wt%, or ≤ 85 wt%, or ≤ 80 wt% of *component b*, based on the weight of the composition.

D3] The composition of any one of A]-C3] above, wherein the composition comprises ≤ 45 wt%, or ≤ 40 wt%, or ≤ 35 wt%, or ≤ 30 wt%, or ≤ 25 wt%, or ≤ 20 wt% of *component a*,

based on the weight of the composition, and/or ≥ 5.0 wt%, or ≥ 10 wt%, or ≥ 15 wt% of *component a*, based on the weight of the composition.

E3] The composition of any one of A]-D3] above, wherein the composition comprises ≥ 50 wt%, or ≥ 60 wt%, ≥ 70 wt%, or ≥ 80 wt%, or ≥ 85 wt%, or ≥ 90 wt%, or ≥ 95 wt% of the
5 sum of *components a and b*, based on the weight of the composition, and/or ≤ 100 wt%, or ≤ 99 wt%, ≤ 98 wt%, or ≤ 97 wt% of the sum of *components a and b*, based on the weight of the composition.

F3] The composition of any one of A]-E3] above, wherein the composition comprises ≥ 50 wt%, or ≥ 60 wt%, ≥ 70 wt%, or ≥ 80 wt%, or ≥ 85 wt%, or ≥ 90 wt%, or ≥ 95 wt%, or $\geq$
10 96 wt%, or ≥ 97 wt% of the first composition and/or ≤ 100 wt%, or ≤ 99 wt%, ≤ 98 wt% of the first composition, based on the weight of the composition.

G3] The composition of any one of A]-F3] above, wherein the composition further comprises at least one additive.

H3] The composition of G3] above, wherein the at least one additive is selected from
15 fillers (for example, talc and a nano clay), flow aids, antioxidants, colorants, processing aids (for example, zinc stearate), lubricants or any combination thereof.

I3] The composition of G3] or H3] above, wherein the composition further comprises at least one filler (for example, talc or a nano clay).

J3] The composition of I3] above, wherein the composition comprises ≥ 0.5 wt%, or 1.0 wt%, or ≥ 2.0 wt%, or ≥ 3.0 wt%, or ≥ 4.0 wt%, or ≥ 5.0 wt% of the at least one filler and/or
20 ≤ 40 wt%, or ≤ 35 wt%, or ≤ 30 wt%, or ≤ 25 wt%, or ≤ 20 wt%, or ≤ 15 wt%, or ≤ 10 wt%, or ≤ 8.0 wt% of the at least one filler, based on the weight of the composition.

K3] The composition of G3] or H3] above, wherein the at least one additive is present in an amount ≥ 0.01 wt%, or ≥ 0.02 wt%, or ≥ 0.05 wt%, or ≥ 0.10 wt%, or ≥ 0.20 wt%, or $\geq$
25 0.50 wt% and/or ≤ 10 wt%, or ≤ 5.0 wt%, or ≤ 2.0 wt%, or ≤ 1.0 wt%, based on the weight of the composition.

L3] The composition of any one of A]-K3] above, wherein the composition further comprises a polymer, different from each of *component a* and *component b*, independently, in one or more features, such as monomer types, monomer distributions, monomer amounts,
30 density, melt index (I2) or melt flow rate (MFR), Mn, MWD, or any combination thereof, and further in one or more features, such as monomer types, monomer distributions, monomer amounts, density, melt index (I2) or melt flow rate (MFR), or any combination thereof.

- M3]** The composition of any one of A]-L3] above, wherein the composition comprises $\leq$ 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of an amide compound (for example, a fatty amide), based on the weight of the composition; and further the composition does not comprise an amide compound.
- 5 **N3]** The composition of any one of A]-M3] above, wherein the composition comprises $\leq$ 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of a polyamide, based on the weight of the composition; and further the composition does not comprise a polyamide.
- O3]** The composition of any one of A]-N3] above, wherein the composition comprises $\leq$
- 10 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of an ethylene vinyl acetate (EVA) polymer, based on the weight of the composition; and further the composition does not comprise an ethylene vinyl acetate (EVA) polymer.
- P3]** The composition of any one of A]-O3] above, wherein the composition comprises $\leq$
- 15 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of a metal hydroxide (for example, magnesium hydroxide), based on the weight of the composition; and further the composition does not comprise a metal hydroxide.
- Q3]** The composition of any one of A]-P3] above, wherein the composition comprises $\leq$
- 20 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of a wax, based on the weight of the composition; and further the composition does not comprise a wax.
- R3]** The composition of any one of A]-Q3] above, wherein the composition comprises $\leq$
- 5.0 wt%, or $\leq$ 2.0 wt%, or $\leq$ 1.0 wt%, or $\leq$ 0.5 wt%, or $\leq$ 0.2 wt%, or $\leq$ 0.1 wt%, or $\leq$ 0.05 wt% of a tackifier, based on the weight of the composition; and further the composition does not comprise a tackifier.
- 25 **S3]** The composition of any one of A]-R3] above, wherein the composition has a MFR $\geq$ 5.0, or $\geq$ 7.0, or $\geq$ 10, or $\geq$ 12, or $\geq$ 15, or $\geq$ 18, or $\geq$ 20 g/10 min and/or $\leq$ 50, or $\leq$ 45, or $\leq$ 40, or $\leq$ 35, or $\leq$ 30, or $\leq$ 25 g/10 min.
- T3]** The composition of any one of A]-S3] above, wherein the composition has a Light Transmittance (3.2 mm thickness), at RT (23°C), $\geq$ 30%, or $\geq$ 35%, or $\geq$ 40%, or $\geq$ 45%, or $\geq$
- 30 50%, or $\geq$ 55%, or $\geq$ 60% and/or $\leq$ 100%, or $\leq$ 95%. Light Transmittance is determined as described herein.

