

(19)



(11)

EP 3 880 875 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
30.04.2025 Bulletin 2025/18

(21) Application number: **19801187.6**

(22) Date of filing: **29.10.2019**

(51) International Patent Classification (IPC):
D01F 6/46 ^(2006.01) **D01D 5/098** ^(2006.01)
D04H 3/007 ^(2012.01) **D04H 3/16** ^(2006.01)

(52) Cooperative Patent Classification (CPC):
D01D 5/098; D01F 6/46; D04H 3/007; D04H 3/16

(86) International application number:
PCT/US2019/058553

(87) International publication number:
WO 2020/101883 (22.05.2020 Gazette 2020/21)

(54) **POLYALPHAOLEFIN MODIFIED POLYMER BLENDS FOR FIBRES AND NONWOVENS**

POLYALPHAOLEFINMODIFIZIERTE POLYMERMISCHUNGEN FÜR FASERN UND VLIESTOFFE

MÉLANGES DE POLYMÈRES MODIFIÉS DE POLYALPHAOLÉFINES POUR FIBRES ET NON-TISSÉS

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **16.11.2018 US 201862768612 P**
17.01.2019 EP 19152351

(43) Date of publication of application:
22.09.2021 Bulletin 2021/38

(73) Proprietor: **ExxonMobil Chemical Patents Inc.**
Baytown TX 77520-2101 (US)

(72) Inventors:
• **ROLLIN, Jr., Paul, E.**
Porter, TX 77365 (US)
• **ROBERTS, John, W., M.**
Houston, TX 77059 (US)

- **PRINCE, Jessica, L.**
Somerville, NJ 08876 (US)
- **TALLURY, Syamal**
Houston, TX 77059 (US)
- **DHARMARAJAN, Narayanaswami**
Houston, TX 77059 (US)
- **STEPHENS, Andrew, V.**
Houston, TX 77007 (US)
- **APRAKU-BOADI, Louis, K.**
Houston, TX 77006 (US)

(74) Representative: **ExxonMobil Petroleum & Chemical BV**
IP Law Europe
Hermeslaan 2
1831 Machelen (BE)

(56) References cited:
WO-A1-2006/118674 WO-A1-2016/192097

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 3 880 875 B1

Description**FIELD OF THE INVENTION**

5 [0001] Embodiments described generally relate to polymer blends for nonwovens.

BACKGROUND

10 [0002] The use of propylene-based polymers and copolymers (sometimes referred to as propylene-based elastomers) for the manufacture of nonwoven fabrics is well known in the art. Such fabrics have a wide variety of uses, such as in medical and hygiene products, clothing, filter media, and sorbent products. Nonwoven fabrics are particularly useful in hygiene products, such as baby diapers, adult incontinence products, and feminine hygiene products. An important aspect of these fabrics is the ability to produce fabrics that have a similar "softness" to fabrics produced from natural fibers.

15 [0003] Nonwoven fabrics often lack the desired soft feel of natural fibers and fabrics. The soft feeling in natural fibers is due to the space-filling characteristic of natural fibers. Natural fibers have a three-dimension structure that allows for space in the material that gives a bounce or soft feeling. However, synthetic fibers are usually flat and therefore lack the soft feel of natural fibers. Several mechanical treatments have been used to impart "softness" to synthetic fibers or fabrics, including crimping, air jet texturing, or pleating. However, these methods are not easily applicable to nonwoven fabrics in cost-effective ways.

20 [0004] There is a need, therefore, for a nonwoven fabric that can be produced economically and increases the "softness" of the fabric. The method should be simple and be suitable for fabric preparation at high production rates typically used on current state-of-the-art spunbond production equipment.

SUMMARY OF THE INVENTION

25 [0005] Fibers and nonwovens are provided herein. The fibers and nonwovens include at least one primary polypropylene, at least one polyalphaolefin, and at least one propylene-based elastomer. The primary polypropylene has a heat of fusion of at least 80 J/g as determined by the Differential Scanning Calorimetry ("DSC"). The polyalphaolefin has a viscosity index of at least 120 as determined according to ASTM D2270. The propylene-based elastomer has a heat of fusion less than about 80 J/g as determined by the Differential Scanning Calorimetry ("DSC"). The propylene-based elastomer can also include greater than 50 wt % propylene and from about 3 to about 25 wt % units derived from one or more C2 or C4-C12 α -olefins, based on a total weight of the propylene-based elastomer. The fiber comprises 50 wt% to 98 wt% of the primary polypropylene; 1 wt% to 20 wt% of the propylene-based elastomer; and 1 wt% to 20 wt% of the polyalphaolefin, based on a combined weight of the primary polypropylene, the polyalphaolefin, and the propylene-based elastomer.

DETAILED DESCRIPTION OF THE INVENTION

40 [0006] It is to be understood that the following disclosure describes several exemplary embodiments for implementing different features, structures, or functions of the invention. Exemplary embodiments of components, arrangements, and configurations are described below to simplify the present disclosure; however, these exemplary embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat various exemplary embodiments herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various exemplary embodiments and/or configurations. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

45 [0007] Additionally, certain terms are used throughout the following description and claims to refer to components. As one skilled in the art will appreciate, various entities may refer to the same component by different names, and as such, the naming convention for the elements described herein is not intended to limit the scope of the invention, unless otherwise specifically defined herein. Further, the naming convention used herein is not intended to distinguish between components that differ in name but not function. Additionally, in the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to." All numerical values in this disclosure may be exact or approximate values unless otherwise specifically stated.

50 [0008] Fibers, nonwoven fabrics, and other nonwoven articles comprising a blend of at least one polyalphaolefins (PAO), at least one propylene-based elastomer, and at least one primary propylene are provided herein, as well as methods for forming the same.

55 [0009] As used herein, the term "copolymer" is meant to include polymers having two or more monomers, optionally with

other monomers, and may refer to interpolymers, terpolymers, etc. The term "polymer" as used herein includes, but is not limited to, homopolymers, copolymers, terpolymers, etc., and alloys and blends thereof. The term "polymer" as used herein also includes impact, block, graft, random, and alternating copolymers. The term "polymer" shall further include all possible geometrical configurations unless otherwise specifically stated. Such configurations may include isotactic, syndiotactic and random symmetries. The term "blend" as used herein refers to a mixture of two or more polymers. The term "elastomer" shall mean any polymer exhibiting some degree of elasticity, where elasticity is the ability of a material that has been deformed by a force (such as by stretching) to return at least partially to its original dimensions once the force has been removed. All molecular weights (M_w , M_n , and M_z) can be determined using a gel permeation chromatography (GPC).

[0010] The term "monomer" or "comonomer" as used herein can refer to the monomer used to form the polymer, i.e., the unreacted chemical compound in the form prior to polymerization, and can also refer to the monomer after it has been incorporated into the polymer, also referred to herein as a "[monomer]-derived unit", which by virtue of the polymerization reaction typically has fewer hydrogen atoms than it does prior to the polymerization reaction. Different monomers are discussed herein, including propylene monomers, ethylene monomers, and diene monomers.

[0011] "Polypropylene" as used herein includes homopolymers and copolymers of propylene or mixtures thereof. Products that include one or more propylene monomers polymerized with one or more additional monomers may be more commonly known as random copolymers (RCP) or impact copolymers (ICP). Impact copolymers may also be known in the art as heterophasic copolymers. "Propylene-based," as used herein, is meant to include any polymer comprising propylene, either alone or in combination with one or more comonomers, in which propylene is the major component (i.e., greater than 50 wt % propylene).

[0012] "Primary polypropylene" as used herein refers to a propylene homopolymer, or a copolymer of propylene, or some mixture of propylene homopolymers and copolymers.

[0013] "Reactor grade" as used herein means a polymer that has not been chemically or mechanically treated or blended after polymerization in an effort to alter the polymer's average molecular weight, molecular weight distribution, or viscosity. Particularly excluded from those polymers described as reactor grade are those that have been visbroken or otherwise treated or coated with peroxide. For the purposes of this disclosure, however, reactor grade polymers include those polymers that are reactor blends.

[0014] "Reactor blend" as used herein means a highly dispersed and mechanically inseparable blend of two or more polymers produced in situ as the result of sequential or parallel polymerization of one or more monomers with the formation of one polymer in the presence of another, or by solution blending polymers made separately in parallel reactors. Reactor blends may be produced in a single reactor, a series of reactors, or parallel reactors and are reactor grade blends. Reactor blends may be produced by any polymerization method, including batch, semi-continuous, or continuous systems. Particularly excluded from "reactor blend" polymers comprising a blend of two or more polymers in which the polymers are blended ex situ, such as by physically or mechanically blending in a mixer, extruder, or other similar device.

