

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property

Organization

International Bureau

(43) International Publication Date

20 August 2020 (20.08.2020)



(10) International Publication Number

WO 2020/167409 A1

(51) International Patent Classification:

C08L 23/08 (2006.01) H01B 7/04 (2006.01)

(21) International Application Number:

PCT/US2020/013879

(22) International Filing Date:

16 January 2020 (16.01.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/804,468 12 February 2019 (12.02.2019) US

(71) Applicant: DOW GLOBAL TECHNOLOGIES LLC

[US/US]; 2211 H.H. Dow Way, Midland, Michigan 48674 (US).

(72) Inventors: SAUNDERS, Madelaine E.; 400 Arcola Road,

Collegeville, Pennsylvania 19426 (US). BRIGANDI, Paul J.; 400 Arcola Road, Collegeville, Pennsylvania 19426 (US).

(74) Agent: TWILLEY, Mark; 2211 H.H. Dow Way, Midland,

Michigan 48674 (US).

(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: POLYMERIC COMPOSITIONS FOR CABLE JACKETS

(57) Abstract: Disclosed are polymeric compositions suitable for use as cable jackets. The polymeric compositions include a polymer component and, optionally, one or more additives. The polymer component consists of an ethylene-based polymer and an olefin block copolymer. The polymer component has a tensile elasticity (G') of less than 1,200 MPa when measured at -40°C, a tensile elasticity (G') below 400 MPa when measured at 20°C, a tensile strength greater than 1,000 psi, and an elongation at break greater than 800%.



WO 2020/167409 A1

POLYMERIC COMPOSITIONS FOR CABLE JACKETS

FIELD

Various embodiments of the present disclosure relate to polymeric compositions comprising an ethylene-based polymer and an olefin block copolymer and methods for their production. Other aspects concern polymeric compositions suitable for use in cable jackets.

INTRODUCTION

Thermoplastic polymeric compositions are known for use in wire-and-cable jacket applications. Current thermoplastic compounds have good physical properties but can lack the required flexibility for some specific applications. Typically, flexibility can be improved but often at the expense of other physical properties, such as tensile strength and elongation at break. Improvements are needed for compositions having improved flexibility with retained mechanical properties.

SUMMARY

One embodiment is a cable comprising:

- (a) a conductor; and
- (b) an outer jacket,

wherein the outer jacket is at least partially formed from a polymeric composition,

wherein the polymeric composition comprises a polymer component and optionally one or more additives,

wherein the polymer component consists of:

- (i) an ethylene-based polymer selected from a low-density polyethylene, a linear-low-density polyethylene, or combinations thereof, and
- (ii) an olefin block copolymer,

wherein the polymer component has a tensile elasticity (G') of less than 1,200 MPa when measured at -40 °C,

wherein the polymer component has a tensile elasticity (G') of less than 400 MPa when measured at 20 °C,

wherein the polymer component has a tensile strength greater than 1,000 psi,

wherein the polymer component has an elongation at break greater than 800 %.

DETAILED DESCRIPTION

Various embodiments of the present disclosure concern a polymeric composition suitable for use as a cable jacket. The polymeric composition comprises a polymer component and

optionally one or more additives. The polymer component consists of (a) an ethylene-based polymer selected from a low-density polyethylene, a linear-low-density polyethylene, and combinations thereof, and (b) an olefin block copolymer.

Ethylene-based Polymer

As noted above, the polymer component of the polymeric composition contains an ethylene-based polymer. As used herein, “ethylene-based” polymers are polymers prepared from ethylene monomers as the primary (i.e., greater than 50 weight percent (“wt%”)) monomer component, though other co-monomers may also be employed. “Polymer” means a macromolecular compound prepared by reacting (i.e., polymerizing) monomers of the same or different type, and includes homopolymers and interpolymers. “Interpolymer” means a polymer prepared by the polymerization of at least two different monomer types. This generic term includes copolymers (usually employed to refer to polymers prepared from two different monomer types), and polymers prepared from more than two different monomer types (e.g., terpolymers (three different monomer types) and quaterpolymers (four different monomer types)).