- U3]** The composition of any one of A]-T3] above, wherein the composition has a Light Transmittance (3.2 mm thickness), at 40°C, $\geq 30\%$, or $\geq 35\%$, or $\geq 40\%$, or $\geq 45\%$, or $\geq 50\%$, or $\geq 55\%$, or $\geq 60\%$ and/or $\leq 100\%$, or $\leq 95\%$.
- V3]** The composition of any one of A]-U3] above, wherein the composition has a Light Transmittance (3.2 mm thickness), at 60°C, $\geq 30\%$, or $\geq 35\%$, or $\geq 40\%$, or $\geq 45\%$, or $\geq 50\%$, or $\geq 55\%$, or $\geq 60\%$ and/or $\leq 100\%$, or $\leq 95\%$.
- W3]** The composition of any one of A]-V3] above, wherein the composition has a % change in Light Transmittance that meets the following relationship: $[(\text{Light Transmittance (3.2 mm thickness), at RT (23°C)}) - (\text{Light Transmittance (3.2 mm thickness), at 60°C})] \leq 15\%$ or $\leq 14\%$, or $\leq 13\%$, or $\leq 12\%$, or $\leq 11\%$, or $\leq 10\%$, or $\leq 9.0\%$, or $\leq 8.0\%$, or $\leq 7.0\%$, or $\leq 6.0\%$, or $\leq 5.0\%$.
- X3]** The composition of any one of A]-W3] above, wherein the composition has a Dart Ductility, at -40°C (2.2 m/s), $\geq 90\%$, or $\geq 95\%$, or 100%. Dart Ductility is described herein.
- Y3]** The composition of any one of A]-X3] above, wherein the composition has a Dart Ductility, at -30°C (2.2 m/s), $\geq 90\%$, or $\geq 95\%$, or 100%.
- Z3]** The composition of any one of A]-Y3] above, wherein the composition has a Dart Ductility, at -20°C (2.2 m/s), $\geq 90\%$, or $\geq 95\%$, or 100%.
- A4]** The composition of any one of A]-Z3] above, wherein the composition has a Dart Ductility, at -10°C (2.2 m/s), $\geq 90\%$, or $\geq 95\%$, or 100%.
- B4]** The composition of any one of A]-A4] above, wherein the composition has a Dart Ductility, at 0°C (2.2 m/s), $\geq 90\%$, or $\geq 95\%$, or 100%.
- C4]** The composition of any one of A]-B4] above, wherein the composition has a Notched Izod, at -30°C, ≥ 3 , or ≥ 4 , or ≥ 5 , or ≥ 6 , or ≥ 7 , or ≥ 8 , or ≥ 9 , or $\geq 10 \text{ kJ/m}^2$. Notched Izod is described herein.
- D4]** The composition of any one of A]-C4] above, wherein the composition has a Notched Izod, at 0°C, ≥ 5 , or ≥ 10 , or ≥ 15 , or ≥ 20 , or ≥ 25 , or $\geq 30 \text{ kJ/m}^2$.
- E4]** The composition of any one of A]-D4] above, wherein the composition has a Notched Izod, at 23°C ≥ 10 , or ≥ 15 , or ≥ 20 , or ≥ 25 , or ≥ 30 , or ≥ 35 , or ≥ 40 , or ≥ 45 , or $\geq 50 \text{ kJ/m}^2$.
- F4]** The composition of any one of A]-E4] above, wherein the composition has a Flexural Modulus ≥ 800 , or ≥ 900 , or $\geq 1000 \text{ MPa}$. Flexural Modulus is described herein.
- G4]** The composition of any one of A]-F4] above, wherein the composition has good light diffusion as seen in Figure 3 (Translucent TPO). See expt. section for definition and testing.

H4] An article comprising at least one component formed from the composition of any one of A]-G4] above.

I4] The article of H4] above, wherein the article is an automotive part.

J4] A method of forming an automotive part, said method comprising mixing the
5 composition of any one of A]-G4] above, and further thermally treating the composition.

TEST METHODS

Melt Index or Melt Flow Rate of a Polymer

The melt index MI (or I2) of an ethylene-based polymer or composition is measured
10 in accordance with ASTM D-1238, condition 190°C/2.16 kg. The melt flow rate MFR of a propylene-based polymer or composition is measured in accordance with ASTM D-1238, condition 230°C/2.16 kg.

Density

The density of a polymer is measured in accordance with ASTM D792, with a testing
15 set-up without annealing (skipped annealing step), using a balance and an isopropanol bath. Each sample is first compression molded at 190°C, 3000 lbs for six minutes, then at 25000 lbs for four minutes, and then cooled at 15°C per minute, until sample has cooled to 30°C. The density of the polymer sample is measured in an isopropanol bath (temperature-controlled to 23°C +/- 0.2°C) within one hour, after compression molding. The result is
20 recorded in grams per cubic centimeter ($\text{g/cc} = \text{g/cm}^3$).

Differential Scanning Calorimetry (DSC) for Ethylene/Alpha-Olefin Multi-Block Interpolymers and Determination of SS-Tm; and DSC for Composition (TPO)

Differential Scanning Calorimetry (DSC) can be used to measure the melting,
25 crystallization, and glass transition behavior of a polymer over a wide range of temperature. For example, the TA Instruments Discovery DSC, equipped with an RCS (refrigerated cooling system) and an autosampler, can be used to perform this analysis. During testing, a nitrogen purge gas flow of 50 ml/min is used. Each sample is melt pressed (preheated for 2 minutes, and pressed at a pressure of 10 MPa for 2 minutes) into a thin film, at about 190°C.
30 The melted sample is then air-cooled to room temperature (about 23-25°C). A "3-10 mg," 6 mm diameter specimen is extracted from the cooled polymer, weighed, placed in a light aluminum pan (about 50 mg), and crimped shut. Analysis is then performed to determine its thermal properties.

The thermal behavior of the sample is determined by ramping the sample temperature up and down to create "heat flow versus temperature" profiles. First, the sample is rapidly heated to 180°C for POE or 230°C for TPO (composition), and held isothermally for 5 minutes, in order to remove its thermal history. Next, the sample is cooled to -90°C, at a
5 10°C/minute cooling rate, and held isothermally at -90°C for 5 minutes. The sample is then heated to 180°C for POE and 230°C for TPO (this is the "second heat" ramp), at a 10°C/minute heating rate. The cooling and second heating curves are recorded.

The glass transition temperature, T_g , is determined from the DSC second heating curve, where half the sample has gained the liquid heat capacity as described in Bernhard
10 Wunderlich, *The Basis of Thermal Analysis, in Thermal Characterization of Polymeric Materials*, 92, 278–279 (Edith A. Turi ed., 2d ed. 1997). Baselines are drawn from below and above the glass transition region and extrapolated through the T_g region. The temperature at which the sample heat capacity is half-way between these baselines is the T_g . The melting point, T_m , of the polymer sample is determined as the temperature
15 corresponding to the maximum heat flow (endotherm) in the second DSC heating curve. The crystallization temperature of the polymer sample is determined as the temperature corresponding to the maximum exotherm in the DSC cooling curve (or the temperature (peak temperature) of the crystallization peak, corresponding to the lowest dip of the exotherm peak). The percent crystallinity is calculated by dividing the heat of fusion (H_f), determined
20 from the second heat curve, by a theoretical heat of fusion, for example, 292 J/g for ethylene-based polymer samples, and multiplying this quantity by 100 (for example, for ethylene-based polymer samples, % cryst. = $(H_f / 292 \text{ J/g}) \times 100$).

The cumulative crystallinity at a specific temperature (T_s) is determined by first calculating the heat of fusion (H_s) for the sample between T_s and 140°C. In this case, the
25 second heating curve is baseline corrected by drawing a linear baseline between the heat flow at -50°C and 140°C. The H_s can then be calculated from the integrated base-line-corrected heat flow curved between two temperature points (i.e., T_s and 140°C). The cumulative crystallinity at a specific temperature (T_s) is then calculated by dividing H_s by a theoretical heat of fusion of 292 J/g for PE, and multiplying this quantity by 100 (for example, %
30 cumulative crystallinity (at T_s) = $(H_s / 292 \text{ J/g}) \times 100$ (for PE)). The change in crystallinity of the POE between RT and 60 °C is then calculated as the difference between the cumulative crystallinity at $T_s = 23^\circ\text{C}$ and the cumulative crystallinity at $T_s = 60^\circ\text{C}$.