Primary Polypropylene

[0015] The primary polypropylene can be predominately crystalline, as evidenced by having a melting point generally greater than 110°C, greater than 115°C, and greater than 130°C, or within a range from 110°, or 115°, or 130°C to 150°, or 160°, or 170°C. The term "crystalline," as used herein, characterizes those polymers which possess high degrees of inter- and intramolecular order. The polypropylene has a heat fusion of at least 80 J/g, as determined by DSC analysis. The heat of fusion can be dependent on the composition of the polypropylene. A polypropylene homopolymer can have a higher heat of fusion than copolymer or blend of homopolymer and copolymer. Determination of this heat of fusion can be influenced by treatment of the sample.

[0016] The primary polypropylene can vary widely in structural composition. For example, substantially isotactic polypropylene homopolymer or propylene copolymer containing equal to or less than 9 wt% of other monomers, that is, at least 90 wt% propylene, can be used. Further, the primary polypropylene can be present in the form of a graft or block copolymer, in which the blocks of polypropylene have substantially the same stereoregularity as the propylene- α -olefin copolymer so long as the graft or block copolymer has a sharp melting point above 110°C, and above 115°C, and above 130°C, characteristic of the stereoregular propylene sequences. The primary polypropylene can be a combination of homopolymer propylene, and/or random, and/or block copolymers as described herein. When the above primary polypropylene is a random copolymer, the percentage of the copolymerized α -olefin in the copolymer can be, in general, up to 9 wt% by weight of the polypropylene, between 0.5 wt% to 8 wt% by weight of the polypropylene, or between 2 wt% to 6 wt% by weight of the polypropylene. The α -olefins can be ethylene or C_4 to C_{10} , or C_{20} α -olefins. One, or two or more α -olefins can be copolymerized with propylene.

[0017] The weight average molecular weight (M_w) of the primary polypropylene can be within a range from 40,000, 50,000, or 80,000 g/mole to 200,000, 400,000, 500,000, or 1,000,000 g/mole. The number average molecular weight (M_n) can be within a range from 20,000, 30,000, or 40,000 g/mole to 50,000, 55,000, 60,000, or 70,000 g/mole. The z-average

molecular weight (M_z) can be at least 300,000 or 350,000 g/mole, or within a range from 300,000 or 350,000 g/mole to 500,000 g/mole. The molecular weight distribution, M_w/M_n , in any embodiment can be less than 5.5, or 5, or 4.5, or 4, or within a range from 1.5, or 2, or 2.5, or 3 to 4, or 4.5 or 5 or 5.5.

[0018] The melt flow rate (MFR) of the primary polypropylene can be within a range from 1 to 500 dg/min, alternatively within a range from 1, or 5, or 10, or 15, or 20, or 25 dg/min to 45, or 55, or 100, or 300, or 350, or 400, or 450, or 500 dg/min, as measured per ASTM 1238, 2.16 kg at 230°C. The primary polypropylene can form thermoplastic blends including from 1 wt% to 95 wt% by weight of the blend of the polypropylene polymer component.

[0019] There is no particular limitation on the method for preparing the primary polypropylene of the invention. For example, the polymer may be a propylene homopolymer obtained by homopolymerization of propylene in a single stage or multiple stage reactor. Copolymers may be obtained by copolymerizing propylene and an ethylene and/or a C_4 to C_{10} , or C_{20} α -olefin in a single stage or multiple stage reactor. Polymerization methods include high pressure, slurry, gas, bulk, or solution phase, or a combination thereof, using a traditional Ziegler-Natta catalyst or a single-site, metallocene catalyst system, or combinations thereof including bimetallic supported catalyst systems. Polymerization may be carried out by a continuous or batch process and may include use of chain transfer agents, scavengers, or other such additives as deemed applicable.

[0020] The primary polypropylene may be reactor grade, meaning that it has not undergone any post-reactor modification by reaction with peroxides, cross-linking agents, e- beam, gamma-radiation, or other types of controlled rheology modification. In any embodiment, the primary polypropylene can have been visbroken by peroxides as is known in the art.

[0021] Exemplary commercial products of the polypropylene polymers in primary polypropylene includes polypropylene homopolymer, random copolymer and impact copolymer produced by using Ziegler-Natta catalyst system have a broad M_w/M_n . An example of such product is ExxonMobil PP3155, a 36 dg/min MFR homopolymer available from ExxonMobil Chemical Company, Baytown, Texas.

Propylene-based elastomer

[0022] In any embodiment, the propylene-based elastomer is a random copolymer having crystalline regions interrupted by non-crystalline regions and within the range from 5 to 25 wt%, by weight of the propylene-based elastomer, of ethylene or C_4 to C_{10} α -olefin derived units, and optionally diene-derived units, the remainder of the polymer being propylene-derived units. Not intended to be limited by any theory, it is believed that the non-crystalline regions may result from regions of non-crystallizable polypropylene segments and/or the inclusion of comonomer units. The crystallinity and the melting point of the propylene-based elastomer are reduced compared to highly isotactic polypropylene by the introduction of errors (stereo and region defects) in the insertion of propylene and/or by the presence of comonomer. The copolymer contains at least 60 wt% propylene-derived units by weight of the propylene-based elastomer. In any embodiment, the propylene-based elastomer can be a propylene-based elastomer having limited crystallinity due to adjacent isotactic propylene units and a melting point as described herein. In other embodiments, the propylene-based elastomer can be generally devoid of any substantial intermolecular heterogeneity in tacticity and comonomer composition, and also generally devoid of any substantial heterogeneity in intramolecular composition distribution.

[0023] The propylene-based elastomer contains greater than 50 wt%, preferably greater than 60 wt%, greater than 65 wt%, or greater more preferably than 75 wt% and most preferably up to 99 wt% propylene-derived units, based on the total weight of the propylene-based elastomer. In some embodiments, the propylene-based elastomer includes propylene-derived units in an amount based on the weight of propylene-based elastomer of from 75 wt% to 95 wt%, 75 wt% to 92.5 wt%, 82.5 wt% to 92.5 wt%, or 82.5 wt% to 90 wt%. Correspondingly, the units, or comonomers, derived from at least one of ethylene or a C_4 to C_{10} α -olefin can be present in an amount of 5, or 10, or 14 wt% to 22, or 25 wt% by weight of the elastomer.

[0024] The comonomer content is adjusted so that the propylene-based elastomer having a heat of fusion of 80 J/g or less, or preferably 75 J/g or less, a melting point (T_m) of 100°C or 90°C or less, and crystallinity of 2% to 65% of isotactic polypropylene, and a melt flow rate ("MFR"), as measured at 230°C and 2.16 kg weight, of less than 800 dg/min.

[0025] The propylene-based elastomer may comprise more than one comonomer. Preferred embodiments of a propylene-based elastomer have more than one comonomer including propylene-ethylene-octene, propylene-ethylene-hexene, and propylene-ethylene-butene copolymers.

[0026] In embodiments where more than one comonomers derived from at least one of ethylene or a C_4 to C_{10} α -olefins are present, the amount of each comonomer may be less than 5 wt% of the propylene-based elastomer, but the combined amount of comonomers by weight of the propylene-based elastomer is 5 wt% or greater.

[0027] In some embodiments, the comonomer is ethylene, 1-hexene, or 1-octene. The comonomer can be present in an amount of 5, or 10, or 14 wt% to 22, or 25 wt% based on the weight of the propylene-based elastomer.

[0028] In any embodiment, the propylene-based elastomer can comprise ethylene-derived units. The propylene-based elastomer can comprise 5, 10, or 14 wt% to 22, or 25 wt% of ethylene-derived units by weight of the propylene-based

elastomer. In any embodiment, the propylene-based elastomer can consist essentially of units derived from propylene and ethylene, i.e., the propylene-based elastomer does not contain any other comonomer in an amount typically present as impurities in the ethylene and/or propylene feedstreams used during polymerization or an amount that would materially affect the heat of fusion, melting point, crystallinity, or melt flow rate of the propylene-based elastomer, or any other comonomer intentionally added to the polymerization process.

[0029] In any embodiment, diene comonomer units can be included in the propylene-based elastomer. Examples of the diene include, but are not limited to, 5-ethylidene-2-norbornene, 5-vinyl-2-norbornene, divinylbenzene, 1,4-hexadiene, 5-methylene-2-norbornene, 1,6-octadiene, 5-methyl-1, 4-hexadiene, 3,7-dimethyl-1,6-octadiene, 1,3-cyclopentadiene, 1,4-cyclohexadiene, dicyclopentadiene, or a combination thereof. The amount of diene comonomer can be equal to or more than 0 wt%, or 0.5 wt%, or 1 wt%, or 1.5 wt% and lower than, or equal to, 5 wt%, or 4 wt%, or 3 wt% or 2 wt% based on the weight of propylene-based elastomer.

[0030] The propylene-based elastomer has a heat of fusion ("Hf"), as determined by the Differential Scanning Calorimetry ("DSC"), of 80 J/g or less, or 75 J/g or less, 70 J/g or less, 50 J/g or less, or 35 J/g or less. The propylene-based elastomer can have a lower limit Hf of 0.5 J/g, 1 J/g, or 5 J/g. For example, the Hf value may be anywhere from 1.0, 1.5, 3.0, 4.0, 6.0, or 7.0 J/g, to 30, 35, 40, 50, 60, 70, or 75 J/g.