In an embodiment, the ethylene-based polymer can be a low-density polyethylene (“LDPE”). LDPEs are generally highly branched ethylene homopolymers, and can be prepared via high pressure processes (i.e., HP-LDPE). LDPEs suitable for use herein can have a density ranging from 0.91 to 0.94 g/cm³. In various embodiments, the ethylene-based polymer is a high-pressure LDPE having a density of at least 0.91 g/cm³, but less than 0.94 g/cm³, or less than 0.93 g/cm³. In an embodiment, the LDPE can have a density in the range of from 0.915 to 0.925 g/cm³, or a density of about 0.92 g/cm³. Polymer densities provided herein are determined according to ASTM International (“ASTM”) method D792. LDPEs suitable for use herein can have a melt index (I₂) of less than 20 g/10 min., or ranging from 0.1 to 10 g/10 min., from 0.1 to 5 g/10min., from 0.1 to 1 g/10 min., or an I₂ of about 0.25 g/10 min. Melt indices provided herein are determined according to ASTM method D1238. Unless otherwise noted, melt indices are determined at 190 °C and 2.16 Kg (i.e., I₂). Generally, LDPEs have a broad molecular weight distribution (“MWD”) resulting in a relatively high polydispersity index (“PDI;” ratio of weight-average molecular weight to number-average molecular weight).

In an embodiment, the ethylene-based polymer can be a linear-low-density polyethylene (“LLDPE”). LLDPEs are generally ethylene-based polymers having a heterogeneous distribution of comonomer (e.g., α -olefin monomer), and are characterized by short-chain

branching. For example, LLDPEs can be copolymers of ethylene and α -olefin monomers, such as 1-butene, 1-hexene, or 1-octene. LLDPEs suitable for use herein can have a density ranging from 0.915 to 0.925 g/cm³, or a density of about 0.92 g/cm³. LLDPEs suitable for use herein can have a melt index (I₂) ranging from 0.1 to 20 g/10 min., from 0.1 to 5 g/10 min., from 0.1 to 1 g/10 min., or from 0.5 to 1 g/10 min., or an I₂ of about 0.7 g/10 min.

Production processes used for preparing ethylene-based polymers are wide, varied, and known in the art. Any conventional or hereafter discovered production process for producing ethylene-based polymers having the properties described above may be employed for preparing the ethylene-based polymers described herein. In general, polymerization can be accomplished at conditions known in the art for Ziegler-Natta or Kaminsky-Sinn type polymerization reactions, that is, at temperatures from 0 to 250 °C, or 30 or 200 °C, and pressures from atmospheric to 10,000 atmospheres (1,013 megaPascal (“MPa”)). In most polymerization reactions, the molar ratio of catalyst to polymerizable compounds employed is from 10-12:1 to 10-1:1, or from 10-9:1 to 10-5:1.

The ethylene-based polymer can be a combination of LDPE and LLDPE.

Examples of suitable commercially available ethylene-based polymers include, but are not limited to, DOWTM 132I, an LDPE commercially available from The Dow Chemical Company, and DFDA-7530 NT, an LLDPE commercially available from The Dow Chemical Company, Midland, MI, USA.

In various embodiments, the ethylene-based polymer constitutes from 40 to 80 weight percent (“wt%”), or from 50 to 70 wt%, of the polymer component, based on the total weight of the polymer component. In some embodiments, the ethylene-based polymer constitutes about 50 wt% of the polymer component.

Olefin Block Copolymer

As noted above, the polymer component of the polymeric composition also contains an olefin block copolymer. As used herein, the terms “ethylene/ α -olefin block copolymer,” “olefin block copolymer,” or “OBC” are used interchangeably and mean an ethylene/ α -olefin multi-block copolymer, and includes ethylene and one or more copolymerizable α -olefin comonomer in polymerized form, characterized by multiple blocks or segments of two or more polymerized monomer units differing in chemical or physical properties. The terms “interpolymer” and “copolymer” are used interchangeably, herein, for the term ethylene/ α -olefin block copolymer, and similar terms discussed in this paragraph. When referring to amounts of “ethylene” or

“comonomer” in the copolymer, it is understood that this means polymerized units thereof. In some embodiments, the multi-block copolymer can be represented by the following formula:



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, “A” represents a hard block or segment and “B” represents a soft block or segment. Preferably, A’s and B’s are linked in a substantially linear fashion, as opposed to a substantially branched or substantially star-shaped fashion. In other embodiments, A blocks and B blocks are randomly distributed along the polymer chain. In other words, the block copolymers usually do not have a structure as follows.



In still other embodiments, the block copolymers do not usually have a third type of block, 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 than the rest of the block.