The soft segment melting temperature (SS-T_m) is determined from the DSC second heating curve. For example, an ethylene/octene multi-block copolymer typically has two melting peaks, one melting peak associated with the soft segments and one melting point associated with the hard segments. The SS-T_m is associated with the lower temperature peak for the soft segments. For some block copolymers, the peak associated with the melting of the soft segments is a small hump (or bump) over the baseline, making it difficult to assign a peak maximum. This difficulty can be overcome by converting a normal DSC profile into a weighted DSC profile using the following method.

In DSC, the heat flow depends on the amount of the material melting at a certain temperature, as well as on the temperature-dependent specific heat capacity. The temperature dependence of the specific heat capacity, in the melting regime, of linear low-density polyethylene leads to an increase in the heat of fusion with decreasing comonomer content. That is, the heat of fusion values get progressively lower as the crystallinity is reduced with increasing comonomer content. See Wild, L. Chang, S.; Shankernarayanan, M J., *Improved Method for Compositional Analysis of Polyolefins by DSC*, Polym. Prep 1990; 31: 270-1, which is incorporated by reference herein, in its entirety. For a given point in the DSC curve (defined by its heat flow in watts per gram (W/g) and temperature in degrees Celsius), by taking the ratio of “the temperature-dependent heat of fusion (ΔH (T))” to “the heat of fusion expected for a linear copolymer,” the DSC curve can be converted into a weight-dependent distribution curve, as discussed below.

For a DSC analysis of a composition, the second heating curve is baseline corrected, for example, by drawing a linear baseline between the heat flow at -50°C and 135°C. The temperature-dependent heat of fusion curve (or “Enthalpy (J/g) versus Temperature (°C)”) can then be generated from the summation of the integrated heat flow between two consecutive data points (from the “Heat Flow (W/g) versus Time (min)” profile). This summation is represented overall by a cumulative enthalpy curve (“Enthalpy (J/g) versus Temperature (°C)” profile). Note, *Joule (J) = Watt (W) * sec*, and each temperature is determined from the respective time point and the temperature ramp.

The expected relationship between the heat of fusion for linear ethylene/octene copolymers, at a given temperature, is shown by the “heat of fusion versus melting temperature” curve. Using random ethylene/octene copolymers, one can obtain the following relationship (calibration equation) for the expected heat of fusion of linear copolymers, ΔH_{linear copolymer}, and melting temperature, T_m (in °C): $\Delta H_{linear\ copolymer}(J/g) =$

$0.0072 * T_m^2 + 0.3138 * T_m + 8.9767$. See also Figure 1 (“Melt Enthalpy (J/g) versus Melting Temperature (°C)” for linear copolymers).

For each integrated data point from the cumulative enthalpy curve (“Enthalpy (J/g) versus Temperature (°C)” profile), at a given temperature (T), the ratio of ‘the enthalpy from the cumulative enthalpy curve’ to the expected heat of fusion for linear copolymers at that temperature,” yields a fractional weight that can be assigned to the respective data point. Thus, *DSC Wt. Fraction* = [*Cumulative Enthalpy (at T) / Melt Enthalpy (at T) from the calibration equation*]. Using this ratio, a plot of the *DSC Wt. Fraction versus Temperature (°C)* can be generated, and the area under this curve (or A_{Total}) can be calculated. A *normalized DSC Wt. Fraction*, at each T, can be calculated by dividing the value for the *DSC Wt. Fraction* by A_{Total} (or *DSC Wt. Fraction* / A_{Total}). Thus, a *normalized DSC Wt. Fraction versus Temperature (°C)* curve can be generated. The soft segment T_m (SS- T_m) is assigned as temperature at the location of the maximum in the *normalized DSC Wt. Fraction versus Temperature (°C)* curve. The method is applicable to copolymers containing polymerized ethylene and polymerized octene, but can be adapted to other polymers as well.

Notched Izod Strength, kJ/m² (-30°C, 0°C, and 23°C)

The notched IZOD tests were conducted according to ASTM D256. Each test sample was die cut from an injection molded Type I tensile bars for a final dimension of “2.5 inch by 0.5 inch by 0.125 inch.” The sample was notched along the length of the sample, at the center, in the thickness direction, using an automated notcher with depth of 0.1 inch. The notching half angle was 22.5°, and the radius of curvature at the tip was 0.01 inch. The samples were conditioned for at least 40 hours, at 23+/-2°C and 50+/-10 % relative humidity. For samples that were tested at non-ambient temperatures (-30°C and 0°C), each test sample was further conditioned at the test temperature for a minimum of one hour. Here, the testing was conducted at three temperatures (-30°C, 0°C, and 23°C), and for each temperature, five test samples (per composition) were tested and an average reported.

Notched Charpy, kJ/m² (-30°C, and 23°C)

This test is based on ISO 179 for Determination of Charpy Impact Properties. It calculates the impact energy absorbed by a specimen after windage and friction loss has automatically been determined. Ten specimens are die cut from an ISO injected molded bar with a thickness of 4mm. Specimens are 80 mm in length and 10 mm in width. The sample was notched along the length of the sample, at the center, in the thickness direction, using an

automated notcher. The samples were conditioned for at least 40 hours, at 23+/-2°C and 50+/-10 % relative humidity. For samples that were tested at non-ambient temperatures (i.e. -30°C), each test sample was further conditioned at the test temperature for a minimum of one hour.

Flexural Modulus

- 5 Flexural modulus was measured according to ASTM D790, using the injection molded Type I tensile bars, and an INSTRON testing machine. The test speed of 0.05 in/min was chosen. Five test samples (per composition) were measured, and the average reported. The tangent modulus of elasticity described in ASTM D790 was reported as the flexural modulus of the composition.

10 ***Multiaxial Dart Impact (Dart Ductility)***

- Multiaxial dart testing on each composition was performed on an Instron CEAST 9350 Drop Tower Impact System (DYNATUP) according to ASTM D3763. Testing was run at 2.2 m/s, which translates to 5 miles per hour, an automotive industry standard rate. The sample temperature was carefully controlled. Samples were placed, for a minimum of four
15 hours, in a freezer unit that controlled the temperature to +/- 2°C. Impact testing was run in a temperature controlled chamber that controlled the temperature to +/- 2°C. In the current case, samples were tested in -20°C, -30°C, and -40°C. A sample (disk with 3.2 mm thickness) may break in a ductile, semi-ductile, or brittle mode. The mode was determined by visually examining the impacted disks. See, for example, Figure 2. The semi-brittle (C)
20 sample had a crack but no missing piece (score 0.5), and the brittle (B) sample had a missing piece from the disk (score 0). The ductile (D) sample had just a hole in the center of the disk (score 1). The Ductile % for each composition was calculated as the total score for each batch of testing divided by the total number (at least 5) of the samples in the batch. Here, the lowest temperature (in the three tested temperatures) with 100% Dart Ductility was reported,
25 or the average % ductility was reported at each temperature.

Light Transmittance%

- The light transmittance of each composition was measured from an injection molded disk with 3.2 mm thickness, according to ASTM D1003, using the Haze-Gard Plus (BYK Instruments). This method measured the luminous transmittance from the ratio of the
30 luminous flux transmitted by a body to the flux incident upon the body. The reported value is the percentage (%) of the flux (light) transmitted. For the transmittance at room temperature, the measurements were made without any prior sample treatment. For the light transmittance at 40°C and 60°C, the measurements were immediately taken after storing the test sample in

an oven set at 40°C and 60°C, respectively, for two hours. Per composition, the obtained light transmittance at each temperature was an average of at least 3 (typically 3 to 5) independent measurements.

