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(54) Title: SPUNBOND NONWOVEN COMPRISING A MIXTURE OF FIBERS

(57) Abstract: Provided are spunbond nonwovens comprising a mixture of fibers, and a process for making a nonwoven. The nonwovens according to embodiments disclosed herein include a mixture of a first fiber and a second fiber. The first fiber includes an ethylene/ α -olefin multi-block interpolymer. The second fiber includes an ethylene-based polymer. The nonwovens can be compatible with polyethylene recycling streams and can exhibit improved or comparable characteristics, such as softness, elongation at maximum force, and donning force at 100% elongation.

SPUNBOND NONWOVEN COMPRISING A MIXTURE OF FIBERS

TECHNICAL FIELD

[0001] Embodiments of the present disclosure generally relate to spunbond nonwovens comprising a mixture of fibers.

INTRODUCTION

[0002] Nonwoven fabrics are cloth-like materials that are manufactured from filaments which are brought together via different bonding techniques (e.g., spunbond or meltblown processes). The demand for elastic nonwovens has risen considerably in recent years. Elastic nonwovens can include a mixture of fibers and be incorporated into a wide variety of products, including, for example, bandages, garments, and disposable hygiene products. The elastomeric components of the nonwovens can provide better fit, improve comfort, and prevent leakage of materials. Incumbent elastic nonwovens are based on mixed fiber spunbond technology that combines elastic thermoplastic polyurethane (TPU) and inelastic polypropylene fibers. These existing nonwovens, however, have several drawbacks. For example, they typically require activation (e.g., ring rolling or stretching) to unleash the elastic performance, and due to the presence of different polymeric materials, it can be challenging to optimize spinning conditions for the materials which results in different diameter fibers and an unattractive visual appearance. Elastic nonwovens can also be difficult to recycle due to including non-recycle compatible polymeric materials, and can exhibit poor characteristics, such as softness, elongation at maximum force, and donning force at 100% elongation.

SUMMARY

[0003] Embodiment of the present disclosure attempt to address the foregoing drawbacks in the art and provide spunbond nonwovens comprising a mixture of fibers that can exhibit comparable or improved characteristics, such as recyclability, softness, elongation at maximum force, and donning force at 100 % elongation.

[0004] Disclosed herein are spunbond nonwovens. In one aspect, the spunbond nonwoven comprises a mixture of a first fiber and a second fiber; the first fiber comprising an ethylene/ α -olefin multi-block interpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C;

the second fiber comprising an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and melt index (I_2) in the range of from 10 to 100 g/10 min; wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymers is less than 20°C.

[0005] Also disclosed herein are laminates. In one aspect, the laminates comprise the spunbond nonwoven according to embodiments disclosed herein.

[0006] Also disclosed herein are articles. In one aspect, the articles comprise the spunbond nonwoven according to embodiments disclosed herein.

[0007] Also disclosed herein are a process for making a nonwoven. In one aspect, the process for making a nonwoven comprises providing an ethylene/ α -olefin multi-block interpolymers having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C and an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and a melt index (I_2) in the range of from 10 to 100 g/10 min (as disclosed above), wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymers is less than 20°C; extruding each of the ethylene/ α -olefin multi-block interpolymers and the ethylene-based polymer through a spinneret having corresponding holes for extrusion of the ethylene/ α -olefin multi-block interpolymers and the ethylene-based polymer to form a mixture of at least a first fiber corresponding to the ethylene/ α -olefin multi-block interpolymers and a second fiber corresponding to the ethylene-based polymer; and forming the nonwoven.

[0008] These and other embodiments are described in more detail in the Detailed Description.

DETAILED DESCRIPTION

[0009] As used herein, the terms “comprising,” “including,” “having,” and their derivatives, are not intended to exclude the presence of any additional component, step or procedure, whether or not the same is specifically disclosed. In order to avoid any doubt, all compositions claimed through use of the term “comprising” may include any additional additive, adjuvant, or compound, whether polymeric or otherwise, unless stated to the contrary. In contrast, the term, “consisting essentially of” excludes from the scope of any succeeding recitation any other component, step or procedure, excepting those that are not essential to

operability. The term “consisting of” excludes any component, step or procedure not specifically delineated or listed.

[0010] As used herein, the term “interpolymer” refers to polymers prepared by the polymerization of at least two different types of monomers. The term interpolymer thus includes copolymers (employed to refer to polymers prepared from two different types of monomers), and polymers prepared from more than two different types of monomers.