Preferably, ethylene comprises the majority mole fraction of the whole block copolymer, i.e., ethylene comprises at least 50 mole percent of the whole polymer. More preferably ethylene comprises at least 60 mole percent, at least 70 mole percent, or at least 80 mole percent, with the substantial remainder of the whole polymer comprising at least one other comonomer that is preferably an α -olefin having 3 or more carbon atoms. In some embodiments, the olefin block copolymer may comprise 50 mol% to 90 mol% ethylene, preferably 60 mol% to 85 mol%, more preferably 65 mol% to 80 mol%. For many ethylene/octene block copolymers, the preferred composition comprises an ethylene content greater than 80 mole percent of the whole polymer and an octene content of from 10 to 15, preferably from 15 to 20 mole percent of the whole polymer.

The olefin block copolymer includes various amounts of “hard” and “soft” segments. “Hard” segments are blocks of polymerized units, in which ethylene is present in an amount greater than 95 weight percent, or greater than 98 weight percent, based on the weight of the polymer, up to 100 weight percent. In other words, the comonomer content (content of monomers other than ethylene) in the hard segments is less than 5 weight percent, or less than 2 weight percent based on the weight of the polymer, and can be as low as zero. In some

embodiments, the hard segments include all, or substantially all, units derived from ethylene. “Soft” segments are blocks of polymerized units in which the comonomer content (content of monomers other than ethylene) is greater than 5 weight percent, or greater than 8 weight percent, greater than 10 weight percent, or greater than 15 weight percent based on the weight of the polymer. In some embodiments, the comonomer content in the soft segments can be greater than 20 weight percent, greater than 25 weight percent, greater than 30 weight percent, greater than 35 weight percent, greater than 40 weight percent, greater than 45 weight percent, greater than 50 weight percent, or greater than 60 weight percent, and can be up to 100 weight percent.

The soft segments can be present in an OBC from 1 weight percent to 99 weight percent of the total weight of the OBC, or from 5 weight percent to 95 weight percent, from 10 weight percent to 90 weight percent, from 15 weight percent to 85 weight percent, from 20 weight percent to 80 weight percent, from 25 weight percent to 75 weight percent, from 30 weight percent to 70 weight percent, from 35 weight percent to 65 weight percent, from 40 weight percent to 60 weight percent, or from 45 weight percent to 55 weight percent of the total weight of the OBC. 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, U.S. Patent No. 7,608,668, entitled “Ethylene/ α -Olefin Block Interpolymers,” filed on March 15, 2006, in the name of Colin L. P. Shan, Lonnie Hazlitt, et al., and assigned to Dow Global Technologies Inc., the disclosure of which is incorporated by reference herein in its entirety. In particular, hard and soft segment weight percentages and comonomer content may be determined as described in Column 57 to Column 63 of US 7,608,668.

The olefin block copolymer is a polymer comprising two or more chemically distinct regions or segments (referred to as “blocks”) preferably joined in a linear manner, that is, a polymer comprising chemically differentiated units, which are joined end-to-end with respect to polymerized ethylenic functionality, rather than in pendent or grafted fashion. In an embodiment, the blocks differ in the amount or type of incorporated comonomer, density, amount of crystallinity, crystallite size attributable to a polymer of such composition, type or degree of tacticity (isotactic or syndiotactic), regio-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 catalysts, or anionic polymerization

techniques, the present OBC is characterized by unique distributions of both polymer polydispersity (PDI or Mw/Mn or MWD), block length distribution, and/or block number distribution, due, in an embodiment, to the effect of the shuttling agent(s) in combination with multiple catalysts used in their preparation.

5 In an embodiment, the OBC is produced in a continuous process and possesses a polydispersity index, PDI (or MWD), 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 OBC possesses PDI from 1.0 to 3.5, or from 1.3 to 3, or from 1.4 to 2.5, or from 1.4 to 2.

10 In addition, the olefin block copolymer possesses a PDI fitting a Schultz-Flory distribution rather than a Poisson distribution. The present OBC 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.

In an embodiment, the present olefin block copolymer possesses a most probable distribution of block lengths. In an embodiment, the olefin block copolymer is defined as having:

15 (A) Mw/Mn from 1.7 to 3.5, at least one melting point, T_m , in degrees Celsius, and a density, d , in grams/cubic centimeter, where in the numerical values of T_m and d correspond to the relationship:

$$T_m > -2002.9 + 4538.5(d) - 2422.2(d)^2, \text{ and/or}$$

20 (B) Mw/Mn from 1.7 to 3.5, and is characterized by a heat of fusion, ΔH in J/g, and a delta quantity, ΔT , in degrees Celsius, defined as the temperature difference between the tallest DSC peak and the tallest Crystallization Analysis Fractionation ("CRYSTAF") peak, wherein the numerical values of ΔT and ΔH have the following relationships:

$$\Delta T > -0.1299 \Delta H + 62.81 \text{ for } \Delta H \text{ greater than zero and up to } 130 \text{ J/g}$$