Gel Permeation Chromatography (GPC) – Ethylene-based Polymers

5 The chromatographic system consists of a PolymerChar GPC-IR (Valencia, Spain) high temperature GPC chromatograph, equipped with an internal IR5 infra-red detector (IR5). The autosampler oven compartment is set at 160° Celsius, and the column compartment is set at 150° Celsius. The columns are four AGILENT “Mixed A” 30 cm, 20-micron linear mixed-bed columns. The chromatographic solvent is 1,2,4-trichlorobenzene, which
10 contained 200 ppm of butylated hydroxytoluene (BHT). The solvent source is nitrogen sparged. The injection volume is 200 microliters, and the flow rate is 1.0 milliliters/minute.

Calibration of the GPC column set is performed with 21 narrow molecular weight distribution polystyrene standards, with molecular weights ranging from 580 to 8,400,000, and which are arranged in six “cocktail” mixtures, with at least a decade of separation
15 between individual molecular weights. The standards are purchased from Agilent Technologies. The polystyrene standards are prepared at “0.025 grams in 50 milliliters” of solvent, for molecular weights equal to, or greater than, 1,000,000, and at “0.05 grams in 50 milliliters” of solvent, for molecular weights less than 1,000,000. The polystyrene standards are dissolved at 80° Celsius, with gentle agitation, for 30 minutes. The polystyrene standard
20 peak molecular weights are converted to polyethylene molecular weights using Equation 1 (as described in Williams and Ward, J. Polym. Sci., Polym. Let., 6, 621 (1968)):

$$M_{polyethylene} = A \times (M_{polystyrene})^B$$
 (EQ1), where M is the molecular weight, A has a value of 0.4315 and B is equal to 1.0.

A fifth order polynomial is used to fit the respective polyethylene equivalent
25 calibration points. A small adjustment to A (from approximately 0.375 to 0.445) is made to correct for column resolution and band-broadening effects, such that linear homopolymer polyethylene standard is obtained at 120,000 Mw.

The total plate count of the GPC column set is performed with decane (prepared at “0.04 g in 50 milliliters” of TCB, and dissolved for 20 minutes with gentle agitation). The
30 plate count (Equation 2) and symmetry (Equation 3) are measured on a 200 microliter injection according to the following equations:

$$Plate\ Count = 5.54 * \left(\frac{(RV_{Peak\ Max})}{Peak\ Width\ at\ \frac{1}{2}height} \right)^2 \quad (EQ2), \text{ where RV is the retention volume}$$

in milliliters, the peak width is in milliliters, the peak max is the maximum height of the peak, and ½ height is ½ height of the peak maximum; and

$$Symmetry = \frac{(Rear\ Peak\ RV_{one\ tenth\ height} - RV_{Peak\ max})}{(RV_{Peak\ max} - Front\ Peak\ RV_{one\ tenth\ height})} \quad (EQ3), \text{ where RV is the retention}$$

- 5 volume in milliliters, and the peak width is in milliliters, Peak max is the maximum position of the peak, one tenth height is 1/10 height of the peak maximum, and where rear peak refers to the peak tail at later retention volumes than the peak max, and where front peak refers to the peak front at earlier retention volumes than the peak max. The plate count for the chromatographic system should be greater than 18,000, and symmetry should be between
10 0.98 and 1.22.

- Samples are prepared in a semi-automatic manner with the PolymerChar “Instrument Control” Software, wherein the samples are weight-targeted at “2 mg/ml,” and the solvent (contained 200 ppm BHT) is added to a pre nitrogen-sparged, septa-capped vial, via the PolymerChar high temperature autosampler. The samples are dissolved for two hours at 160°
15 Celsius under “low speed” shaking.

- The calculations of Mn(GPC), Mw(GPC), and Mz(GPC) are based on GPC results using the internal IR5 detector (measurement channel) of the PolymerChar GPC-IR chromatograph according to Equations 4-6, the PolymerChar GPCOne™ software, the baseline-subtracted IR chromatogram at each equally-spaced data collection point (i), and the
20 polyethylene equivalent molecular weight obtained from the narrow standard calibration curve for the point (i) from Equation 1. Equations 4-6 are as follows:

$$Mn_{(GPC)} = \frac{\sum_i IR_i}{\sum_i \left(\frac{IR_i}{M_{polyethylene_i}} \right)} \quad (EQ\ 4), \quad MW_{(GPC)} = \frac{\sum_i (IR_i * M_{polyethylene_i})}{\sum_i IR_i} \quad (EQ\ 5), \text{ and}$$

$$Mz_{(GPC)} = \frac{\sum_i (IR_i * M_{polyethylene_i}^2)}{\sum_i (IR_i * M_{polyethylene_i})} \quad (EQ\ 6).$$

- In order to monitor the deviations over time, a flowrate marker (decane) is introduced
25 into each sample, via a micropump controlled with the PolymerChar GPC-IR system. This flowrate marker (FM) is used to linearly correct the pump flowrate (Flowrate(nominal)) for each sample, by RV alignment of the respective decane peak within the sample (RV(FM

- Sample)), to that of the decane peak within the narrow standards calibration (RV(FM Calibrated))). Any changes in the time of the decane marker peak are then assumed to be related to a linear-shift in flowrate (Flowrate(effective)) for the entire run. To facilitate the highest accuracy of a RV measurement of the flow marker peak, a least-squares fitting routine is used to fit the peak of the flow marker concentration chromatogram to a quadratic equation. The first derivative of the quadratic equation is then used to solve for the true peak position. After calibrating the system, based on a flow marker peak, the effective flowrate (with respect to the narrow standards calibration) is calculated from Equation 7:
- $$\text{Flowrate(effective)} = \text{Flowrate(nominal)} * (\text{RV(FM Calibrated)} / \text{RV(FM Sample)}) \text{ (EQ7).}$$
- Processing of the flow marker peak is done via the PolymerChar GPCOne™ software. Acceptable flowrate correction is such that the effective flowrate should be within +/-0.7% of the nominal flowrate.

EXPERIMENTAL

- Polymers and polymer blends are listed in Table 1A below.