[0011] As used herein, the term “polymer” means a polymeric compound prepared by polymerizing monomers, whether of the same or a different type. The term polymer thus embraces the term homopolymer (employed to refer to polymers prepared from only one type of monomer, with the understanding that trace amounts of impurities can be incorporated into the polymer structure), and the term interpolymer as defined above. Trace amounts of impurities (for example, catalyst residues) may be incorporated into and/or within the polymer. A polymer may be a single polymer or a polymer blend.

[0012] As used herein, the term “polyolefin” refers to a polymer that comprises, in polymerized form, a majority amount of olefin monomer, for example ethylene or propylene (based on the weight of the polymer), and optionally may comprise one or more comonomers

[0013] As used herein, the terms “polyethylene” or “ethylene-based polymer” shall mean polymers comprising a majority amount (>50 mol %) of units which have been derived from ethylene monomer. This includes polyethylene homopolymers, copolymers, and interpolymers.

[0014] As used herein, the terms “nonwoven,” “nonwoven web,” and “nonwoven fabric” are used herein interchangeably. “Nonwoven” refers to a web or fabric having a structure of individual fibers or threads which are randomly interlaid, but not in an identifiable manner as is the case for a knitted fabric.

[0015] As used herein, the term “spunbond” refers to the fabrication of nonwoven fabric generally includes the following steps: (a) extruding molten thermoplastic strands from a plurality of fine capillaries called a spinneret; (b) quenching the strands with a flow of air which is generally cooled in order to hasten the solidification of the molten strands; (c) attenuating the strands by advancing them through the quench zone with a draw tension that can be applied by either pneumatically entraining the stands in an air stream or by winding them around

mechanical draw rolls of the type commonly used in the textile fibers industry; (d) collecting the drawn strands into a web on a foraminous surface, e.g., moving screen or porous belt; and (e) bonding the web of loose strands into a nonwoven fabric. Bonding can be achieved by a variety of means including, but not limited to, thermo-calendaring process, adhesive bonding process, hot air bonding process, needle punch process, hydroentangling process, and combinations thereof.

[0016] As used herein, the term “meltblown” refers to the fabrication of nonwoven fabrics via a process which generally includes the following steps: (a) extruding molten thermoplastic strands from a spinneret; (b) simultaneously quenching and attenuating the polymer stream immediately below the spinneret using streams of high velocity heated air; (c) collecting the drawn strands into a web on a collecting surface. Meltblown webs can be bonded by a variety of means including, but not limited to, autogeneous bonding, i.e., self bonding without further treatment, thermo-calendaring process, adhesive bonding process, hot air bonding process, needle punch process, hydroentangling process, and combinations thereof.

[0017] As used herein, the terms “alpha-olefin” or “ α -olefin” refers to a hydrocarbon molecule or a substituted hydrocarbon molecule (i.e., a hydrocarbon molecule comprising one or more atoms other than hydrogen and carbon, e.g., halogen, oxygen, nitrogen, etc.), the hydrocarbon molecule comprising (i) only one ethylenic unsaturation, this unsaturation located between the first and second carbon atoms, and (ii) at least 2 carbon atoms, preferably of 3 to 20 carbon atoms, in some cases preferably of 4 to 10 carbon atoms and in other cases preferably of 4 to 8 carbon atoms. Nonlimiting examples of α -olefins include ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-dodecene, and mixtures of two or more of these monomers.

[0018] The spunbond nonwoven according to embodiments disclosed herein comprises a mixture of a first fiber and a second fiber. The first fiber comprises an ethylene/ α -olefin multi-block interpolpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C. The second fiber comprises an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and melt index (I_2) in the range of from 10 to 100 g/10 min, wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolpolymer is less than 20°C. In some embodiments, the difference between the crystallization point of the ethylene based polymer and the ethylene/ α -olefin multi-block interpolpolymer is less than 20°C.

[0019] The spunbond nonwoven according to embodiments disclosed herein has at least two different fibers, a first fiber and a second fiber. In some embodiments, the spunbond nonwoven has more than two different fibers (e.g., three different fibers, four different fibers, or five different fibers).

First Fiber

[0020] The spunbond nonwoven according to embodiments disclosed herein comprises a mixture of a first fiber and a second fiber. The first fiber comprises an ethylene/ α -olefin multi-block interpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C.

