THERMOPLASTIC COMPOSITIONS COMPRISING RECYCLED POLYMERS AND ARTICLES MANUFACTURED THEREFROM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/061,350, 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 recycled polymers and articles manufactured therefrom.

BACKGROUND

[0003] Thermoplastic compositions are commonly used to form coatings, such as insulation and jacket layers for wires and cables, and there is a growing interest regarding the sustainability of such compositions. One method of improving the sustainability of thermoplastic compositions is to utilize recycled polymers, such as post-consumer and/or pre-consumer recycled polymers. However, such recycled polymers often exhibit poor environmental stress-cracking resistance and mechanical properties, which makes them unsuitable to form coatings with long-term durability suitable for wire and cable applications. As such, recycled polymers may be mixed with virgin raw polymers in order to balance the environmental stress-cracking resistance, mechanical properties, and sustainability of the resulting thermoplastic composition; however, significant amounts of virgin raw polyethylene are typically required. Accordingly, there is an ongoing need to improve the sustainability of thermoplastic compositions by increasing the amounts of post-consumer recycled polymers included while also maintaining suitable environmental stress-cracking resistance and mechanical properties

SUMMARY

[0004] The present disclosure addresses these needs by providing a thermoplastic composition comprising from 0.5 wt.% to 75.0 wt.% of recycled polyethylene comprising a blend of polyethylene recovered from post-consumer material, pre-consumer material, or combinations thereof, and from 25.0 wt.% to 99.5 wt.% of virgin raw polyethylene comprising unimodal polyethylene, bimodal polyethylene, or combinations thereof, wherein at least 90.0 wt.% of the thermoplastic composition is comprised of the post-consumer recycled polyethylene and the virgin raw polyethylene. The recycled polyethylene has a density of from 0.920 g/cm^3 to 0.975 g/cm^3, a melt index (I_2) of from 0.30 dg/min to 3.00 dg/min, and a melt flow

ratio (MFR_{21}) greater than or equal to 50. The unimodal polyethylene has a density of from 0.930 g/cm^3 to 0.950 g/cm^3, a melt index (I_2) of from 0.30 dg/min to 1.00 dg/min, and a melt flow ratio (MFR_{21}) greater than or equal to 30. The bimodal polyethylene has a density of from 0.933 g/cm^3 to 0.960 g/cm^3, a melt index (I_2) of from 0.30 dg/min to 2.00 dg/min, a melt flow ratio (MFR_{21}) greater than 80.0 dg/min, a molecular weight distribution (M_w/M_n) greater than 6, and a reverse short-chain branching distribution (SCBD).

[004a] In one aspect, the present disclosure refers to a thermoplastic composition comprising: from 0.5 wt% to 75.0 wt.% of a recycled polyethylene comprising a blend of polyethylene recovered from post-consumer material, pre-consumer material, or combinations thereof; and from 25.0 wt.% to 99.5 wt% of virgin raw polyethylene comprising unimodal polyethylene, bimodal polyethylene, or combinations thereof, wherein:

the recycled polyethylene has:

a density of from 0.920 g/cm^3 to 0.975 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 3.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load; and

a melt flow ratio (MFR_{21}) greater than or equal to 50, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the recycled polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10, Method B, at 190 °C and a 21.6 kg load;

the unimodal polyethylene has:

a density of from 0.930 g/cm^3 to 0.950 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 1.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load; and

a melt flow ratio (MFR_{21}) greater than or equal to 30, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the unimodal polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10, Method B, at 190 °C and a 21.6 kg load; and

a high load melt index (I_{21}) of greater than or equal to 30 dg/min;

the bimodal polyethylene has:

a density of from 0.933 g/cm^3 to 0.960 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 2.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load;

a melt flow ratio (MFR_{21}) greater than or equal to 80.0, 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, Method B, at 190 °C and a 21.6 kg load; and

a high load melt index (I_{21}) of greater than or equal to 75.0 dg/min;

a molecular weight distribution (M_w/M_n) greater than or equal to 6, 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); and

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

at least 90.0 wt.% of the thermoplastic composition is comprised of the recycled polyethylene and the virgin raw polyethylene.