25 $\Delta T \geq 48^\circ\text{C}$ for ΔH greater than 130 J/g

wherein the CRYSTAF peak is determined using at least 5 percent of the cumulative polymer, and if less than 5 percent of the polymer has an identifiable CRYSTAF peak, then the CRYSTAF temperature is 30°C ; and/or

30 (C) elastic recovery, Re , in percent at 300 percent strain and 1 cycle measured with a compression-molded film of the ethylene/ α -olefin interpolpolymer, and has a density, d , in grams/cubic centimeter, wherein the numerical values of Re and d satisfy the

following relationship when ethylene/ α -olefin interpolymer is substantially free of crosslinked phase:

$$Re > 1481 - 1629(d); \text{ and/or}$$

(D) has a molecular fraction which elutes between 40°C and 130°C when fractionated using TREF, characterized in that the fraction has a molar comonomer content greater than, or equal to, the quantity $(-0.2013)T + 20.07$, more preferably greater than or equal to the quantity $(-0.2013)T + 21.07$, where T is the numerical value of the peak elution temperature of the TREF fraction, measured in °C; and/or,

(E) has a storage modulus at 25°C, $G'(25^\circ\text{C})$, and a storage modulus at 100°C, $G'(100^\circ\text{C})$, wherein the ratio of $G'(25^\circ\text{C})$ to $G'(100^\circ\text{C})$ is in the range of 1:1 to 9:1.

The olefin block copolymer may also have:

(F) a molecular fraction which elutes between 40°C and 130°C when fractionated using TREF, characterized in that the fraction has a block index of at least 0.5 and up to 1, and a molecular weight distribution, M_w/M_n , greater than 1.3; and/or

(G) average block index greater than zero and up to 1.0 and a molecular weight distribution, M_w/M_n greater than 1.3.

It is understood that the olefin block copolymer may have one, some, all, or any combination of properties (A)-(G). Block Index can be determined as described in detail in US Patent No. 7,608,668 herein incorporated by reference for that purpose. Analytical methods for determining properties (A) through (G) are disclosed in, for example, US Patent No 7,608,668, Col. 31, line 26 through Col. 35, line 44, which is herein incorporated by reference for that purpose.

Suitable monomers for use in preparing the present OBC include ethylene and one or more addition polymerizable monomers other than ethylene. Examples of suitable comonomers include straight-chain or branched α -olefins of 3 to 30, preferably 3 to 20, carbon atoms, such as propylene, 1-butene, 1-pentene, 3-methyl-1-butene, 1-hexene, 4-methyl-1-pentene, 3-methyl-1-pentene, 1-octene, 1-decene, 1-dodecene, 1-tetradecene, 1-hexadecene, 1-octadecene and 1-eicosene; cycloolefins of 3 to 30, preferably 3 to 20, carbon atoms, such as cyclopentene, cycloheptene, norbornene, 5-methyl-2-norbornene, tetracyclododecene, and 2-methyl-1,4,5,8-dimethano-1,2,3,4,4a,5,8,8a-octahydronaphthalene; di- and polyolefins, such as butadiene, isoprene, 4-methyl-1,3-pentadiene, 1,3-pentadiene, 1,4-pentadiene, 1,5-hexadiene, 1,4-hexadiene, 1,3-hexadiene, 1,3-octadiene, 1,4-octadiene, 1,5-octadiene, 1,6-octadiene,

1,7-octadiene, ethyldenenorbornene, vinyl norbornene, dicyclopentadiene, 7-methyl-1,6-octadiene, 4-ethylidene-8-methyl-1,7-nonadiene, and 5,9-dimethyl-1,4,8-decatriene; and 3-phenylpropene, 4-phenylpropene, 1,2-difluoroethylene, tetrafluoroethylene, and 3,3,3-trifluoro-1-propene.

5 In one embodiment, the ethylene/ α -olefin block copolymer has a density of from 0.850 g/cc to 0.900 g/cc, or from 0.855 g/cc to 0.890 g/cc or from 0.860 g/cc to 0.880 g/cc. In one embodiment, the ethylene/ α -olefin block copolymer has a Shore A value of 40 to 70, preferably from 45 to 65 and more preferably from 50 to 65. In one embodiment, the ethylene/ α -olefin block copolymer has a melt index (MI) from 0.1 g/10 min to 50 g/10 min, or from
10 0.3 g/10 min to 30 g/10 min, from 0.5 g/10 min to 20 g/10 min, from 0.5 to 10 g/10 min., from 0.5 to 1.5 g/10 min., or from 0.75 to 1.25 g/10 min. In one embodiment, the ethylene/ α -olefin block copolymer comprises polymerized ethylene and one α -olefin as the only monomer types. In a further embodiment, the α -olefin is selected from propylene, 1-butene, 1-hexene or 1-octene.