[0031] The propylene-based elastomer can have a percent crystallinity, as determined according to the DSC procedure described herein, of 2% to 65%, 0.5% to 40%, 1% to 30%, or 5% to 35%, of isotactic polypropylene. The thermal energy for the highest order of propylene (i.e., 100% crystallinity) is estimated at 189 J/g. In any embodiment, the copolymer has a crystallinity in the range of 0.25% to 25%, or 0.5% to 22% of isotactic polypropylene.

[0032] The propylene-based elastomer can have a triad tacticity of three propylene units (mmm tacticity), as measured by ¹³C NMR, of 75% or greater, 80% or greater, 85% or greater, 90% or greater, 92% or greater, 95% or greater, or 97% or greater. For example, the triad tacticity may range from about 75 to about 99%, from about 80 to about 99%, from about 85 to about 99%, from about 90 to about 99%, from about 90 to about 97%, or from about 80 to about 97%. Triad tacticity may be determined by the methods described in U.S. Pat. No. 7,232,871.

[0033] The propylene-based elastomer may have a tacticity index m/r ranging from a lower limit of 4 or 6 to an upper limit of 8 or 10 or 12. The tacticity index, expressed herein as "m/r", is determined by ¹³C nuclear magnetic resonance ("NMR"). The tacticity index, m/r, is calculated as defined by H. N. Cheng in Vol. 17, MACROMOLECULES, pp. 1950-1955 (1984), incorporated herein by reference. The designation "m" or "r" describes the stereochemistry of pairs of contiguous propylene groups, "m" referring to meso, and "r" to racemic. An m/r ratio of 1.0 generally describes a syndiotactic polymer, and an m/r ratio of 2.0 describes an atactic material. The propylene-based elastomer can have a single peak melting transition as determined by DSC. In any embodiment, the copolymer has a primary peak transition of 90°C or less, with a broad end-of-melt transition of 110°C or greater. The peak "melting point" ("Tm") is defined as the temperature of the greatest heat absorption within the range of melting of the sample. However, the copolymer may show secondary melting peaks adjacent to the principal peak, and/or at the end-of-melt transition. For the purposes of this disclosure, such secondary melting peaks are considered together as a single melting point, with the highest of these peaks being considered the Tm of the propylene-based elastomer. The propylene-based elastomer can have a Tm of 100°C or less, 90°C or less, 80°C or less, or 70°C or less. In any embodiment, the propylene-based elastomer can have a Tm of 25°C to 100°C, 25°C to 85°C, 25°C to 75°C, or 25°C to 65°C. In any embodiment, the propylene-based elastomer can have a Tm of 30°C to 80°C or 30°C to 70°C.

[0034] For the thermal properties of the propylene-based elastomers, Differential Scanning Calorimetry ("DSC") was used. Such DSC data was obtained using a Perkin-Elmer DSC 7.5 mg to 10 mg of a sheet of the polymer to be tested was pressed at approximately 200°C to 230°C, then removed with a punch die and annealed at room temperature for 48 hours. The samples were then sealed in aluminum sample pans. The DSC data was recorded by first cooling the sample to -50°C and then gradually heating it to 200°C at a rate of 10°C/minute. The sample was kept at 200°C for 5 minutes before a second cooling-heating cycle was applied. Both the first and second cycle thermal events were recorded. Areas under the melting curves were measured and used to determine the heat of fusion and the degree of crystallinity. The percent crystallinity (X%) was calculated using the formula, $X\% = [\text{area under the curve (Joules/gram)} / B(\text{Joules/gram})] * 100$, where B is the heat of fusion for the homopolymer of the major monomer component. These values for B were found from the Polymer Handbook, Fourth Edition, published by John Wiley and Sons, New York 1999. A value of 189 J/g (B) was used as the heat of fusion for 100% crystalline polypropylene. The melting temperature was measured and reported during the second heating cycle (or second melt).

[0035] In one or more embodiments, the propylene-based elastomer can have a Mooney viscosity [ML (1+4) @ 125°C], as determined according to ASTM D-1646, of less than 100, in other embodiments less than 75, in other embodiments less than 60, and in other embodiments less than 30.

[0036] The propylene-based elastomer can have a density of 0.850 g/cm³ to 0.920 g/cm³, 0.860 g/cm³ to 0.900 g/cm³, or 0.860 g/cm³ to 0.890 g/cm³, at room temperature as measured per ASTM D-1505.

[0037] The propylene-based elastomer can have a melt flow rate ("MFR") greater than 0.5 dg/min, and less than or equal to 1,000 dg/min, or less than or equal to 800 dg/min, less than or equal to 500 dg/min, less than or equal to 200 dg/min, less

than or equal to 100 dg/min, or less than or equal to 50 dg/min. Some embodiments can include a propylene-based elastomer with an MFR of less than or equal to 25 dg/min, such as from 1 to 25 dg/min or 1 to 20 dg/min. The MFR is determined according to ASTM D-1238, condition L (2.16 kg, 230°C).

[0038] The propylene-based elastomer can have a weight average molecular weight ("Mw") of 5,000 to 5,000,000 g/mole, 10,000 to 1,000,000 g/mole, or 50,000 to 400,000 g/mole; a number average molecular weight ("Mn") of 2,500 to 2,500,00 g/mole, 10,000 to 250,000 g/mole, or 25,000 to 200,000 g/mole; and/or a z-average molecular weight ("Mz") of 10,000 to 7,000,000 g/mole, 80,000 to 700,000 g/mole, or 100,000 to 500,000 g/mole. The propylene-based elastomer can have a molecular weight distribution (Mw/Mn, or "MWD") of 1.5 to 20, or 1.5 to 15, 1.5 to 5, 1.8 to 5, or 1.8 to 4.

[0039] The propylene-based elastomer can have an Elongation at Break of less than 2000%, less than 1000%, or less than 800%, as measured per ASTM D412.

[0040] The propylene-based elastomer can also include one or more dienes. The term "diene" is defined as a hydrocarbon compound that has two unsaturation sites, i.e., a compound having two double bonds connecting carbon atoms. Depending on the context, the term "diene" as used herein refers broadly to either a diene monomer prior to polymerization, e.g., forming part of the polymerization medium, or a diene monomer after polymerization has begun (also referred to as a diene monomer unit or a diene-derived unit). In some embodiments, the diene can be selected from 5-ethylidene-2-norbornene (ENB); 1,4-hexadiene; 5-methylene-2-norbornene (MNB); 1,6-octadiene; 5-methyl-1,4-hexadiene; 3,7-dimethyl-1,6-octadiene; 1,3-cyclopentadiene; 1,4-cyclohexadiene; vinyl norbornene (VNB); dicyclopentadiene (DCPD), and combinations thereof. In embodiments where the propylene-based elastomer composition comprises a diene, the diene can be present at from 0.05 wt % to about 6 wt %, from about 0.1 wt % to about 5.0 wt %, from about 0.25 wt % to about 3.0 wt %, from about 0.5 wt % to about 1.5 wt %, diene-derived units, where the percentage by weight is based upon the total weight of the propylene-derived, α -olefin derived, and diene-derived units.

[0041] The propylene-based elastomer can be grafted (i.e., "functionalized") using one or more grafting monomers. As used herein, the term "grafting" denotes covalent bonding of the grafting monomer to a polymer chain of the propylene-based elastomer. The grafting monomer can be or include at least one ethylenically unsaturated carboxylic acid or acid derivative, such as an acid anhydride, ester, salt, amide, imide, or acrylates. Illustrative grafting monomers include, but are not limited to, acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, citraconic acid, mesaconic acid, maleic anhydride, 4-methyl cyclohexene-1,2-dicarboxylic acid anhydride, bicyclo(2.2.2)octene-2,3-dicarboxylic acid anhydride, 1,2,3,4,5,8,9,10-octahydronaphthalene-2,3-dicarboxylic acid anhydride, 2-oxa-1,3-diketospiro(4.4)nonene, bicyclo(2.2.1)heptene-2,3-dicarboxylic acid anhydride, maleopimaric acid, tetrahydrophthalic anhydride, norbornene-2,3-dicarboxylic acid anhydride, nadic anhydride, methyl nadic anhydride, himic anhydride, methyl himic anhydride, and 5-methylbicyclo(2.2.1)heptene-2,3-dicarboxylic acid anhydride. Other suitable grafting monomers include methyl acrylate and higher alkyl acrylates, methyl methacrylate and higher alkyl methacrylates, acrylic acid, methacrylic acid, hydroxymethyl methacrylate, hydroxyethyl methacrylate and higher hydroxy-alkyl methacrylates and glycidyl methacrylate. Maleic anhydride can be used as a grafting monomer. In embodiments where the graft monomer is maleic anhydride, the maleic anhydride concentration in the grafted polymer can be to about 6 wt %, at least about 0.5 wt %, or at least about 1.5 wt % based on the total weight of the propylene-based elastomer.