[004b] In another aspect, the present disclosure refers to a method of making the thermoplastic composition as disclosed herein, the method comprising melt-blending the recycled polyethylene, the virgin polyethylene, and any optional additives, thereby making the thermoplastic composition.

[004c] In yet another aspect, the present disclosure refers to a manufactured article comprising the thermoplastic composition as disclosed herein.

[004d] In yet another aspect, the present disclosure refers to a coated conductor comprising a coating layer and a conductive core, wherein the coating layer comprises the thermoplastic composition as disclosed herein and covers at least a portion of the conductive core.

[004e] In yet another aspect, the present disclosure refers to a method of transmitting electricity and/or light through a conductive core of the coated conductor as disclosed herein, wherein the conductive core comprises a metallic wire, an optical fiber, or both; the method

comprising step (a) and/or step (b): (a) applying a voltage across the metallic wire, thereby causing electrical energy to flow through the metallic wire; and/or (b) sending a pulse of light (e.g., infrared light) through the optical fiber, thereby causing light to transmit through the optical fiber; thereby transmitting electricity and/or light, respectively, through a conductive core of the coated conductor.

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

BRIEF DESCRIPTION OF THE DRAWING

[0006] The following detailed description can be best understood when read in conjunction with the drawing enclosed herewith, wherein:

[0007] FIG. 1 graphically plots the molecular weight distributions of three polyethylene samples, according to one or more embodiments disclosed herein; and

[0006] FIG. 2 graphically plots the molecular weight distributions of two other polyethylene samples, according to one or more embodiments disclosed herein.

[0008] Reference will now be made in greater detail to various embodiments of the present disclosure, some of which are illustrated in the accompanying drawing.

DETAILED DESCRIPTION

[0009] Embodiments of the present disclosure are directed to thermoplastic compositions comprising recycled polymers and articles manufactured therefrom. In particular, embodiments of the present disclosure are directed to a thermoplastic composition comprising from 0.5 wt.% to 75.0 wt.% of recycled polyethylene comprising a blend of polyethylene recovered from post-consumer material, pre-consumer material, or combinations thereof, and from 25.0 wt.% to 99.5 wt.% of virgin raw polyethylene comprising unimodal polyethylene, bimodal polyethylene, or combinations thereof, wherein at least 90.0 wt.% of the thermoplastic composition is comprised of the post-consumer recycled polyethylene and the virgin raw polyethylene. The recycled polyethylene has a density of from 0.920 g/cm^3 to 0.975 g/cm^3, a melt index (I_2) of from 0.30 dg/min to 3.00 dg/min, and a melt flow ratio (MFR_{21}) greater than or equal to 50. The unimodal polyethylene has a density of from 0.930 g/cm^3 to 0.950 g/cm^3, a melt index (I_2) of from 0.30 dg/min to 1.00 dg/min, and a melt flow ratio (MFR_{21}) greater than or equal to 30. The bimodal polyethylene has a density of from 0.933 g/cm^3 to 0.960 g/cm^3, a melt index (I_2) of from 0.30

CLAIMS

1. A thermoplastic composition comprising: from 0.5 wt% to 75.0 wt.% of a recycled polyethylene comprising a blend of polyethylene recovered from post-consumer material, pre-consumer material, or combinations thereof; and from 25.0 wt.% to 99.5 wt% of virgin raw polyethylene comprising unimodal polyethylene, bimodal polyethylene, or combinations thereof, wherein:

the recycled polyethylene has:

a density of from 0.920 g/cm^3 to 0.975 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 3.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load; and

a melt flow ratio (MFR_{21}) greater than or equal to 50, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the recycled polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10, Method B, at 190 °C and a 21.6 kg load;

the unimodal polyethylene has:

a density of from 0.930 g/cm^3 to 0.950 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 1.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load; and

a melt flow ratio (MFR_{21}) greater than or equal to 30, wherein the melt flow ratio (MFR_{21}) is a ratio of a high load melt index (I_{21}) of the unimodal polyethylene to the melt index (I_2), and the high load melt index (I_{21}) is measured according to ASTM D1238-10, Method B, at 190 °C and a 21.6 kg load; and