Table 1A: Polymers and Polymer Blends

Product Name	Chemical Description	SS-Tm (°C)	
ENGAGE™ 8450 Polyolefin Elastomer	Ethylene/octene copolymer, Density = 0.902 g/cc, MI = 3.0 g/10min, available from The Dow Chemical Company	NA	POE A
ENGAGE™ 8003/ENGAGE™ 8401 1/1 weight ratio,	Density = 0.885 g/cc MI = 5.5 g/10min		POE B
ENGAGE™ 8200 Polyolefin Elastomer	Ethylene/octene copolymer, density = 0.87 g/cc, MI = 5.0 g/10 min, available from The Dow Chemical Company	NA	POE C
INFUSE™ 9530 Olefin Block Copolymer	Ethylene/octene multi-block copolymer, density = 0.887 g/cc, MI = 5.0 g/10 min, available from The Dow Chemical Company	6	POE D
INFUSE™ 9500 Olefin Block Copolymer	Ethylene/octene multi-block copolymer, density = 0.877 g/cc, MI (or I2) = 5.0 g/10 min, available from The Dow Chemical Company	6	POE E
Olefin Block Copolymer 1 (OBC 1)*	Ethylene/octene multi-block copolymer, density = 0.885 g/cc, MI = 0.5 g/10 min.	6	POE F
OBC 1/ INFUSE™ 9530 1/1 weight ratio	Density = 0.886 g/cc MI = 1.6 g/10min		-
ENGAGE™ XLT 8677	Density = 0.87 g/cc, MI = 0.5 g/10 min available from the Dow Chemical Company	-	POE 1
Olefin Block Copolymer 2 (OBC 2)*	Density = 0.885 g/cc, MI = 4.7 g/10 min	27	POE 2
Olefin Block Copolymer 3 (OBC 3)*	Density = 0.894 g/cc, MI = 4.3 g/10 min	16	POE 3
Olefin Block Copolymer 4 (OBC 4)*	Density = 0.902 g/cc, MI = 4.9 g/10 min	13	POE 4
Olefin Block Copolymer 5 (OBC 5)*	Density = 0.902 g/cc, MI = 1.1 g/10 min	36	POE 5
ENGAGE™ 8003 Polyolefin Elastomer	Ethylene/octene copolymer, Density = 0.885 g/cc, MI = 1.0 g/10min,	NA	-

	available from The Dow Chemical Company		
ENGAGE™ 8401 Polyolefin Elastomer	Ethylene/octene copolymer, Density = 0.885 g/cc, MI = 30 g/10min, available from The Dow Chemical Company	NA	-
Ultraclear™ GP110BW	Polypropylene clarifier masterbatch from Milliken Corporation	-	CF
Braskem D115A	Polypropylene homopolymer MFR = 11 g/10 min, Density = 0.90-0.92 g/cc (average 0.91 g/cc), available from Braskem.	NA	hPP 1
Braskem F1000HC	Polypropylene homopolymer MFR = 115 g/10 min, Density = 0.90-0.92 g/cc (average 0.91 g/cc), available from Braskem.	NA	hPP 2
ADSTIF HA802H	Polypropylene homopolymer MFR = 2.3 g/10 min, Density = 0.90 g/cc, available from LyondellBasell.	NA	-
ADSTIF HA801U	Polypropylene homopolymer MFR = 65 g/10 min, Density = 0.90 g/cc, available from LyondellBasell.	NA	-
Braskem D115A/Braskem F1000HC 2/1 weight ratio	MFR = 24.0 g/10 mins Ave. Density = 0.91 g/cc	NA	hPP A
ADSTIF HA802H/ADSTIF HA801U 1/1 weight ratio	MFR = 12.2 g/10 mins Density = 0.90 g/cc	NA	hPP B
ADSTIF HA802H/ADSTIF HA801U 2/3 weight ratio	MFR = 17.1 g/10 min Density = 0.90 g/cc	NA	hPP C
Braskem D115A/Braskem F1000HC 1/1 weight ratio	MFR = 35.6 g/10 min Ave. Density = 0.91 g/cc	N/A	hPP D
JETFINE™ 3CW	Ultra-fine talc Available from IMERYS North America Performance Additives	N/A	Filler A
CESA – Brite™ PPA0642725	Optical brightener polypropylene homopolymer masterbatch purchased from Avient Corporation under brand name Cesa™ Bright masterbatch	-	OB
Irganox™ B225	Antioxidant available from BASF	-	AO 1

*See synthesis below.

NA = Not Applicable.

- For each blend in Table 1A, the density and the melt flow rate (MFR) or melt index
- 5 (MI) were calculated from the following respective equations. The density equation for a blend is as follows, where w_a and w_b are the respective weight fractions of the blend components, and p_a and p_b are the respective densities of the blend components: $1/p = w_a/p_a + w_b/p_b$. The MFR equation for a blend is as follows, where w_a and w_b are the respective weight fractions of the blend components, and MFR_a and MFR_b are the respective
- 10 MFR values of the blend components: $MFR = 10^{(w_a \log MFR_a + w_b \log MFR_b)}$. The MI equation for a blend is as follows, where w_a and w_b are the respective weight fractions of the blend components, and MI_a and MI_b are the respective MI values of the blend components:

$MI = 10^{(w_a \log MI_a + w_b \log MI_b)}$. Each blend in Table 1A was prepared by mixing the respective polymer components (pellets) together, with extensive shaking, to form a pellet blend.

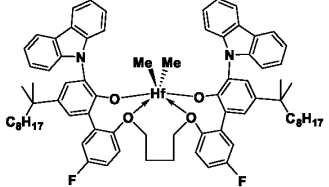
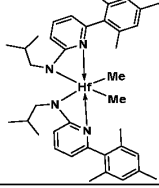
Pilot Plant Synthesis of OBCs 1, 2, 3, 4, and 5

5 All raw materials (ethylene and 1-octene) and the process solvent (a narrow boiling range high-purity isoparaffinic solvent, Isopar-E) are purified with molecular sieves before introduction into the reaction environment. Hydrogen is supplied pressurized 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 are
10 pressurized via a pump to above reaction pressure. The individual catalyst components are manually batch diluted with purified solvent and pressurized to above reaction pressure. All reaction feed flows are measured with mass flow meters and independently controlled with computer automated valve control systems.

The continuous solution polymerization reactor consists of either a continuous stirred
15 tank reactor (CSTR); or a liquid full, non-adiabatic, isothermal, circulating, loop reactor which mimics a continuously stirred tank reactor 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 to maintain a single solution phase by passing the feed stream through
20 a heat exchanger. The catalyst components are injected into the polymerization reactor through specially designed injection stingers. The primary catalyst component feed (Catalyst 1 from Table 1B) is computer controlled to maintain the reactor monomer conversion at the specified target. The molar ratio of the secondary catalyst feed (Catalyst 2 from Table 1B) to total catalyst feed is adjusted to maintain the desired split between the polymer soft segment
25 and hard segment. The Co-catalyst 3 component is fed based on calculated specified molar ratio to the catalyst components. The Co-catalyst 4 component is fed to maintain a constant specified concentration in the reactor. Immediately following each reactor feed injection location, the feed streams are mixed with the circulating polymerization reactor contents with static mixing elements. For the loop reactor configuration, the contents of the reactor are
30 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 of the reactor contents is provided via a pump for the loop reactor, or via an agitator for the CSTR.

The reactor effluent enters a zone where it is deactivated with the addition of and reaction with a suitable reagent (water). At this same reactor exit location other additives are added for polymer stabilization. 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 was either: 1. passed to the waste or 2. through various pieces of equipment which separate most of the ethylene which was removed from the system. In the second case, 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 was purged from the process. Polymerization conditions for the polymers are further provided in Table 1C.