In an embodiment, the ethylene/ α -olefin block copolymer excludes styrene.

15 In an embodiment, the ethylene/ α -olefin block copolymer is an ethylene/octene block copolymer.

The ethylene/ α -olefin block copolymers can be produced via a chain shuttling process, such as described in US Patent No. 7,858,706, which is herein incorporated by reference. In particular, suitable chain shuttling agents and related information are listed in Col. 16, line 39,
20 through Col. 19, line 44. Suitable catalysts are described in Col. 19, line 45, through Col. 46, line 19, and suitable co-catalysts in Col. 46, line 20, through Col. 51 line 28. The process is described throughout the document, but particularly in Col. Col 51, line 29, through Col. 54, line 56. The process is also described, for example, in the following: US Patent Nos. 7,608,668; US 7,893,166; and US 7,947,793.

25 The ethylene/ α -olefin block copolymer may comprise a combination or two or more embodiments described herein.

In various embodiments, the olefin block copolymer can have a melt index (I_2) in the range of from 0.5 to 1.5 g/10 min., a tensile elongation of greater than 370 %, and a tensile strength greater than 600 psi.

30 Examples of suitable olefin block copolymers include those commercially available under the trade name INFUSETM from The Dow Chemical Company, Midland, MI, USA). An example of a specific commercially available olefin block copolymer suitable for use herein

includes, but is not limited to, INFUSE™ 9107, available from The Dow Chemical Company, Midland, MI, USA.

In various embodiments, the olefin block copolymer constitutes from 20 to 60 wt%, or from 30 to 50 wt%, of the polymer component, based on the total weight of the polymer component. In some embodiments, the olefin block copolymer constitutes about 50 wt% of the polymer component.

Polymer Component

The polymer component consisting of the ethylene-based polymer and the olefin block copolymer can have a certain balance of properties.

In one or more embodiments, the polymer component can have a tensile elasticity (G') of less than 1,200 MPa when measured at -40 °C, a tensile elasticity (G') of less than 400 MPa when measured at 20 °C, a tensile strength greater than 1,000 psi, and an elongation at break greater than 800 %. All mechanical properties of the polymer component are measured according to the methods provided in the Test Methods section, below.

In one or more embodiments, the polymer component can have a tensile elasticity (G') of less than 1,100 MPa when measured at -40 °C, a tensile elasticity (G') of less than 300 MPa when measured at 20 °C, a tensile strength greater than 1,200 psi, and an elongation at break greater than 820 %.

In one or more embodiments, the polymer component can have a tensile elasticity (G') of less than 1,000 MPa when measured at -40 °C, a tensile elasticity (G') of less than 200 MPa when measured at 20 °C, a tensile strength greater than 1,400 psi, and an elongation at break greater than 850 %.

In one or more embodiments, the polymer component can have a tensile elasticity (G') of less than 900 MPa when measured at -40 °C, a tensile elasticity (G') of less than 150 MPa when measured at 20 °C, a tensile strength greater than 1,500 psi, and an elongation at break greater than 900 %.

Additives

The polymeric composition can optionally contain a non-conductive carbon black, such as those commonly used in cable jackets. The carbon black component can be compounded with the polymer component, as described above, either neat or as part of a pre-mixed masterbatch. In various embodiments, the amount of a carbon black in the polymeric composition can be greater than zero (>0), typically from 1, more typically from 2, to 3, wt%, based on the total

weight of the polymeric composition. All individual values and subranges from >0 to 3 wt% are included and disclosed herein, for example from 2 to 3 wt%.

Non-limiting examples of conventional carbon blacks include the grades described by ASTM N550, N472, N351, N110 and N660, Ketjen blacks, furnace blacks and acetylene blacks.

5 Other non-limiting examples of suitable carbon blacks include those sold under the tradenames BLACK PEARLS®, CSX®, ELFTEx®, MOGUL®, MONARCH®, REGAL® and VULCAN®, available from Cabot.

The polymeric composition can optionally contain one or more antioxidants. Non-limiting examples of suitable antioxidants include phenolic antioxidants, thio-based antioxidants, 10 phosphate-based antioxidants, and hydrazine-based metal deactivators. Antioxidants may be present in the polymeric composition in an amount ranging from greater than zero to 5 wt%, from 0.1 to 3 wt%, or from 0.1 to 1 wt%, based on the entire weight of the polymeric composition.