a high load melt index (I_{21}) of greater than or equal to 30 dg/min;

the bimodal polyethylene has:

a density of from 0.933 g/cm^3 to 0.960 g/cm^3 when measured according to ASTM D792-08, Method B;

a melt index (I_2) of from 0.30 dg/min to 2.00 dg/min when measured according to ASTM D1238-10, Method B, at 190 °C and a 2.16 kg load;

a melt flow ratio (MFR_{21}) greater than or equal to 80.0, 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, Method B, at 190 °C and a 21.6 kg load; and

a high load melt index (I_{21}) of greater than or equal to 75.0 dg/min;

a molecular weight distribution (M_w/M_n) greater than or equal to 6, 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); and

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

at least 90.0 wt.% of the thermoplastic composition is comprised of the recycled polyethylene and the virgin raw polyethylene.

2. The thermoplastic composition of claim 1, wherein the recycled polyethylene has:

a melting point (T_m) of from 105 °C to 135 °C when measured by Dynamic Scanning Calorimetry (DSC) according to ASTM D3418-15; and

from 0.1 wt.% to 10 wt.% of polymer chains having a logarithm molecular weight (LogM) less than 2.5 when measured using gel permeation chromatography (GPC).

3. The thermoplastic composition of any one of claims 1 to 2, wherein the unimodal polyethylene has a melting temperature (T_m) of from 120 °C to 130 °C when measured by Dynamic Scanning Calorimetry (DSC) according to ASTM D3418-15.

4. The thermoplastic composition of any one of claims 1 to 3, wherein the virgin polyethylene is the unimodal polyethylene.

5. The thermoplastic composition of any one of claims 1 to 3, wherein the virgin raw polyethylene is the bimodal polyethylene.

6. The thermoplastic composition of any one of claims 1 to 5, further comprising up to 10 wt.% of one or more additives

7. The thermoplastic composition of claim 6, wherein the additives comprise 0.01 wt.% to 0.5 wt.% of antioxidant.

8. The thermoplastic composition of any one of claims 6 to 7, wherein the additives comprise 0.05 wt.% to 9 wt.% carbon black.

9. The thermoplastic composition of any one of claims 1 to 8, wherein the thermoplastic composition comprises 5.0 wt.% to 50.0 wt.% of the recycled polyethylene and from 45.0 wt.% to 95.0 wt.% of the virgin raw polyethylene.

10. A method of making the thermoplastic composition of any one of claims 1 to 9, the method comprising melt-blending the recycled polyethylene, the virgin polyethylene, and any optional additives, thereby making the thermoplastic composition.

11. A manufactured article comprising the thermoplastic composition of any one of claims 1 to 9.

12. The manufactured article of claim 11, wherein the thermoplastic composition exhibits one or more of the following:

an average tensile strength at break greater than or equal to 1,400 psi when measured according to ASTM D638-14, Type IV;

an elongation at break greater than or equal to 200% when measured according to ASTM D638-14, Type IV;

an environmental stress-cracking resistance (ESCR) (F_0) greater than or equal to 24 hours when measured according to ASTM D1693-1, Method B, in a 10% Igepal solution at 50 °C; and

a secant modulus (E_s) greater than 450 MPa when measured according to ASTM D790-17.

13. The manufactured article of any one of claims 11 to 12, further comprising a coating and a support component, wherein the coating comprises the thermoplastic composition and is disposed on or in the support component.

14. A coated conductor comprising a coating layer and a conductive core, wherein the coating layer comprises the thermoplastic composition of any one of claims 1 to 9 and covers at least a portion of the conductive core.

15. A method of transmitting electricity and/or light through a conductive core of the coated conductor of claim 14, wherein the conductive core comprises a metallic wire, an optical fiber, or both; the method comprising step (a) and/or step (b): (a) applying a voltage across the metallic wire, thereby causing electrical energy to flow through the metallic wire; and/or (b) sending a pulse of light (e.g., infrared light) through the optical fiber, thereby causing light to transmit through the optical fiber; thereby transmitting electricity and/or light, respectively, through a conductive core of the coated conductor.