[0042] In some embodiments, the propylene-based elastomer can be a reactor blended polymer as defined herein. That is, the propylene-based elastomer is a reactor blend of a first polymer component and a second polymer component. Thus, the comonomer content of the propylene-based elastomer can be adjusted by adjusting the comonomer content of the first polymer component, adjusting the comonomer content of second polymer component, and/or adjusting the ratio of the first polymer component to the second polymer component present in the propylene-based elastomer.

[0043] In embodiments where the propylene-based elastomer is a reactor blended polymer, the α -olefin content of the first polymer component ("R1") can be greater than 5 wt % α -olefin, greater than 7 wt % α -olefin, greater than 10 wt % α -olefin, greater than 12 wt % α -olefin, greater than 15 wt % α -olefin, or greater than 17 wt % α -olefin, where the percentage by weight is based upon the total weight of the propylene-derived and α -olefin-derived units of the first polymer component. The α -olefin content of the first polymer component can be less than 30 wt % α -olefin, less than 27 wt % α -olefin, less than 25 wt % α -olefin, less than 22 wt % α -olefin, less than 20 wt % α -olefin, or less than 19 wt % α -olefin, where the percentage by weight is based upon the total weight of the propylene-derived and α -olefin-derived units of the first polymer component. In some embodiments, the α -olefin content of the first polymer component can range from 5 wt % to 30 wt % α -olefin, from 7 wt % to 27 wt % α -olefin, from 10 wt % to 25 wt % α -olefin, from 12 wt % to 22 wt % α -olefin, from 15 wt % to 20 wt % α -olefin, or from 17 wt % to 19 wt % α -olefin. The first polymer component can comprise propylene and ethylene, and in some embodiments the first polymer component can consist only of propylene and ethylene derived units.

[0044] In embodiments where the propylene-based elastomer is a reactor blended polymer, the α -olefin content of the second polymer component ("R2") can be greater than 1.0 wt % α -olefin, greater than 1.5 wt % α -olefin, greater than 2.0 wt % α -olefin, greater than 2.5 wt % α -olefin, greater than 2.75 wt % α -olefin, or greater than 3.0 wt % α -olefin, where the percentage by weight is based upon the total weight of the propylene-derived and α -olefin-derived units of the second polymer component. The α -olefin content of the second polymer component can be less than 10 wt % α -olefin, less than 9 wt % α -olefin, less than 8 wt % α -olefin, less than 7 wt % α -olefin, less than 6 wt % α -olefin, or less than 5 wt % α -olefin,

where the percentage by weight is based upon the total weight of the propylene-derived and α -olefin-derived units of the second polymer component. In some embodiments, the α -olefin content of the second polymer component can range from 1.0 wt % to 10 wt % α -olefin, or from 1.5 wt % to 9 wt % α -olefin, or from 2.0 wt % to 8 wt % α -olefin, or from 2.5 wt % to 7 wt % α -olefin, or from 2.75 wt % to 6 wt % α -olefin, or from 3 wt % to 5 wt % α -olefin. The second polymer component can comprise propylene and ethylene, and in some embodiments the first polymer component can consist only of propylene and ethylene derived units.

[0045] In embodiments where the propylene-based elastomer is a reactor blended polymer, the propylene-based elastomer can comprise from 1 to 25 wt % of the second polymer component, from 3 to 20 wt % of the second polymer component, from 5 to 18 wt % of the second polymer component, from 7 to 15 wt % of the second polymer component, or from 8 to 12 wt % of the second polymer component, based on the weight of the propylene-based elastomer. The propylene-based elastomer can comprise from 75 to 99 wt % of the first polymer component, from 80 to 97 wt % of the first polymer component, from 85 to 93 wt % of the first polymer component, or from 82 to 92 wt % of the first polymer component, based on the weight of the propylene-based elastomer.

[0046] The propylene-based elastomer can be prepared by any suitable means as known in the art. The propylene-based elastomer can be prepared using homogeneous conditions, such as a continuous solution polymerization process, using a metallocene catalyst. In some embodiments, the propylene-based elastomer can be prepared in parallel solution polymerization reactors, such that the first reactor component is prepared in a first reactor and the second reactor component is prepared in a second reactor, and the reactor effluent from the first and second reactors are combined and blended to form a single effluent from which the final propylene-based elastomer is separated. Exemplary methods for the preparation of propylene-based elastomers can be found in U.S. Pat. Nos. 6,881,800; 7,803,876; 8,013,069; and 8,026,323 and PCT Publications WO 2011/087729; WO 2011/087730; and WO 2011/087731.

[0047] Commercial examples of such propylene-based elastomers include Vistamaxx™ propylene-based elastomers from ExxonMobil Chemical Company, Tafmer™ elastomers from Mitsui Chemicals, and Versify™ elastomers from Dow Chemical Company. Polyalphaolefins

[0048] Polyalphaolefins (PAO) can comprise oligomers of α -olefins (also known as 1-olefins) and are often used as the base stock for synthetic lubricants. PAO can be produced by the polymerization of α -olefins, such as linear α -olefins. A PAO can be characterized by any type of tacticity, including isotactic or syndiotactic and/or atactic, and by any degree of tacticity, including isotactic-rich or syndiotactic-rich or fully atactic. PAO liquids are described in, for example, U.S. Pat. Nos. 3,149,178; 4,827,064; 4,827,073; 5,171,908; and 5,783,531; and in SYNTHETIC LUBRICANTS AND HIGH-PERFORMANCE FUNCTIONAL FLUIDS, Leslie R. Rudnick & Ronald L. Shubkin, eds. (Marcel Dekker, 1999), pp. 3-52. PAOs are Group 4 compounds, as defined by the American Petroleum Institute (API). The PAO can comprise C₂₀ to C₁₅₀₀ paraffins, C₄₀ to C₁₀₀₀ paraffins, C₅₀ to C₇₅₀ paraffins, or C₅₀ to C₅₀₀ paraffins. The PAO can be dimers, trimers, tetramers, pentamers, etc. of C₅ to C₁₄ α -olefins, and C₆ to C₁₂ α -olefins, or C₈ to C₁₂ α -olefins. Suitable olefins include 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene and 1-dodecene. Exemplary PAO are described more particularly in, for example, U.S. Pat. No. 5,171,908, and U.S. Pat. No. 5,783,531 and in SYNTHETIC LUBRICANTS AND HIGH-PERFORMANCE FUNCTIONAL FLUIDS 1-52 (Leslie R. Rudnick & Ronald L. Shubkin, ed. Marcel Dekker, Inc. 1999), the entire contents of which are incorporated herein by reference.

[0049] PAO can be made by any suitable means known in the art. For example, the PAOs can be prepared by the oligomerization of an α -olefin in the presence of a polymerization catalyst, such as a Friedel-Crafts catalyst (including, for example, AlCl₃, BF₃, and complexes of BF₃ with water, alcohols, carboxylic acids, or esters), a coordination complex catalyst (including, for example, the ethylaluminum sesquichloride+TiCl₄ system), or a homogeneous or heterogeneous (supported) catalyst more commonly used to make polyethylene and/or polypropylene (including, for example, Ziegler-Natta catalysts, metallocene or other single-site catalysts, and chromium catalysts). Subsequent to the polymerization, the PAO can be hydrogenated in order to reduce any residual unsaturation. PAO can be hydrogenated to yield substantially (>99 wt. %) paraffinic materials. The PAO can also be functionalized to comprise, for example, esters, polyethers, polyalkylene glycols, and the like.

[0050] PAO can possess a number average molecular weight (Mn) of from 100 to 21,000 in one embodiment, and from 200 to 10,000 in another embodiment, and from 200 to 7,000 in yet another embodiment, and from 200 to 2,000 in yet another embodiment, and from 200 to 500 in yet another embodiment.

[0051] The PAOs may have a weight average molecular weight (Mw) of less than 10,000 g/mol, or less than 5,000 g/mol, or less than 4,000 g/mol, or less than 2,000 g/mol, or less than 1,000 g/mol. In some embodiments, the PAO may have an Mw of 250 g/mol or more, 400 g/mol or more, or 500 g/mol or more, or 600 g/mol or more, or 700 g/mol or more, or 750 g/mol or more. In some embodiments, the PAO may have a Mw in the range of from 250 to 10,000 g/mol, or from 400 to 5,000 g/mol, or from 500 to 4,000 g/mol, or from 600 to 2000 g/mol, or from 700 to 1000 g/mol. The molecular weight of the PAO can be determined by GPC method using a column for medium to low molecular weight polymers, tetrahydrofuran as solvent and polystyrene as calibration standard, correlated with the fluid viscosity according to a power equation. Unless otherwise indicated Mw values reported herein are GPC values and are not calculated from kinematic viscosity at 100° C.

