THERMOPLASTIC COMPOSITIONS COMPRISING BIMODAL POLYETHYLENE AND ARTICLES MANUFACTURED THEREFROM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/061,369, filed on August 5, 2020, the entire disclosure of which is hereby incorporated by reference.

TECHNICAL FIELD

[0002] Embodiments of the present disclosure are generally directed to thermoplastic compositions and, in particular, thermoplastic compositions comprising bimodal polyethylene and articles manufactured therefrom.

BACKGROUND

[0003] When manufacturing insulation and jacket layers for wires and cables, both the performance (*e.g.*, mechanical properties, environmental stress-cracking resistance, etc.) and the processability of the thermoplastic compositions used for the manufacture of the insulation and jacket layers are critical in order to ensure both success in fabrication and long-term durability during service. While some thermoplastic compositions may have superior mechanical properties, such as elongation at break, these superior mechanical properties are typically achieved by sacrificing processability, environmental stress-cracking resistance, or combinations thereof. In contrast, other thermoplastic compositions may achieve superior processability by sacrificing mechanical properties, environmental stress-cracking resistance, or combinations thereof. Accordingly, there is an ongoing need for thermoplastic compositions that balance mechanical properties and processability while also maintaining environmental stress-cracking resistance.

SUMMARY

[0004] The present disclosure addresses these needs by providing a bimodal polyethylene comprising a high molecular weight component and a low molecular weight component. The bimodal polyethylene may have a density of from 0.933 grams per centimeter (g/cm^3) to $0.960 g/cm^3$, a melt index (I_2) of from 0.3 decigrams per minute (dg/min) to 1.2 dg/min, a melt flow ratio (MFR_{21}) greater than or equal to 80.0, a molecular weight distribution (M_w/M_n) greater than or equal to 10, a reverse comonomer distribution, and a shear thinning index of from 5.0 to 20.0.

[0004a] In one aspect, the present disclosure provides a bimodal polyethylene comprising a high molecular weight component and a low molecular weight component, wherein the bimodal polyethylene has:

a density of from 0.933 g/cm^3 to 0.960 g/cm^3 when measured according to ASTM D792-13, Method B;

a melt index (I_2) of from 0.3 dg/min to 1.2 dg/min when measured according to ASTM D1238-10 at 190 °C and a 2.16 kg load;

a melt flow ratio (MFR_{21}) greater than 80.0 and less than or equal to 120, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the bimodal polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10 at 190 °C and a 21.6 kg load;

a molecular weight distribution (M_w/M_n) greater than 10.0, wherein the molecular weight distribution (M_w/M_n) is a ratio of a weight average molecular weight (M_w) of the bimodal polyethylene to a number average molecular weight (M_n) of the bimodal polyethylene, and the weight average molecular weight (M_w) and the number average molecular weight (M_n) are measured using gel permeation chromatography (GPC);

a molecular weight distribution (M_z/M_w) from 4 to 6, wherein the molecular weight distribution (M_z/M_w) is a ratio of a z-average molecular weight (M_z) of the bimodal polyethylene, measured using GPC, to the weight average molecular weight (M_w);

a z-average molecular weight (M_z) of from 900,000 g/mol to 1,500,000 g/mol, measured using GPC;

a reverse comonomer distribution, wherein a ratio of a short chain branching distribution of the high molecular weight component ($SCBD_2$) to a short chain branching distribution of the low molecular weight component ($SCBD_1$) is greater than 1.0, and the short chain branching distribution of the high molecular weight component ($SCBD_2$) and the short chain branching distribution of the low molecular weight component ($SCBD_1$) are measured using gel permeation chromatography (GPC); and

a shear thinning index (SHI) of from 5.0 to 20.0, wherein the shear thinning index (SHI) is a ratio of a complex viscosity of the bimodal polyethylene measured at 0.1 radians per second ($\eta^*0.1$) to a complex viscosity of the bimodal polyethylene measured at 100 radians per second (η^*100), and the complex viscosities of the

bimodal polyethylene are determined at 190 °C using Dynamic Mechanical Spectroscopy (DMS).

[0004b] In another aspect, the present disclosure provides a method for producing the bimodal polyethylene as defined herein, the method comprising polymerizing via gas-phase polymerization ethylene and at least one 1-alkene comonomer in the presence of a main catalyst and a trim catalyst in a single reactor to produce the bimodal polyethylene.

[0004c] In another aspect, the present disclosure provides a thermoplastic composition comprising from 50.1 wt.% to 99.9 wt.% of the bimodal polyethylene as defined herein; and from 0.1 wt.% to 1.0 wt.% of a first antioxidant component, and optionally from 0.0 wt.% to 1.0 wt.% of a second antioxidant; from 0.0 wt.% to 5.0 wt.% of an ultraviolet stabilizer; from 0.0 wt.% to 1.0 wt.% of a processing aid; from 0.0 wt.% to 1.0 wt.% of a flame retardant; and from 0.0 wt.% to 1.0 wt.% of a filler.