Table 1B: Catalysts and Co-Catalysts

	Hafnium, [[2',2''-[1,4-butanediylbis(oxy-κO)]bis[3-(9H-carbazol-9-yl)-5-(1,1-dimethylnonyl)-5'-fluoro[1,1'-biphenyl]-2-olato-κO]](2-)-]dimethyl-
	Hafnium, dimethylbis[N-(2-methylpropyl)-6-(2,4,6-trimethylphenyl)-2-pyridinaminato-κN1, κN2]-
Co-catalyst 3	Bis(hydrogenated tallow alkyl)methyl, tetrakis(pentafluorophenyl)borate(1-) amine (RIBS-2) available from Boulder Scientific
Co-catalyst 4	Iso-butyl, methyl, branched, cyclic and linear modified methyl alumino-siloxane (MMAO), available from AkzoNobel
Chain Shuttling Agent	diethylzinc

15

Table 1C: Polymerization Conditions

Reactor Configuration	Type	OBC 1	OBC 2	OBC 3	OBC 4	OBC 5
Comonomer type	Type	1-octene	1-octene	1-octene	1-octene	1-octene
		*single reactor	*single reactor	*single reactor	*single reactor	*single reactor
Reactor Feed Solvent / Ethylene Mass Flow Ratio	g/g	4.6	6.2	5.5	5.0	5.4
Reactor Feed Comonomer / Ethylene Mass Flow Ratio	g/g	1.75	1.47	1.74	2.09	1.24
Reactor Feed Hydrogen / Ethylene Mass Flow Ratio	g/g	6.0E-05	2.3E-04	2.1E-04	1.9E-04	1.4E-04

Reactor Zn / Ethylene Mass Flow Ratio	g/g	4.2E-04	5.4E-04	5.1E-04	4.8E-04	3.4E-04
Reactor Temperature	°C	150	150.0	150.0	151.4	150.0
Reactor Pressure	barg	34	28	28	28	28
Reactor Ethylene Conversion	%	89.1	86.0	86.7	87.1	87.8
Reactor % of Total Catalyst from Catalyst 2	Mole %	66.8	72.0	86.0	89.1	87.0
Cocatalyst 3 to Catalyst Molar Ratio (B to Catalyst Metal ratio)	Ratio	1.2	1.2	1.2	1.22	1.2
Cocatalyst 4 to Catalyst Molar Ratio (Al to Catalyst Metal ratio)	Ratio	7.6	28.4	22.4	33.4	19.6
Reactor Residence Time	min	12.8	6.4	6.5	6.4	6.5

Compositions: Inv. 1-10 and Comparatives A and B

Compounding

Inventive Compositions Inv. 1-10 and Comparatives A and B are shown in Tables 5 to 8B below. For each composition (TPO), the components (pellets and/or pellet blend) were mixed in a twin-screw extruder; that is a COPERION ZSK-26 mm twin screw extruder, equipped with a water bath and strand cutter. The extruder configuration and the temperature profile, for each composition, is shown in Table 2. All the components, except for the talc, were dry blended in a plastic bag, and then fed to the main feed throat via a *loss-in-weight* feeder. The talc was fed to the main feed throat via a separate powder feeder.

Table 2: Compounding Conditions

ZSK-26	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Extruder
Set points	130°C	180°C	200°C	200°C	200°C	200°C	200°C	200°C	300 RPM

Injection Molding - Type I and ISO Tensile Bars

ASTM D638 Type I tensile bars and ISO tensile bars were injection molded on a TOYO injection molding machine. Molding conditions were optimized to ensure minimal defects in the molded parts, via various control experiments. The key injection molding settings are tabulated in Table 3 A and B. The tensile bars were used for all of the mechanical properties, except Dart Ductility. See Tables 5-8B below.

Table 3A: Injection Molding Conditions for ASTM D638 Type I tensile bars

Set Temperature (degree C)				Dosage Volume (mm)	Inj.-Hold Switch Over Position (mm)
Zone 1	Zone 2	Zone 3	Zone 4		
226	226	226	226	60	15
Setting Injection Pressure (Bar)	Hold Pressure (Bar)	Back Pressure (Bar)	Plasticizing Speed/Screw Spd (rpm)	Injection Speed (mm/s)	
2000	250-400	50	90	40-100	

Table 3A: Injection Molding Conditions for ISO tensile bars

Set Temperature (degree C)				Dosage Volume (mm)	Inj.-Hold Switch Over Position (mm)
Zone 1	Zone 2	Zone 3	Zone 4		
235	235	235	235	64.5	15
Setting Injection Pressure (Bar)	Hold Pressure (Bar)	Back Pressure (Bar)	Plasticizing Speed/Screw Spd (rpm)	Injection Speed (mm/s)	
2000	250-400	50	75	120	

5 Injection Molding – TPO Discs

TPO discs (4 inch diameter) with thickness of 1/8 inch (3.2 mm) were injection molded on a TOYO injection molding machine. Molding conditions were optimized to ensure minimal defects in the molded parts, via various control experiments. The key injection molding settings are tabulated in Table 4. The discs were used for the optical properties and the Dart Ductility. See Tables 5-8B below.

Table 4: Injection Molding Settings

Set Temperature (degree C)				Dosage Volume (mm)	Inj.-Hold Switch Over Position (mm)
Zone 1	Zone 2	Zone 3	Zone 4		
226	226	226	226	66	17
Setting Injection Pressure (Bar)	Hold Pressure (Bar)	Back Pressure (Bar)	Plasticizing Speed/Screw Spd (rpm)	Injection Speed (mm/s)	
2000	150	50	90	40-100	

Studies

A. Effects of Tg on TPO Performance – Mechanical Properties

A summary of the TPO performance of two compositions (inventive vs. comparative) is shown below in Table 5 ($T_{gPOE D} < (T_{gPOE B} - 10^{\circ}C)$). The inventive composition (Inventive 1) has improved lower temperature impact performance (see Notched Izod values and Dart Ductility) at comparable optical properties (see Transmittance at RT), as compared to the comparative composition (Comparative A).

Table 5: Mechanical and Optical Properties

Testing	Comp. A (hPP A/POE B = 65/35 wt/wt)	Inv. 1 (hPP A/POE D = 65/35 wt/wt)
MFR 230°C (dg/min)	20	20
Notched Izod RT (kJ/m ²)	50	60
Notched Izod 0°C (kJ/m ²)	8	40
Notched Izod -30 °C (kJ/m ²)	6	10
Lowest temperature with 100% Dart Ductility, 2.2m/s*	100% at -30°C	100% at -40°C ^a
Transmittance at RT (% , 3.2 mm)	62	59
Flex Mod (MPa)	1120	1150

Note RT = 23°C.

*See Dart Ductility test method.

- 5 a) Note, since “100% ductility” was achieved at -40°C, “100% ductility” is also achievable at higher temperatures, such as, for example, -30°C, -20°C, -10°C and 0°C.

B. Effects of Crystallinity on TPO Performance – Optical Properties

- 10 The effects of crystallinity on the TPO performance of an inventive composition and a comparative composition are shown below in Table 6. Comparative B and Inventive 2 have comparable physical performance, but Inventive 2 has a substantially reduced change in optical transmittance from RT to 60°C.