[0021] The term “ethylene/ α -olefin multi-block interpolymer”, also called “olefin block copolymer (OBC)” as used herein, refers to an interpolymer that includes ethylene and one or more copolymerizable α -olefin comonomers in polymerized form, characterized by multiple blocks or segments of two or more (preferably three or more) polymerized monomer units, the blocks or segments differing in chemical or physical properties. Specifically, this term refers to a polymer comprising two or more (preferably three or more) chemically distinct regions or segments (referred to as “blocks”) joined in a linear manner, that is, a polymer comprising chemically differentiated units which are joined (covalently bonded) end-to-end with respect to polymerized functionality, rather than in pendent or grafted fashion. The blocks differ in the amount or type of comonomer incorporated therein, the density, the amount of crystallinity, the type of crystallinity (e.g., polyethylene versus polypropylene), the crystallite size attributable to a polymer of such composition, the type or degree of tacticity (isotactic or syndiotactic), region-regularity or region-irregularity, the amount of branching, including long chain branching or hyper-branching, the homogeneity, and/or any other chemical or physical property. The block copolymers are characterized by unique distributions of both polymer polydispersity (PDI or M_w/M_n) and block length distribution, e.g., based on the effect of the use of a shuttling agent(s) in combination with catalyst systems. Non-limiting examples of the olefin block copolymers of the present disclosure, as well as the processes for preparing the same, are disclosed in PCT/US20/66870; PCT/US20/66896; WO 2018/170208; WO 2018/170227; WO 2018/170248; WO 2018/170138; WO 2018/170056; and U.S. Patent Nos. 7,858,706 B2, 8,198,374 B2, 8,318,864 B2, 8,609,779 B2, 8,710,143 B2, 8,785,551 B2, and 9,243,090 B2, which are all incorporated herein by reference in their entirety.

[0022] Ethylene/ α -olefin multi-block interpolymers are characterized by multiple blocks or segments of two or more polymerized monomer units, differing in chemical or physical properties.

[0023] In some embodiments, the multi-block copolymers can be represented by the following formula: $(AB)_n$, where n is at least 1, preferably an integer greater than 1, such as 2, 3, 4, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, or higher. Here, “A” represents a hard block or segment, and “B” represents a soft block or segment. Preferably the A segments and the B segments are linked in a substantially linear fashion, as opposed to a substantially branched or substantially star-shaped fashion. In other embodiments, the A segments and the B segments are randomly distributed along the polymer chain. In other words, for example, the block copolymers usually do not have a structure as follows: AAA-AA-BBB-BB. In still other embodiments, the block copolymers do not usually have a third type of block or segment, which comprises different comonomer(s). In yet other embodiments, each of block A and block B has monomers or comonomers substantially randomly distributed within the block. In other words, neither block A nor block B comprises two or more sub-segments (or sub-blocks) of distinct composition, such as a tip segment, which has a substantially different composition than the rest of the block.

[0024] The olefin block copolymers, in general, are produced via a chain shuttling process, such as, for example, described in U.S. Patent 7,858,706, which is herein incorporated by reference. Some chain shuttling agents and related information are listed in Col. 16, line 39, through Col. 19, line 44. Some catalysts are described in Col. 19, line 45, through Col. 46, line 19, and some co-catalysts in Col. 46, line 20, through Col. 51 line 28. Some process features are described in Col 51, line 29, through Col. 54, line 56. See also the following: U.S. Patent 7,608,668; U.S. Patent 7,893,166; and U.S. Patent 7,947,793 as well as US Patent Publication 2010/0197880. See also U.S. Patent 9,243,173.

[0025] Preferably, ethylene comprises the majority mole fraction of the whole ethylene/ α -olefin multi-block copolymer, i.e., ethylene comprises at least 50 wt% of the whole ethylene/ α -olefin multi-block copolymer. More preferably, ethylene comprises at least 60 wt%, at least 70 wt%, or at least 80 wt%, with the substantial remainder of the whole ethylene/ α -olefin multi-block interpolpolymer comprising the C4–C8 α -olefin comonomer, preferably, the C4–C8 α -olefin comonomer may be selected from 1-butene, 1-hexene, and 1-octene. In an embodiment, the ethylene/ α -olefin multi-block interpolpolymer contains from 50 wt%, or 60 wt%, or 65 wt% to 80

wt%, or 85 wt%, or 90 wt% ethylene. For many ethylene/octene multi-block interpolymers, the composition comprises an ethylene content greater than 80 wt% of the whole ethylene/octene multi-block interpolymers and an octene content of from 10 wt% to 15 wt%, or from 15 wt% to 20 wt% of the whole ethylene/octene multi-block interpolymers.