[0052] PAO can have a kinematic viscosity ("KV") at 100° C., as measured by ASTM D445 at 100° C., of 3 cSt (1 cSt=1

mm²/s) to 3,000 cSt, 4 to 1,000 cSt, 6 to 300 cSt, 8 to 125 cSt, 8 to 100 cSt, or 10 to 60 cSt. In some embodiments, the PAO can have a KV at 100° C. of 5 to 1000 cSt, 6 to 300 cSt, 7 to 100 cSt, or 8 to 50 cSt.

[0053] PAO can have a viscosity index ("VI"), as determined by ASTM D2270, of greater than 120, preferably greater than 150, more preferably greater than 200.

[0054] PAO can have a pour point, as determined by ASTM D5950/D97, of -100° C to 0° C, -100° C to -10° C, -90° C. to -15° C, or -80° C to -20° C. In some embodiments, the PAO or blend of PAO can have a pour point of -25 to -75° C or -40 to -60° C.

[0055] PAO can have a flash point, as determined by ASTM D92, of 150° C. or more, 200° C. or more, 210° C. or more, 220° C. or more, 230° C. or more, or between 240° C. and 290° C.

[0056] The PAO can have a specific gravity (15.6/15.6° C., 1 atm/1 atm) of 0.79 to 0.90, 0.80 to 0.89, 0.81 to 0.88, 0.82 to 0.87, or 0.83 to 0.86.

[0057] PAO can have (a) a flash point of 200° C. or more, 210° C. or more, 220° C. or more, or 230° C. or more; and (b) a pour point less than -20° C., less than -25° C., less than -30° C., less than -35° C., or less than -40° C., and (c) a KV at 100° C. of 2 cSt or more, 4 cSt or more, 5 cSt or more, 6 cSt or more, 8 cSt or more.

[0058] PAO can have a KV at 100° C. of 5 to 50 cSt or 8 to 20 cSt; a pour point of -25 to -75° C or -40 to -60° C.; and a specific gravity of 0.81 to 0.87 or 0.82 to 0.86.

[0059] Other useful PAO include those sold under the tradenames Synfluid™ available from ChevronPhillips Chemical Co. in Pasadena Tex., Durasyn™ available from BP Amoco Chemicals in London England, Nexbase™ available from Fortum Oil and Gas in Finland, Synton™ available from Crompton Corporation in Middlebury Conn., USA, EMERY™ available from Cognis Corporation in Ohio, USA.

[0060] The PAO can have a Kinematic viscosity of 10 cSt or more at 100° C, 30 cSt or more, 50 cSt or more, 80 cSt or more, 110 or more, 150 cSt or more, 200 cSt or more, 500 cSt or more, 750 or more, 1000 cSt or more, 1500 cSt or more, 2000 cSt or more, or 2500 or more. The PAO can have a kinematic viscosity at 100° C of between 10 cSt and 3000 cSt, between 10 cSt and 1000 cSt, or between 10 cSt and 40 cSt.

[0061] The PAO has a viscosity index of 120 or more, preferably 130 or more, 140 or more, 150 or more, 170 or more, 190 or more, 200 or more, 250 or more, or 300 or more.

Polymer Compositions

[0062] The Polymer compositions can comprise at least one polyalphaolefin (PAO), at least one propylene-based elastomer, and at least one primary propylene as previously described. In the invention the primary propylene in the polymer composition is comprised from about 50 wt%, preferably from about 60 wt%, 65 wt%, or 70 wt% of the polymer composition to about 98 wt%, preferably to about 75 wt%. 80 wt%, 85 wt%, 90 wt%, 95 wt%, of the polymer composition. In the invention the propylene-based elastomer in the polymer composition is comprised from about 1 wt%, preferably from about 5 wt%, or 10 wt%, of the polymer composition to about 20 wt%, preferably to about 15 wt%, of the polymer composition. In the invention the PAO in the polymer composition is comprised from about 1 wt%, preferably from about 5 wt%, or 10 wt%, of the polymer composition to about 20 wt%, preferably 15 wt%, of the polymer composition. In some embodiments, only the weight of the PAO, propylene-based elastomer, and primary polypropylene are used to determine the weight of the polymer composition to determine the wt% described in this paragraph.

[0063] A variety of additives may be incorporated into the polymer compositions described herein, depending upon the intended purpose. For example, when the blends are used to form fibers and nonwoven fabrics, such additives may include but are not limited to stabilizers, antioxidants, fillers, colorants, nucleating agents, dispersing agents, mold release agents, slip additives, fire retardants, plasticizers, pigments, vulcanizing or curative agents, vulcanizing or curative accelerators, cure retarders, processing aids, tackifying resins, and the like. Other additives may include fillers and/or reinforcing materials, such as carbon black, clay, talc, calcium carbonate, mica, silica, silicate, combinations thereof, and the like. Primary and secondary antioxidants include, for example, hindered phenols, hindered amines, and phosphates. Nucleating agents include, for example, sodium benzoate and talc. Also, to improve crystallization rates, other nucleating agents may also be employed such as Ziegler-Natta olefin products or other highly crystalline polymers. Other additives such as dispersing agents, for example, Acrowax C, can also be included. Slip additives can include, for example, oleamide and erucamide. Catalyst deactivators are also commonly used, for example, calcium stearate, hydrotalcite, and calcium oxide, and/or other acid neutralizers known in the art. The additives can be present within a range from 0 wt%, 0.1 wt%, 0.2 wt%, 0.3 wt% to 1 wt%, 2, 3 wt%, or 4 wt%, or 5 wt% of additives by weight of the polymer composition. The slip additive can be used in an amount of less than 100 ppm, 50 ppm, 30 ppm, 10 ppm, or 1 ppm.

[0064] Further, in some exemplary embodiments, additives may be incorporated into the polymer compositions directly or as part of a masterbatch, i.e., an additive package containing several additives to be added at one time in predetermined proportions. In one or more embodiments herein, the fiber further comprises a masterbatch comprising a slip agent. The masterbatch may be added in any suitable amount to accomplish the desired result. For example, a masterbatch comprising a slip additive may be used in an amount ranging from about 0.1 to about 10 wt %, or from about 0.25 to about

7.5 wt %, or from about 0.5 to about 5 wt %, or from about 1 to about 5 wt %, or from about 2 to about 4 wt %, based on the total weight of the polymer composition and the masterbatch. In an embodiment, the masterbatch can comprises erucamide as the slip additive.

[0065] The polymer compositions can have a handle (grams) as measured by the Thwing-Albert Instruments Co. Handle-O-Meter (Model 211-10-B/AERGLA) of from about 1 g, 2 g, 3 g, 4 g, 5 g to about 7 g, 8 g, 9 g, 10 g, or 11 g. The polymer compositions can have a handle (grams) as measured by the Thwing-Albert Instruments Co. Handle-O-Meter (Model 211-10-B/AERGLA) of less than about 11 g, 10 g, 9 g, 8 g, or 7 g.

Fibers, Nonwoven Compositions, and Laminates Prepared from Polymer Compositions

[0066] In one or more embodiments, the polymer compositions described above can be meltspun (e.g., meltblown or spunbond) fibers and nonwoven compositions (e.g. fabrics). As used herein, "meltspun nonwoven composition" refers to a composition having at least one meltspun layer and does not require that the entire composition be meltspun or nonwoven. In some embodiments, the nonwoven compositions can additionally comprise one or more layers positioned on one or both sides of the nonwoven layer(s) comprising the PAO/propylene-based elastomer blend. As used herein, "nonwoven" refers to a textile material that has been produced by methods other than weaving. In nonwoven fabrics, the fibers can be processed directly into a planar sheet-like fabric structure and then either bonded chemically, thermally, or interlocked mechanically (or a combination thereof) to achieve a cohesive fabric.

[0067] In one or more embodiments, the process for forming nonwoven compositions can comprise the steps of forming a molten polymer composition comprising a blend of at least one PAO, at least one propylene-based elastomer, and at least one primary propylene as described above, and forming fibers comprising the polymer composition. The fibers can have a thickness from about 1 to about 10 denier, or from about 2 to about 8 denier, or from about 4 to about 6 denier. Although commonly referred to in the art and used herein for convenience as an indicator of thickness, denier is more accurately described as the linear mass density of a fiber. A denier is the mass (in grams) of a fiber per 9,000 meters. In practice, measuring 9,000 meters may be both time-consuming and wasteful. Usually, a sample of lesser length (i.e., 900 meters, 90 meters, or any other suitable length) is weighed and the result multiplied by the appropriate factor to obtain the denier of the fiber. The fibers can be monocomponent fibers or bicomponent fibers. A monocomponent fiber has a consistent composition throughout its cross-section.