Table 6: Mechanical and Optical Properties

Testing	Comp. B hPP A/POE C = 65/35 wt/wt	Inv. 2 hPP A/POE E = 65/35 wt/wt
Change in cumulative crystallinity of POE between RT and 60°C (%)*	9.5	1.8
MFR 230°C (dg/min)	20	20
Notched Izod RT (kJ/m ²)	59.4	60.7
Notched Izod -30 °C (kJ/m ²)	9.6	10.5
Dart Ductility %, 2.2m/s	100% at -40°C	100% at -40°C ^a
Transmittance at RT (% , 3.2 mm)	46	49
Transmittance at 40°C (% , 3.2 mm)	37	46
Transmittance at 60°C (% , 3.2 mm)	30	45
Flex Mod (MPa)	1100	1139

Note RT = 23°C.

*Method described in DSC test method.

- 15 a) Note, since “100% ductility” was achieved at -40°C, “100% ductility” is also achievable at higher temperatures, such as, for example, -30°C, -20°C, -10°C and 0°C.

C. Optical Diffusion

- 20 Optical diffusion or light diffusion is a measure of the ability of a material to transmit light from a light source, in a homogeneous manner through the material, without depicting one or more features of the pattern of the light source (for example, LED lighting) underneath the material. Figure 3 depicts pictures of two TPO plaques, each with a 3.2 mm thickness, on top of a LED light source. The plaque on the left was prepared using a comparative composition (hPP A/POE A = 65/35 wt/wt). The plaque on the right was prepared using an

inventive composition (hPP A/POE D = 65/35 wt/wt). The comparative composition, typically used for a clear tough application, showed greater than 60% light transmittance, however, this composition had inhomogeneous light transmittance (or poor diffusion), since a large number of hot spots, due to the light intensity from the LED device, can be seen through the plaque. Moreover, a part formed from this comparative composition has poor impact performance (0% Dart Ductility at -40°C). The inventive (translucent TPO) composition provides a greater amount of homogeneous light transmittance (or good diffusion) at the same thickness (i.e. 3.2 mm), where a significantly lower number of hot spots are observed on the plaque.

D. Performance of Filler Free and Low-Filler Compositions

The TPO performance of three filler free compositions and one low filler composition is shown in Table 7 below. Each composition had very good low temperature Dart Ductility, good/consistent light transmittance in the noted operating temperature(s), and good light diffusion.

Table 7: Mechanical and Optical Properties

	Inv. 3	Inv. 4	Inv. 5	Inv. 6
	hPP A/POE D = 65/35	hPP A/POE D = 70/30	hPP A/POE F = 75/25	hPP D/POE D/POE F/ Filler A =65/15/15/5
MFR (dg/min)	20	20	13	18
Flexural Modulus (MPa)	1130	1260	1310	1350
Notched IZOD RT (kJ/m ²)	57	42	19	44
Notched IZOD 0°C (kJ/m ²)	32	9	9	8
Notched IZOD -30°C (kJ/m ²)	10.3	5.2	6.3	5.3
Lowest Temperature (°C) with a Dart Ductility of 100% ^a (2.2 m/s)	-40	-40	-40	-40
Light transmittance (3.2 mm thickness, at RT)	59%	60%	57%	37%
Light transmittance (3.2 mm thickness, at 60°C)	52%	-	-	-
Light Diffusion	Good	Good	Good	Good

Note RT = 23°C. a) Note, since “100% ductility” was achieved at -40°C for each composition, “100% ductility” is also achievable at higher temperatures, such as, for example, -30°C, -20°C, -10°C and 0°C.

E. Variation in the hPP

Table 8B summarizes the stiffness (Flex Mod.)/toughness (Izod and Dart Ductility)/flow (MFR) for several compositions, each containing a different type of polypropylene homopolymer as seen in Table 8A. Inventive 9 and Inventive 10 showed substantially improved stiffness/toughness/flow performance. Table 8A depicts the DSC peaks identified from the first cooling curve for each of Inventive 9 and Inventive 8'. As

seen in this table, the better performing composition (Inv. 9) has two separate crystallization peaks, each at a temperature above 100°C, and with the highest temperature crystallization peak occurring at a temperature greater than 120°C.

Table 8A: Compositions and Properties

	Composition						DSC Profile	
	POE	hPP	POE amount	PP MFR	POE MI	POE Type	Cryst. peak 2	Cryst. peak 1
			(%)	(dg/min)	(dg/min)		(°C)	(°C)
Inv. 7'	POE D	hPP C	29	17.1	5.0	OBC	-	-
Inv. 8'	POE D	hPP B	32	12.2	5.0	OBC	115.4	-
Inv. 9	POE D	hPP A	35	24.0	5.0	OBC	129.8	110.0
Inv. 10	POE D	hPP A	30	24.0	5.0	OBC	-	-

5

Table 8B: Compositions and Properties Continued

	TPO Properties							
	MFR	Flex Mod	IZOD			Dart Ductility 2.2 m/s		Transmittance at RT
	dg/min	MPa	RT	0°C	-30°C	-30 C	-40°C	%
Inv. 7'	14.2	1119	18.9	6.1	3.7	0	0	61
Inv. 8'	10.6	991	34.1	18.8	4.8	60	0	61
Inv. 9	19.8	1126	57.2	31.5	10.3	100	100 ^a	61
Inv. 10	22.3	1259	41.6	8.6	5.2	100	100 ^b	61

Note RT = 23°C.
a), b) Note, since “100% ductility” was achieved at -40°C for each composition, “100% ductility” is also achievable at higher temperatures, such as, for example, -30°C, -20°C, -10°C and 0°C.

10

F. Addition of the optical brightener and polypropylene clarifier

Inv. A was formulated to incorporate an optical brightener and polypropylene clarifier masterbatch to mitigate the yellowness of the molded parts likely due to the addition of the talc fillers. The formulation and TPO performance are shown in Table 9A and 9B. After making parts, the Inv. A formulation with optical brightener and clarifier was observed to have visually less yellowness than formulations without optical brighteners and clarifiers (i.e. Inv. 6), and meanwhile still offer comparable level of light transmittance, and ductility at -40 °C.

15

Table 9A. Composition of compound with optical brightener and clarifier

Formulation Ingredients (by parts)	Inv. A
hPP 1	16.8
hPP 2	35.8
POE D	24.8
POE 1	10
AO1	0.6
Filler A	5
CF	4
Total	100

20

Table 9B. Properties of compound with optical brightener and clarifier

Property	Inv. A
Flex Modulus (MPa)	1760
Notched Charpy at 23 C (kJ/m ²)	38.5
Notched Charpy at -30 C (kJ/m ²)	4.2
Light transmittance @ room temperature (3.2 mm thick parts)	37.6
Dart ductility%, 3.3 m/s (-40°C)	100

Note, since “100% ductility” was achieved at -40°C for each composition, “100% ductility” is also achievable at higher temperatures, such as, for example, -30°C, -20°C, -10°C and 0°C.

5 Compositions: Inv. B-D and Comparative C

Compounding

Inventive Compositions B-D and Comparative C are shown in Table 9 below. For each composition (TPO), the components (See Table 10) were compounded in a twin screw extruder (TSE) (model: Coperion ZSK 18 MEGA1ab), a high speed (maximum: 1200 RPM), high torque (maximum specific torque: 18 Nm/cm³) 18 mm co-rotating TSE, with L/D = 40 and Do/Di = 1.55. The processing conditions and the screw design used to compound the materials are provided in Table 11, respectively.