The polymeric composition can optionally contain one or more additional additives, which are generally added in conventional amounts, either neat or as part of a masterbatch. Such 15 additives include, but are not limited to, flame retardants, processing aids, fillers, pigments or colorants, coupling agents, ultraviolet stabilizers (including UV absorbers), tackifiers, antistatic agents, plasticizers, lubricants, viscosity control agents, anti-blocking agents, surfactants, extender oils, acid scavengers, metal deactivators, and the like.

Non-limiting examples of flame retardants include, but are not limited to, aluminum 20 hydroxide and magnesium hydroxide.

Non-limiting examples of processing aids include, but are not limited to, fatty amides such as stearamide, oleamide, erucamide, or N,N' ethylene bis-stearamide; polyethylene wax; oxidized polyethylene wax; polymers of ethylene oxide; copolymers of ethylene oxide and propylene oxide; vegetable waxes; petroleum waxes; non-ionic surfactants; silicone fluids; 25 polysiloxanes; and fluoroelastomers such as Viton® available from DuPont Performance Elastomers LLC, or Dynamar™ available from Dyneon LLC.

Non-limiting examples of fillers include, but are not limited to, various flame retardants, clays, precipitated silica and silicates, fumed silica, metal sulfides and sulfates (e.g., molybdenum disulfide and barium sulfate), metal borates (e.g., barium borate and zinc borate), metal 30 anhydrides (e.g., aluminum anhydride), and ground minerals. If present, fillers are generally added in conventional amounts, e.g., from 5 wt% or less to 50 or more wt% based on the weight of the composition.

Compounding

The polymeric composition comprising the polymer component and optional additives can be prepared by any suitable method. For example, the additives (e.g., carbon black, fillers, etc.) can be added to a melt containing the ethylene-based polymer and the olefin block copolymer. Compounding of the components can be performed by blending, for example, using an internal batch mixer such as a Banbury or Bolling internal mixer. Alternatively, continuous single or twin screw mixers can be used, such as a Farrel continuous mixer, a Werner and Pfleiderer twin screw mixer, or a Buss kneading continuous extruder.

The additives can be introduced into the polymer component alone (neat) or as a pre-mixed masterbatch. Such masterbatches are commonly formed by dispersing the additives into an inert plastic resin, such as LDPE or LLDPE. Masterbatches are conveniently formed by melt compounding methods.

Polymeric Composition

The resulting polymeric composition can have certain properties and exclusions.

In various embodiments, the polymeric composition, and the polymer component specifically, is free of propylene-based polymers. As used herein, a propylene-based polymer is any polymer prepared from a majority, by weight, of propylene monomer.

In various embodiments, the polymeric composition is thermoplastic. As such, the polymeric composition can be substantially free of crosslinking.

In various embodiments, the polymeric composition is not foamed.

In various embodiments, the polymeric composition is substantially free from any polymers other than the polymer component. As used herein, the term “substantially free” means having a content of less than about 10 parts per million by weight.

Articles of Manufacture

In an embodiment, the polymeric composition of this invention can be applied to a cable, a wire, or a conductor as a sheath or insulation layer in known amounts and by known methods, for example, with the equipment and methods described in USP 5,246,783, USP 6,714,707, USP 6,496,629 and USPA 2006/0045439. In an embodiment, the polymeric composition can be applied to a cable, a wire, or a conductor as a jacket. “Jacket” denotes the outer-most coating or layer of a cable or other type of coated conductor. Typically, the polymeric composition is prepared in a reactor-extruder equipped with a cable-coating die and, after the components of the

composition are formulated, the composition is extruded over the cable or conductor as the cable or conductor is drawn through the die.

In an embodiment, the polymeric composition forms at least a portion of a jacket on a coaxial cable.

5 In various embodiments, the polymeric composition forms the jacket of a coaxial cable.

DEFINITIONS

As used herein, the term “and/or,” when used in a list of two or more items, means that any one of the listed items can be employed by itself or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing
10 components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B, and C in combination.

“Wire” means a single strand of conductive metal, e.g., copper or aluminum, or a single strand of optical fiber.

“Cable” means at least one wire or optical fiber within a sheath, e.g., an insulation
15 covering or a protective outer jacket. Typically, a cable is two or more wires or optical fibers bound together, typically in a common insulation covering and/or protective jacket. The individual wires or fibers inside the sheath may be bare, covered or insulated. Combination cables may contain both electrical wires and optical fibers. The cable can be designed for low, medium, and/or high voltage applications. Typical cable designs are illustrated in
20 USP 5,246,783, 6,496,629 and 6,714,707.