[0068] In some embodiments, the methods can further comprise forming a nonwoven composition from the fibers. In further embodiments, the nonwoven composition formed from the polymer composition is employed as a facing layer, and the process may further comprise the steps of forming one or more nonwoven elastic layers and disposing the facing layer comprising the polymer composition upon the elastic layer. Optionally, two or more facing layers may be disposed upon the elastic layer or layers on opposite sides, such that the elastic layers are sandwiched between the facing layers. In one or more embodiments, the elastic layer or layers may comprise a propylene-based elastomer having the composition and properties described above. In certain embodiments, nonwoven compositions comprising the polymer composition can be described as extensible. "Extensible," as used herein, means any fiber or nonwoven composition that yields or deforms (i.e., stretches) upon application of a force. While many extensible materials are also elastic, the term extensible also encompasses those materials that remain extended or deformed upon removal of the force. When an extensible facing layer is used in combination with an elastic core layer, desirable aesthetic properties may result because the extensible layer permanently deforms when the elastic layer to which it is attached stretches and retracts. This results in a wrinkled or textured outer surface with a soft feel that is particularly suited for articles in which the facing layer is in contact with a wearer's skin.

[0069] The fibers and nonwoven compositions can be formed by any method known in the art. For example, the nonwoven compositions can be produced by a meltblown or spunbond process. In certain embodiments herein, the layer or layers of the nonwoven compositions of the invention can be produced by a spunbond process. When the compositions further comprise one or more elastic layers, the elastic layers can be produced by a meltblown process, by a spunbond or spunlace process, or by any other suitable nonwoven process.

[0070] The nonwoven layer or layers described herein may be composed primarily of a polymer composition as described previously. In one or more embodiments, the nonwoven compositions can have a basis weight of from about 10 to about 75 g/m² ("gsm"), or from about 15 to about 65 gsm, or from about 20 to about 55 gsm, or from about 22 to about 53 gsm, or from about 24 to about 51 gsm, or from about 25 to about 50 gsm. In the same or other embodiments, the nonwovens can have a tensile strength in the machine direction (MD) from about 5 to about 65 N/5 cm, or from about 7 to about 60 N/5 cm, or from about 10 to about 55 N/5 cm, or from about 10 to about 50 N/5 cm, or from about 15 to about 45 N/5 cm. Stated differently, the nonwovens can have an MD tensile strength greater than about 5 N/5 cm, or greater than about 10 N/5 cm, or greater than about 15 N/5 cm, or greater than about 20 N/5 cm. In the same or other embodiments, the nonwovens can have a tensile strength in the cross direction (CD) from about 5 to about 55 N/5 cm, or from about 7 to about 50 N/5 cm, or from about 10 to about 45 N/5 cm, or from about 10 to about 40 N/5 cm, or from about 15 to about 35 N/5 cm. Stated differently, the nonwovens can have an MD tensile strength greater than about 5 N/5 cm, or greater than about 10

N/5 cm, or greater than about 15 N/5 cm, or greater than about 20 N/5 cm.

[0071] In one or more embodiments, the nonwoven compositions can have a peak elongation in the machine direction (MD) greater than about 70%, or greater than about 75%, or greater than about 80%, or greater than about 85%, or greater than about 90%, or greater than about 95%, or greater than about 100%. In the same or other embodiments, the nonwoven compositions can have a peak elongation in the cross direction (CD) greater than about 80%, or greater than about 85%, or greater than about 90%, or greater than about 100%, or greater than about 105%, or greater than about 110%, or greater than about 115%, or greater than about 120%. Tensile strength and elongation are determined in accordance with ASTM D882.

[0072] As used herein, "meltblown fibers" and "meltblown compositions" (or "meltblown fabrics") refer to fibers formed by extruding a molten thermoplastic material at a certain processing temperature through a plurality of fine, usually circular, die capillaries as molten threads or filaments into high velocity, usually hot, gas streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web or nonwoven fabric of randomly dispersed meltblown fibers. Such a process is generally described in, for example, U.S. Pat. Nos. 3,849,241 and 6,268,203. Meltblown fibers are microfibers that are either continuous or discontinuous, and, depending on the resin, may have a diameter smaller than about 10 microns (for example, for high MFR isotactic polypropylene resins such as PP3746G or Achieve™ 6936G1, available from ExxonMobil Chemical Company); whereas for certain resins (for example, Vistamaxx™ propylene-based elastomer, available from ExxonMobil Chemical Company) or certain high throughput processes such as those described herein, meltblown fibers may have diameters greater than 10 microns, such as from about 10 to about 30 microns, or about 10 to about 15 microns. The term meltblowing as used herein is meant to encompass the meltspray process.

[0073] Commercial meltblown processes that utilize extrusion systems can have a relatively high throughput, in excess of 0.3 grams per hole per minute ("ghm"), or in excess of 0.4 ghm, or in excess of 0.5 ghm, or in excess of 0.6 ghm, or in excess of 0.7 ghm. The nonwoven compositions can be produced using commercial meltblown processes, such as a high pressure meltblown process available from Biax-Fiberfilm Corporation, or in test or pilot scale processes. In one or more embodiments, the fibers used to form the nonwoven compositions can be formed using an extrusion system having a throughput rate of from about 0.01 to about 3.0 ghm, or from about 0.1 to about 2.0 ghm, or from about 0.3 to about 1.0 ghm.

[0074] In a typical spunbond process, polymer is supplied to a heated extruder to melt and homogenize the polymers. The extruder supplies melted polymer to a spinneret where the polymer is fiberized as passed through fine openings arranged in one or more rows in the spinneret, forming a curtain of filaments. The filaments are usually quenched with air at a low temperature, drawn, usually pneumatically, and deposited on a moving mat, belt or "forming wire" to form the nonwoven composition. See, for example, in U.S. Pat. Nos. 4,340,563; 3,692,618; 3,802,817; 3,338,992; 3,341,394; 3,502,763; and U.S. Pat. No. 3,542,615. The term spunbond as used herein is meant to include spunlace processes, in which the filaments are entangled to form a web using high-speed jets of water (known as "hydroentanglement").

[0075] The fibers produced in the spunbond process are usually in the range of from about 10 to about 50 microns in diameter, depending on process conditions and the desired end use for the fabrics to be produced from such fibers. For example, increasing the polymer molecular weight or decreasing the processing temperature results in larger diameter fibers. Changes in the quench air temperature and pneumatic draw pressure also have an effect on fiber diameter.

[0076] The nonwoven compositions described herein may be a single layer or may be multilayer laminates. One application is to make a laminate (or "composite") from meltblown ("M") and spunbond ("S") nonwoven compositions, which combines the advantages of strength from the spunbonded component and greater barrier properties of the meltblown component. A typical laminate or composite has three or more layers, a meltblown layer(s) sandwiched between two or more spunbonded layers, or "SMS" nonwoven composites. Examples of other combinations are SSMSS, SMMS, and SMMSS composites. Composites can also be made of the meltblown or spunbond nonwovens of the invention with other materials, either synthetic or natural, to produce useful articles.

[0077] In certain embodiments, the meltblown or spunbond nonwoven compositions of the invention comprise one or more elastic layers comprising a propylene-based elastomer and further comprise one or more facing layers comprising an ICP/propylene-based elastomer blend as described herein positioned on one or both sides of the elastic layer(s). In some embodiments, the elastic layers and the facing layers may be produced in a single integrated process, such as a continuous process. For example, a spunmelt process line can incorporate meltblown technology such that multilayer nonwoven laminates are produced that contain one or more meltblown elastic layers laminated to one or more other spunbond layers (which may be elastic or inelastic) in a single continuous integrated process.

[0078] The nonwoven products described above may be used in many articles such as hygiene products including, but not limited to, diapers, feminine care products, and adult incontinent products. The nonwoven products may also be used in medical products such as sterile wrap, isolation gowns, operating room gowns, surgical gowns, surgical drapes, first aid dressings, and other disposable items.

EXAMPLES

[0079] The spunbonded nonwoven fabrics in Tables 1-4 below were produced on a Reicofil 4 (R4) line having a single spunbond (S) spinneret of about 1.1 m width, 5800-6300 holes with a hole (die) diameter of 0.6 mm. The Reicofil spunbonding process is described in more detail in EP 1340 843 or U.S. Patent No. 6,918,750. Total throughput was about 200kg/hour. The quench air temperature was 20°C for all experiments. The ratio of the volume flow VM of process air to the monomer exhaust device to the process air with volume flow V1 escaping from the first upper cooling chamber section into a second lower cooling chamber section (VM/V1) was maintained in the range of from 0.1 to 0.3. Line speed was kept constant at approximately 205 m/min. The filaments were deposited continuously on a deposition web with a targeted fabric basis weight for all examples of 15 g/m² (gsm). Fabric basis weight defined as the mass of fabric per unit area was measured by weighing 3 12"x12" fabric pieces and reporting an average value expressed in g/m² (gsm). Propylene polymer was delivered to the extruder from the main hopper. The Propylene polymer (PP) is a homopolymer available from ExxonMobil Chemical Company, Houston, Texas, under the tradename PP3155 (MFR of 35dg/min). Propylene based elastomer (PBE), is available from ExxonMobil Chemical Company, Houston, Texas, under the tradename Vistamaxx™ 7020BF and was incorporated at the level identified. The polyalphaolefin (PAO) is available from ExxonMobil Chemical Company, Houston, Texas under the tradename SpectraSyn 10. Slip additive was a masterbatch containing erucamide. The masterbatch was metered in to incorporate 2% of erucamide in all samples. It was obtained from Standridge Color Corporation of Georgia and identified as SCC-88953. Both the PBE and the slip additive from masterbatch were delivered to the extruder from additive feeders running at the appropriate feed rates. The PAO was introduced at the throat of the extruder using a Masterflex L/S Variable-Speed Drive with Remote I/O (600 rpm) pump available from Cole Palmer using a Masterflex L/S Easy-Load® II Head for Precision Tubing (PPS/SS) available from Cole Palmer. The pump was calibrated to deliver the required PAO (5, 10, 13.2%). The existing sight glass on the extruder was replaced with a plexiglass plate having an entry port to receive the required amount of PAO.