Table 10: Compositions

Formulation Ingredients (by parts)	Inv. B	Inv. C	Inv. D	Comp. C
hPP 1	41.8	41.8	41.8	41.8
hPP 2	27.8	27.8	27.8	27.8
POE 2	30	-	-	-
POE 3	-	30	-	-
POE 4	-	-	30	-
POE 5	-	-	-	30
AO1	0.4	0.4	0.4	0.4
Total	100	100	100	100

15 Table 11: Processing conditions used in twin screw extruder for compounding

ZSK-18	Zone 1	Zone 2	Remaining Zone	Extruder	Feed Rate
Set points	140°C	180°C	190°C	300 RPM	10 lbs/hr

Injection Molding – Type I Tensile Bars

ASTM D638 Type I tensile bars (0.125 inch thick) were injection molded on a 100-ton injection molding machine (model: Sodick™ GL100A) fitted with a Master Precision manufactured Master Unit Die (MUD®) frame to fabricate ASTM D638, Type I tensile bars
5 (0.125 inch thick) using an insert gated, according to ASTM D3641-02 table I (2.1 x 19 mm) with a Z-runner (2 tensile bars per shot). Molding conditions were optimized to ensure minimal defects in the molded parts, via various control experiments. The key injection molding settings are tabulated in Table 12.

Table12: Processing Conditions Used in the Injection Molding Machine

Zone Z0 temperature (°C)	190
Remaining zone temperatures (°C)	190
Injection velocity (cc/s)	35
Hold time (s)	10
Mold temperature (F)	140
Cooling time (s)	30

10

TPO discs (4 inch diameter) with thickness of 1/8 inch (3.2 mm) were injection molded using a side gate insert. Molding conditions were optimized to ensure minimal defects in the molded parts, via various control experiments. The discs were used for the optical and mechanical properties. See Tables 13 below.

15

Table 13: Optical and Mechanical Properties of Inv. B-D and Comp. C

Property	Inv. B	Inv. C	Inv. D	Comp. C
Flexural Modulus (MPa)	1386	1323	1354	1536
Notched IZOD RT (kJ/m ²)	17.1	9.8	-	9.7
Notched IZOD -30°C (kJ/m ²)	3.9	4.2	-	3.9
Light transmittance @ room temperature (3.2 mm thick parts)	61	52	50	57
Light transmittance @ 60°C (3.2 mm thick parts)	-	49	50	53

Inv. B-D were formulated with additional OBC based modifiers POE 2 to POE 4 which were synthesized under conditions providing higher densities (0.885 to 0.902 g/cc). These formulations exhibit quite consistent light transmittance measured at both room temperature (23°C) and at the elevated temperature of 60°C, with light transmittance difference less or equal than 6%. Comparative C, which was made with POE 5 having higher SS T_m (SS T_m = 36 °C), the change in light transmittance between room temperature versus light transmittance at 60° was found to increase. Even when compared to the Inv. E which was made with POE 4 with a comparable density around 0.902 g/cc.

CLAIMS

1. A composition comprising a first composition that comprises at least the following *components a and b*:
 - a) at least one ethylene/alpha-olefin multi-block interpolpolymer that comprises a density ≥ 0.870 g/cc and a soft segment melting temperature (SS-T_m) $\leq 35^{\circ}\text{C}$;
 - b) a polymer composition comprising at least one propylene homopolymer, and wherein the *component a* is present in an amount ≤ 50 wt%, based on the weight of *components a and b*.
2. The composition of claim 1, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a density from 0.870 g/cc to 0.910 g/cc.
3. The composition of claim 1 or claim 2, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a SS-T_m from -20°C to 35°C .
4. The composition of any one of claims 1-3, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) is an ethylene/alpha-olefin multi-block copolymer.
5. The composition any one of claims 1-4, wherein the ethylene/alpha-olefin multi-block interpolpolymer (of *component a*) has a melt index (I₂) from 0.1 to 50 g/10 min.
6. The composition of any one of claims 1-5, wherein the propylene homopolymer (of *component b*) has a melt flow rate (MFR) from 1.0 to 200 g/10 min.
7. The composition of any one of claims 1-6, wherein *component b* comprises at least two propylene homopolymers (first and second), and wherein the melt flow rate of the first homopolymer (MFR_{hPP1}) is greater than the melt flow rate of the second homopolymer (MFR_{hPP2}).
8. The composition of claim 7, wherein the ratio of the MFR_{hPP1}/ MFR_{hPP2} is from "greater than 1" to 50.
9. The composition of claim 7 or claim 8, wherein the weight ratio of the first propylene homopolymer to the second propylene homopolymer is from 0.1 to 10.
10. The composition of any one of claims 1 to 9, wherein the weight ratio of *component b* to *component a* is from 1.0 to 10.0.
11. The composition of any one of claims 1-10, wherein the first composition comprises from 80 wt% to 100 wt% of the sum of *components a and b*, based on the weight of the first composition.
12. The composition of any one of claims 1-11, wherein the first composition comprises at least two crystallization peaks (first peak and second peak), and wherein the second peak and

the first peak are the peaks with highest and second highest crystallization temperatures, respectively, and wherein the second and first peaks each, independently, has a crystallization temperature $\geq 100^{\circ}\text{C}$.

13. The composition of claim 12, wherein the first crystallization peak has a crystallization temperature from 100°C to 140°C .

14. The composition of claim 12 or claim 13, wherein the second crystallization peak has a crystallization temperature $\geq 5^{\circ}\text{C}$ higher than the crystallization temperature of the first crystallization peak.

15. The composition of any one of claims 1-14, wherein the composition has a MFR ≥ 5.0 g/10 min.

16. The composition of any one of claims 1-15, wherein the composition has a Light Transmittance (3.2 mm thickness), at RT (23°C), $\geq 30\%$.

17. The composition of any one of claims 1-16, wherein the composition has a % change in Light Transmittance that meets the following relationship: $[(\text{Light Transmittance (3.2 mm thickness), at RT (23}^{\circ}\text{C)}) - (\text{Light Transmittance (3.2 mm thickness), at } 60^{\circ}\text{C})] \leq 15\%$.

18. The composition of any one of claims 1-17, wherein the composition has the following properties a) through g): a) a MFR ≥ 10 g/min, b) a Light Transmittance (3.2 mm thickness), at RT, $\geq 30\%$, c) a Dart Ductility, at -10°C (2.2 m/s), $\geq 90\%$, d) a Notched Izod, at -30°C , ≥ 4 kJ/m², e) a Notched Izod, at 23°C , ≥ 35 kJ/m², f) a Flexural Modulus ≥ 800 MPa, and g) a $[(\text{Light Transmittance (3.2 mm thickness) at RT(23}^{\circ}\text{C)}) - (\text{Light Transmittance (3.2 mm thickness) at } 60^{\circ}\text{C})] \leq 10\%$.

19. An automotive article comprising at least one component formed from the composition of any one of claims 1-18.

20. An article comprising at least one component formed from the composition of any one of claims 1-18.