“Conductor” denotes one or more wire(s) or fiber(s) for conducting heat, light, and/or electricity. The conductor may be a single-wire/fiber or a multi-wire/fiber and may be in strand form or in tubular form. Non-limiting examples of suitable conductors include metals such as silver, gold, copper, carbon, and aluminum. The conductor may also be optical fiber made from
25 either glass or plastic.

TEST METHODS

Density

Density is determined according to ASTM D792.

Melt Index

30 Melt index, or I₂, is measured in accordance with ASTM D1238, condition 190 °C / 2.16 kg, and is reported in grams eluted per 10 minutes.

Tensile Elasticity by DMA (Dynamic Mechanical Analysis)

Perform dynamic mechanical analysis on 50-mil plaque specimens using a Q800 machine, -80 to 120 °C temperature sweep, single cantilever clamp, temperature ramp at 1 °C/min, amplitude of 20-30 micrometer, frequency 1 Hz. Liquid nitrogen is used to bring the temperature to -80 °C.

Flexural Modulus

Analyze samples for flexural modulus using ASTM D790.

Tensile Strength and Elongation

Analyze samples for tensile strength and elongation at break using ASTM D638 and type IV dogbone-shaped samples.

MATERIALS

The following materials are employed in the Examples, below.

DFDA-7530 NT is a linear-low-density polyethylene having a melt index (I_2) of 0.7 g/10 min., a density of 0.921 g/cm³, and is commercially available from The Dow Chemical Company, Midland, MI, USA.

DOWTM LDPE 132I is a low-density polyethylene having a density of 0.921 g/cm³ and a melt index (I_2) of 0.25 g/10 min., which is commercially available from The Dow Chemical Company, Midland, MI, USA.

ENGAGETM 7447 is a polyolefin elastomer having a density of 0.865 g/cm³ and a melt index (I_2) of 5.0 g/10 min., which is commercially available from The Dow Chemical Company, Midland, MI, USA.

ENGAGETM 8842 is a polyolefin elastomer having a density of 0.857 g/cm³ and a melt index (I_2) of 1.0 g/10 min., which is commercially available from The Dow Chemical Company, Midland, MI, USA.

INFUSETM 9107 is an olefin block copolymer having a density of 0.866 g/cm³ and a melt index (I_2) of 1.0 g/10 min., which is commercially available from The Dow Chemical Company, Midland, MI, USA.

EXAMPLES

Prepare six comparative samples (CS1 to CS6) and three inventive samples (IS1 to IS3) according to the formulations provided in Table 1, below. The samples are prepared by weighing and combining the raw materials in a Brabender mixing machine. The samples are mixed using roller blades at 150 °C and 30 rpm after the material is fluxed. The minimum mix time is 5

minutes after the materials have fluxed. After the material is mixed thoroughly, the material is pelletized and transferred to a plaque template of desired thickness. The pelleted material was plaqued in a press machine and then cooled. Plaques are made at the required thicknesses for each test.

- 5 Analyze all samples according to the Test Methods provided above. Results are provided in Table 1, below.

Table 1 – Formulations and Properties of CS1-CS6 and IS1-IS3

	CS1	CS2	CS3	CS4	CS5	CS6	IS1	IS2	IS3
DFDA-7530 (wt%)	100	-	50	50	-	-	-	50	70
LDPE-132i (wt%)	-	100	-	-	50	50	50	-	-
Engage 8842 (wt%)	-	-	50	-	50	-	-	-	-
Engage 7447EL (wt%)	-	-	-	50	-	50	-	-	-
Infuse 9107 (wt%)	-	-	-	-	-	-	50	50	30
Total	100	100	100	100	100	100	100	100	100
Tensile Elasticity (G') @ -40C (MPa)	2105	2200	902	1055	798	1089	865	815	1153
Tensile Elasticity (G') @ -20C (MPa)	1526	1546	398	476	310	464	388	362	745
Tensile Elasticity (G') @ 20C (MPa)	602	588	148	188	77	146	125	118	318
Tensile Elasticity (G') @ 40C (MPa)	330	315	89	109	28	69	70	60	192
Tensile Strength, avg (psi)	2215	2161	788	620	1049	1120	1549	1787	1452
Std. Dev.	66	79	292	28	51	65	81	61	261
Elongation, avg (%)	675	575	958	282	827	849	909	981	801
Std. Dev.	34	61	34	74	20	33	33	5	194
Flex Mod 1% Secant (MPa)	233	222	59	82	42	72	58	69	127
Std. Dev.	7	7	4	1	2	5	2	4	3

- 10 Contrary to CS1 and CS2, which do not have a low enough tensile elasticity, and CS3 and CS4, which do not demonstrate high enough tensile strength, IS1 through IS3 demonstrate increased tensile elasticity with acceptable tensile strength and elongation. CS5 and CS6 demonstrate that ENGAGE™ blends can have lower elasticity than typical wire and cable products but not meet the required tensile strength and elongation.