[0004d] In another aspect, the present disclosure provides an article manufactured using the bimodal polyethylene as defined herein, or the thermoplastic composition as defined herein.

[0005] These and additional features provided by the present disclosure will be more fully understood in view of the following detailed description.

CLAIMS

1. A bimodal polyethylene comprising a high molecular weight component and a low molecular weight component, wherein the bimodal polyethylene has:

a density of from 0.933 g/cm^3 to 0.960 g/cm^3 when measured according to ASTM D792-13, Method B;

a melt index (I_2) of from 0.3 dg/min to 1.2 dg/min when measured according to ASTM D1238-10 at 190 °C and a 2.16 kg load;

a melt flow ratio (MFR_{21}) greater than 80.0 and less than or equal to 120, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the bimodal polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10 at 190 °C and a 21.6 kg load;

a molecular weight distribution (M_w/M_n) greater than 10.0, wherein the molecular weight distribution (M_w/M_n) is a ratio of a weight average molecular weight (M_w) of the bimodal polyethylene to a number average molecular weight (M_n) of the bimodal polyethylene, and the weight average molecular weight (M_w) and the number average molecular weight (M_n) are measured using gel permeation chromatography (GPC);

a molecular weight distribution (M_z/M_w) from 4 to 6, wherein the molecular weight distribution (M_z/M_w) is a ratio of a z-average molecular weight (M_z) of the bimodal polyethylene, measured using GPC, to the weight average molecular weight (M_w);

a z-average molecular weight (M_z) of from 900,000 g/mol to 1,500,000 g/mol, measured using GPC;

a reverse comonomer distribution, wherein a ratio of a short chain branching distribution of the high molecular weight component ($SCBD_2$) to a short chain branching distribution of the low molecular weight component ($SCBD_1$) is greater than 1.0, and the short chain branching distribution of the high molecular weight component ($SCBD_2$) and the short chain branching distribution of the low molecular weight component ($SCBD_1$) are measured using gel permeation chromatography (GPC); and

a shear thinning index (SHI) of from 5.0 to 20.0, wherein the shear thinning index (SHI) is a ratio of a complex viscosity of the bimodal polyethylene measured at 0.1 radians per second ($\eta^*0.1$) to a complex viscosity of the bimodal polyethylene measured at 100 radians per second (η^*100), and the complex viscosities of the

bimodal polyethylene are determined at 190 °C using Dynamic Mechanical Spectroscopy (DMS).

2. The bimodal polyethylene of claim 1, wherein the bimodal polyethylene has a density of from 0.933 g/cm^3 to 0.945 g/cm^3.

3. The bimodal polyethylene of claim 2, wherein the short chain branching distribution of the high molecular weight component ($SCBD_2$) of the bimodal polyethylene is greater than or equal to 4.0 average number of branches/1000 Carbons.

4. The bimodal polyethylene of claim 1, wherein the bimodal polyethylene has a density of from 0.945 g/cm^3 to 0.960 g/cm^3.

5. The bimodal polyethylene of claim 4, wherein the short chain branching distribution of the high molecular weight component ($SCBD_2$) of the bimodal polyethylene is greater than or equal to 3.0 average number of branches/1000 Carbons.

6. A method for producing the bimodal polyethylene of any one of claims 1 to 5, the method comprising polymerizing via gas-phase polymerization ethylene and at least one 1-alkene comonomer in the presence of a main catalyst and a trim catalyst in a single reactor to produce the bimodal polyethylene.

7. A thermoplastic composition comprising from 50.1 wt.% to 99.9 wt.% of the bimodal polyethylene of any one of claims 1 to 5; and from 0.1 wt.% to 1.0 wt.% of a first antioxidant component, and optionally from 0.0 wt.% to 1.0 wt.% of a second antioxidant; from 0.0 wt.% to 5.0 wt.% of an ultraviolet stabilizer; from 0.0 wt.% to 1.0 wt.% of a processing aid; from 0.0 wt.% to 1.0 wt.% of a flame retardant; and from 0.0 wt.% to 1.0 wt.% of a filler.

8. An article manufactured using the bimodal polyethylene of any one of claims 1 to 5, or the thermoplastic composition of claim 7.

9. The article of claim 8, wherein the article is a coated conductor comprising:

a conductive core; and

a coating layer at least partially covering the conductive core,

wherein the coating layer comprises the bimodal polyethylene of any one of claims 1 to 5, or the thermoplastic composition of either claim 7 or 8.

10. The article of claim 9, wherein the conductive core comprises a metallic wire, an optical fiber, or both.

11. The article of any of claims 8 to 10, having:

an environmental stress-cracking resistance (ESCR) (F_0) greater than 48 hours when measured according to ASTM D1693-1, Method B, in a 10% Igepal solution at 50 °C.