[0080] The formed fabric was thermally bonded by compressing it through a set of two heated rolls (calenders) for improving fabric integrity and improving fabric mechanical properties. Fundamentals of the fabric thermal bonding process can be found in the review paper by Michielson et al. "Review of Thermally Point-bonded Nonwovens: Materials, Processes, and Properties", J. Applied Polym. Sci. Vol. 99, p. 2489-2496 (2005) or the paper by Bhat et al. "Thermal Bonding of Polypropylene Nonwovens: Effect of Bonding Variables on the Structure and Properties of the Fabrics", J. Applied Polym. Sci., Vol. 92, p. 3593-3600 (2004). The two rolls are referred to as "embossing" and S rolls. In a typical trial, after establishing stable spinning conditions, the calender temperature was varied to create the bonding curve (i.e., tensile strength versus calender temperature). Bonding temperatures varied for the embossed roll from 140° to 155° C and temperatures for the S roll varied from 137° to 152° degrees C. Spinnability of the inventive and comparison compositions was assessed to be excellent.

[0081] Tensile properties of nonwoven fabrics such as tensile strength in both machine (MD) and cross (CD) directions were measured according to standard method WSP 110.4 (05) with a gauge length of 200 mm and a testing speed of 100 mm/min, unless otherwise indicated. The width of the fabric specimen was 5 cm. For the tensile testing, an Instron machine was used (Model 5565) equipped with Instron Bluehill 2 (version 2.5) software for the data analysis.

[0082] Softness or "handle" as it is known in the art is measured using the Thwing-Albert Instruments Co. Handle-O-Meter (Model 211-10-B/AERGLA). The quality of "handle" is considered to be the combination of resistance due to the surface friction and flexibility of a fabric material. The Handle-O-Meter measures the above two factors using an LVDT (Linear Variable Differential Transformer) to detect the resistance that a blade encounters when forcing a specimen of material into a slot of parallel edges. A 3 1/2 digit digital voltmeter (DVM) indicates the resistance directly in gram force. The "handle" of a given fabric is defined as the average of 8 readings taken on two fabric specimens (4 readings per specimen). For each test specimen (5 mm slot width), the handle is measured on both sides and both directions (MD and CD) and is recorded in grams. A decrease in "handle" indicates the improvement of fabric softness.

[0083] Coefficient of friction (COF) can decrease with increasing amounts of PBE. Decreasing values of COF indicate that the surface is more for silk-like or has less of a rubbery feeling. The coefficient of friction (COF) of a sheet or nonwoven product is a measure of the ability of the sheet to slide over itself or other surfaces. The TMI Monitor/Slip and Friction Tester, Model 32-06-00 was used to test the coefficient of starting friction (static friction) and the sliding friction (kinetic friction) between two sheet specimens or between a sheet specimen and an alternative substrate. The sled has the following dimensions, B-sled - 2.5" x 2.5" 200± 5 grams. The tester used a 0 - 1200 grams load cell.

[0084] The COF can be drastically altered by the use of additives. These additives sometimes bloom or exude to the surface making the sheet product more or less slippery. The blooming action may not always be uniform over the film surface. Those skilled in the art will appreciate that the value can be affected by the amount of slip additive incorporated. COF is dependent on the rate of motion between two surfaces. Care must be exercised to ensure that the rate of motion of the equipment is controlled. Since COF is a surface phenomenon, films produced by different processes, or under different conditions may give different results. These factors must be considered when evaluating the results.

EP 3 880 875 B1

Table 1

	PBE %	PAO %	PP %	Slip Additive (ppm)	Bonding Temperature °C	Static COF	Kinetic COF	Handle (grams)
5	0	0	100	0	145	0.50	0.37	12.2
	5	0	95	0	145	0.45	0.36	11.9
	5	5	90	0	145	0.47	0.36	6.5
	5	10	85	0	145	0.51	0.42	4.7
10	5	13.2	81.8	0	145	0.52	0.38	4.4
	10	0	90	0	145	0.52	0.44	10.0
	10	5	85	0	145	0.60	0.53	6.3
15	10	10	80	0	145	0.47	0.36	4.3
	10	13.2	76.8	0	145	0.49	0.39	4.1
	15	0	85	0	145	0.52	0.41	9.6
	15	5	80	0	145	0.70	0.61	5.7
20	15	10	75	0	145	0.48	0.39	4.3
	15	13.2	71.8	0	145	0.47	0.37	4.4

Table 2

	PBE %	PAO %	PP %	Slip Additive (ppm)	Bonding Temperature °C	Static COF	Kinetic COF	Handle (grams)
25	0	0	100	0	150	0.48	0.41	13.3
	5	0	95	0	150	0.43	0.35	12.4
30	5	5	90	0	150	0.31	0.24	7.3
	5	10	85	0	150	0.38	0.31	4.8
	5	13.2	81.8	0	150	0.43	0.34	4.7
35	10	0	90	0	150	0.50	0.43	11.3
	10	5	85	0	150	0.59	0.52	8.0
	10	10	80	0	150	0.37	0.30	5.2
	10	13.2	76.8	0	150	0.51	0.38	4.7
40	15	0	85	0	150	0.52	0.44	10.7
	15	5	80	0	150	0.68	0.57	8.0
	15	10	75	0	150	0.47	0.37	5.6
45	15	13.2	71.8	0	150	0.46	0.37	4.6

Table 3

	PBE %	PAO %	PP %	Slip Additive (ppm)	Bonding Temperature °C	Static COF	Kinetic COF	Handle (grams)
50	0	0	98	2000	145	0.43	0.29	10.4
	5	0	93	2000	145	0.39	0.28	9.4
	5	5	88	2000	145	0.32	0.24	7.1
55	5	10	83	2000	145	0.40	0.31	4.6
	5	13.2	79.8	2000	145	0.40	0.33	4.3

(continued)

	PBE %	PAO %	PP %	Slip Additive (ppm)	Bonding Temperature °C	Static COF	Kinetic COF	Handle (grams)
5	10	0	88	2000	145	0.40	0.26	8.7
	10	5	83	2000	145	0.30	0.22	7.0
	10	10	78	2000	145	0.39	0.32	5.0
10	10	13.2	74.8	2000	145	0.43	0.36	3.6
	15	0	83	2000	145	0.36	0.27	7.8
	15	5	78	2000	145	0.34	0.24	6.0
	15	10	73	2000	145	0.41	0.34	4.2
15	15	13.2	69.8	2000	145	0.44	0.36	3.5

Table 4

	PBE %	PAO %	PP %	Slip Additive (ppm)	Bonding Temperature °C	Static COF	Kinetic COF	Handle (grams)
20	0	0	98	2000	150	0.40	0.28	11.4
	5	0	93	2000	150	0.41	0.27	9.6
25	5	5	88	2000	150	0.55	0.47	6.6
	5	10	83	2000	150	0.47	0.36	5.6
	5	13.2	79.8	2000	150	0.51	0.38	4.5
	10	0	88	2000	150	0.35	0.25	8.8
30	10	5	83	2000	150	0.32	0.25	5.9
	10	10	78	2000	150	0.47	0.36	4.9
	10	13.2	74.8	2000	150	0.45	0.36	4.3
35	15	0	83	2000	150	0.36	0.25	8.3
	15	5	78	2000	150	0.32	0.24	6.4
	15	10	73	2000	150	0.34	0.25	6.4
	15	13.2	69.8	2000	150	0.35	0.26	3.5

[0085] Certain embodiments and features have been described using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges including the combination of any two values, e.g., the combination of any lower value with any upper value, the combination of any two lower values, and/or the combination of any two upper values are contemplated unless otherwise indicated. Certain lower limits, upper limits and ranges appear in one or more claims below. All numerical values are "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[0086] Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent.