CLAIMS

1. A cable comprising:

(a) a conductor; and

(b) an outer jacket,

wherein the outer jacket is at least partially formed from a polymeric composition,

wherein the polymeric composition comprises a polymer component and optionally one or more additives,

wherein the polymer component consists of:

(iii) an ethylene-based polymer selected from a low-density polyethylene, a linear-low-density polyethylene, or combinations thereof, and

(iv) an olefin block copolymer,

wherein the polymer component has a tensile elasticity (G') of less than 1,200 MPa when measured at -40 °C,

wherein the polymer component has a tensile elasticity (G') of less than 400 MPa when measured at 20 °C,

wherein the polymer component has a tensile strength greater than 1,000 psi,

wherein the polymer component has an elongation at break greater than 800 %.

2. The cable of claim 1, wherein the olefin block copolymer has a melt index (I_2) in the range of from 0.5 to 1.5 g/10 min, a tensile elongation of greater than 370 %, and a tensile strength greater than 600 psi.

3. The cable of claim 2, wherein the olefin block copolymer is an ethylene/octene block copolymer.

4. The cable of claim 1, wherein the polymeric composition is thermoplastic.

5. The cable of claim 1, wherein the polymeric composition comprises one or more additives selected from the group consisting of antioxidants, carbon black, flame retardants, processing aids, fillers, pigments or colorants, coupling agents, ultraviolet stabilizers, tackifiers,

antistatic agents, plasticizers, lubricants, viscosity control agents, anti-blocking agents, surfactants, extender oils, acid scavengers, and metal deactivators.

5 6. The cable of any one of the foregoing claims, wherein the ethylene-based polymer constitutes from 40 to 80 weight percent of the polymer component, wherein the olefin block copolymer constitutes from 20 to 60 weight percent of the polymer component.

10 7. The cable of claim 6, wherein the ethylene-based polymer constitutes from 50 to 70 weight percent of the polymer component, wherein the olefin block copolymer constitutes from 30 to 50 weight percent of the polymer component,

8. The cable of claim 7, wherein the ethylene-based polymer has a melt index (I_2) of less than 1 g/10 min.

15 9. The cable of claim 8, wherein the ethylene-based polymer has a density in the range of from 0.915 to 0.925 g/cm³.

10. The cable according to claim 9, wherein the cable is a coaxial cable.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2020/013879

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C08L23/08 H01B7/04
 ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 H01B C08L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/319960 A1 (CREE STEPHEN H [CH] ET AL) 23 December 2010 (2010-12-23) paragraphs [0048], [0051]; examples 6, 13 -----	1-10
X A	US 2010/084158 A1 (GAU YIMSAN [US] ET AL) 8 April 2010 (2010-04-08) examples I-IV; tables 1, 2, 3, 5 -----	1,3-6, 8-10 2,7
X A	US 2014/367144 A1 (SEGAWA KENTARO [JP] ET AL) 18 December 2014 (2014-12-18) examples 1-3, 5-7, cel-4; tables 1, 2 -----	1,3-7,9, 10 2,8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

18 March 2020

Date of mailing of the international search report

27/03/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Ritter, Nicola

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/013879

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010319960 A1	23-12-2010	CN 102007175 A EP 2247655 A1 JP 2011513515 A KR 20100117124 A TW 200940631 A US 2010319960 A1 WO 2009105636 A1	06-04-2011 10-11-2010 28-04-2011 02-11-2010 01-10-2009 23-12-2010 27-08-2009
US 2010084158 A1	08-04-2010	CA 2739588 A1 CN 102227469 A EP 2342278 A1 JP 2012504682 A KR 20110066194 A US 2010084158 A1 WO 2010042304 A1	15-04-2010 26-10-2011 13-07-2011 23-02-2012 16-06-2011 08-04-2010 15-04-2010
US 2014367144 A1	18-12-2014	CN 104231513 A JP 2015000913 A US 2014367144 A1	24-12-2014 05-01-2015 18-12-2014