[0087] While the foregoing is directed to certain embodiments, other and further embodiments may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A fiber comprising:

at least one primary polypropylene having a heat of fusion of at least 80 J/g as determined according to the method

in the description,

at least one polyalphaolefin having a viscosity index of at least 120 as determined according to ASTM D2270, and at least one propylene-based elastomer having a heat of fusion less than about 80 J/g as determined according to the method in the description,

wherein the propylene-based elastomer comprises greater than 50 wt % propylene and from about 3 to about 25 wt % units derived from one or more C_2 or C_4 - C_{12} α -olefins, based on a total weight of the propylene-based elastomer, and

wherein the fiber comprises 50 wt% to 98 wt% of the primary polypropylene; 1 wt% to 20 wt% of the propylene-based elastomer; and 1 wt% to 20 wt% of the polyalphaolefin, based on a combined weight of the primary polypropylene, the polyalphaolefin, and the propylene-based elastomer.

2. The fiber of claim 1, wherein the primary polypropylene is produced by using a Ziegler-Natta catalyst system.
3. The fiber of claim 1, wherein the primary polypropylene has a M_w/M_n within a range from 3 to 4.5, as determined by GPC.
4. The fiber of claim 1, wherein the primary polypropylene has a melt flow rate of 10 dg/min to 250 dg/min, as determined in accordance with ASTM 1238, 2.16 kg at 230°C.
5. The fiber of claim 1, wherein the propylene-based elastomer has a triad tacticity greater than about 90%, as measured by ^{13}C NMR.
6. The fiber of claim 1, where the propylene-based elastomer is a reactor blend of a first polymer component and a second polymer component.
7. The fiber of claim 6, where the first polymer component comprises propylene and ethylene and has an ethylene content of greater than 10 wt %, based on a total weight of the first polymer component, and where the second polymer component comprises propylene and ethylene and has an ethylene content of greater than 2 wt %, based on a total weight of the second polymer component.
8. A nonwoven composition comprising the fibers of claim 1.

Patentansprüche

1. Faser, umfassend:

mindestens ein primäres Polypropylen mit einer Schmelzwärme von mindestens 80 J/g, bestimmt gemäß dem in der Beschreibung angegebenen Verfahren,

mindestens ein Polyalphaolefin mit einem Viskositätsindex von mindestens 120, bestimmt gemäß ASTM D2270, und

mindestens ein Elastomer auf Propylenbasis mit einer Schmelzwärme von weniger als etwa 80 J/g, bestimmt nach dem in der Beschreibung angegebenen Verfahren,

wobei das Elastomer auf Propylenbasis, bezogen auf das Gesamtgewicht des Elastomers auf Propylenbasis, mehr als 50 Gew.-% Propylen- und etwa 3 bis etwa 25 Gew.-% Einheiten umfasst, die von einem oder mehreren C_2 - oder C_4 - C_{12} - α -Olefinen abgeleitet sind, und

wobei die Faser 50 Gew.-% bis 98 Gew.-% des primären Polypropylens, 1 Gew.-% bis 20 Gew.-% des Elastomers auf Propylenbasis und 1 Gew.-% bis 20 Gew.-% des Polyalphaolefins umfasst, bezogen auf ein kombiniertes Gewicht des primären Polypropylens, des Polyalphaolefins und des Elastomers auf Propylenbasis.

2. Faser nach Anspruch 1, wobei das primäre Polypropylen unter Verwendung eines Ziegler-Natta-Katalysatorsystems hergestellt wird.
3. Faser nach Anspruch 1, wobei das primäre Polypropylen ein M_w/M_n im Bereich von 3 bis 4,5 aufweist, bestimmt mittels GPC.
4. Faser nach Anspruch 1, wobei das primäre Polypropylen eine Schmelzflussrate von 10 dg/min bis 250 dg/min aufweist, bestimmt gemäß ASTM 1238, 2,16 kg bei 230 °C.

5. Faser nach Anspruch 1, wobei das Elastomer auf Propylenbasis eine Triadentaktizität von mehr als etwa 90 % aufweist, gemessen mittels ^{13}C -NMR.
6. Faser nach Anspruch 1, wobei das Elastomer auf Propylenbasis eine Reaktor-Mischung aus einer ersten Polymerkomponente und einer zweiten Polymerkomponente ist.
7. Faser nach Anspruch 6, wobei die erste Polymerkomponente Propylen und Ethylen umfasst und einen Ethylengehalt von mehr als 10 Gew.-%, bezogen auf das Gesamtgewicht der ersten Polymerkomponente, aufweist, und wobei die zweite Polymerkomponente Propylen und Ethylen umfasst und einen Ethylengehalt von mehr als 2 Gew.-%, bezogen auf das Gesamtgewicht der zweiten Polymerkomponente, aufweist.
8. Vliesstoffzusammensetzung, umfassend die Fasern gemäß Anspruch 1.

Revendications

1. Fibre comprenant :

au moins un polypropylène primaire ayant une chaleur de fusion d'au moins 80 J/g comme déterminée selon le procédé décrit dans la description,

au moins une polyalphaoléfine ayant un indice de viscosité d'au moins 120 tel que déterminé selon la norme ASTM D2270, et

au moins un élastomère à base de propylène ayant une chaleur de fusion inférieure à environ 80 J/g comme déterminée selon le procédé décrit dans la description,

dans laquelle l'élastomère à base de propylène comprend plus de 50 % en poids de propylène et d'environ 3 à environ 25 % en poids de motifs dérivés d'une ou plusieurs α -oléfines en C_2 ou C_4 - C_{12} , sur la base du poids total de l'élastomère à base de propylène, et

dans laquelle la fibre comprend 50 % en poids à 98 % en poids du polypropylène primaire ; 1 % en poids à 20 % en poids de l'élastomère à base de propylène ; et 1 % en poids à 20 % en poids de la polyalphaoléfine, sur la base d'un poids combiné du polypropylène primaire, de la polyalphaoléfine et de l'élastomère à base de propylène.

2. Fibre selon la revendication 1, dans laquelle le polypropylène primaire est produit en utilisant un système de catalyseur Ziegler-Natta.

3. Fibre selon la revendication 1, dans laquelle le polypropylène primaire a un rapport Mw/Mn dans une plage de 3 à 4,5, tel que déterminé par GPC.

4. Fibre selon la revendication 1, dans laquelle le polypropylène primaire a un indice de fluidité à chaud de 10 dg/min à 250 dg/min, tel que déterminé selon la norme ASTM 1238, 2,16 kg à 230 °C.

5. Fibre selon la revendication 1, dans laquelle l'élastomère à base de propylène a une tacticité de triade supérieure à environ 90 %, telle que mesurée par RMN du ^{13}C .

6. Fibre selon la revendication 1, où l'élastomère à base de propylène est un mélange de réacteur d'un premier composant polymère et d'un second composant polymère.

7. Fibre selon la revendication 6, où le premier composant polymère comprend du propylène et de l'éthylène et a une teneur en éthylène supérieure à 10 % en poids, par rapport à un poids total du premier composant polymère, et où le second composant polymère comprend du propylène et de l'éthylène et présente une teneur en éthylène supérieure à 2 % en poids, par rapport à un poids total du second composant polymère.

8. Composition non tissée comprenant les fibres selon la revendication 1.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 7232871 B [0032]
- US 6881800 B [0046]
- US 7803876 B [0046]
- US 8013069 B [0046]
- US 8026323 B [0046]
- WO 2011087729 A [0046]
- WO 2011087730 A [0046]
- WO 2011087731 A [0046]
- US 3149178 A [0048]
- US 4827064 A [0048]
- US 4827073 A [0048]
- US 5171908 A [0048]
- US 5783531 A [0048]
- US 3849241 A [0072]
- US 6268203 B [0072]
- US 4340563 A [0074]
- US 3692618 A [0074]
- US 3802817 A [0074]
- US 3338992 A [0074]
- US 3341394 A [0074]
- US 3502763 A [0074]
- US 3542615 A [0074]
- EP 1340843 A [0079]
- US 6918750 B [0079]

Non-patent literature cited in the description

- **H. N. CHENG.** *MACROMOLECULES*, 1984, vol. 17, 1950-1955 [0033]
- Polymer Handbook. John Wiley and Sons, 1999 [0034]
- SYNTHETIC LUBRICANTS AND HIGH-PERFORMANCE FUNCTIONAL FLUIDS. Marcel Dekker, 1999, 3-52 [0048]
- SYNTHETIC LUBRICANTS AND HIGH-PERFORMANCE FUNCTIONAL FLUIDS. Marcel Dekker, Inc., 1999, 1-52 [0048]
- **MICHIELSON et al.** Review of Thermally Point-bonded Nonwovens: Materials, Processes, and Properties. *J. Applied Polym. Sci.*, 2005, vol. 99, 2489-2496 [0080]
- **BHAT et al.** Thermal Bonding of Polypropylene Nonwovens: Effect of Bonding Variables on the Structure and Properties of the Fabrics. *J. Applied Polym. Sci.*, 2004, vol. 92, 3593-3600 [0080]