[0026] The ethylene/ α -olefin multi-block copolymer includes various amounts of “hard” segments and “soft” segments. “Hard” segments are blocks of polymerized units in which ethylene is present in an amount greater than 90 wt%, or 95 wt%, or greater than 95 wt%, or greater than 98 wt%, based on the weight of the polymer, up to 100 wt%. In other words, the comonomer content (content of monomers other than ethylene) in the hard segments is less than 10 wt%, or 5 wt%, or less than 5 wt%, or less than 2 wt%, 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 wt%, or greater than 8 wt%, or greater than 10 wt%, or greater than 15 wt%, based on the weight of the polymer. In an embodiment, the comonomer content in the soft segments is greater than 20 wt%, or greater than 25 wt%, or greater than 30 wt%, or greater than 35 wt%, or greater than 40 wt%, or greater than 45 wt%, or greater than 50 wt%, or greater than 60 wt% and can be up to 100 wt%.

[0027] The soft segments can be present in an ethylene/ α -olefin multi-block interpolymers from 1 wt%, or 5 wt%, or 10 wt%, or 15 wt%, or 20 wt%, or 25 wt%, or 30 wt%, or 35 wt%, or 40 wt%, or 45 wt% to 55 wt%, or 60 wt%, or 65 wt%, or 70 wt%, or 75 wt%, or 80 wt%, or 85 wt%, or 90 wt%, or 95 wt%, or 99 wt% of the total weight of the ethylene/ α -olefin multi-block interpolymers. Conversely, the hard segments can be present in similar ranges. The soft segment weight percentage and the hard segment weight percentage can be calculated based on data obtained from DSC or NMR. Such methods and calculations are disclosed in, for example, USP 7,608,668, the disclosure of which is incorporated by reference herein in its entirety. In particular, hard and soft segment weight percentages and comonomer content may be determined as described in column 57 to column 63 of USP 7,608,668.

[0028] In some embodiments, the ethylene/ α -olefin multi-block copolymer is produced in a continuous process and possesses a polydispersity index (M_w/M_n) from 1.7 to 3.5, or from 1.8 to 3, or from 1.8 to 2.5, or from 1.8 to 2.2. When produced in a batch or semi-batch process,

the ethylene/ α -olefin multi-block copolymer possesses Mw/Mn 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.

[0029] Nonlimiting examples of suitable ethylene/ α -olefin multi-block copolymer are disclosed in U.S. Patent No. 7,608,668, the entire content of which is incorporated by reference herein.

[0030] In some embodiments, the ethylene/ α -olefin multi-block copolymer has hard segments and soft segments, is styrene-free, consists of only (i) ethylene and (ii) a C4–C8 α -olefin, and is defined as having a Mw/Mn from 1.7 to 3.5.

[0031] In some embodiments, the ethylene/ α -olefin multi-block interpolymer has a density from 0.860 to 0.885 g/cc. All individual values and subranges of from 0.860 to 0.885 g/cc are included and disclosed herein. For example, the ethylene/ α -olefin multi-block interpolymer can have density of from 0.860 to 0.883 g/cc, or from 0.861 to 0.882 g/cc or from 0.862 to 0.880 g/cc.

[0032] In some embodiments, the ethylene/ α -olefin multi-block interpolymer has a melt index (I_2) in the range of from 10 to 100 g/10 min. All individual values and subranges of from 10 to 100 g/10 min are disclosed and included herein. For example, the ethylene/ α -olefin multi-block interpolymer can have a melt index (I_2) in the range of from 10 to 100 g/10 min, from 10 to 90 g/10 min, from 10 to 80 g/10 min, from 10 to 70 g/10 min, from 10 to 60 g/10 min, from 10 to 50 g/10 min, from 10 to 40 g/10 min, from 10 to 30 g/10 min, or from 10 to 20 g/10 min.

[0033] In some embodiments, the ethylene/ α -olefin multi-block interpolymer has a melting point in the range of from 115 to 125°C. All individual values and subranges of from 115 to 125°C are disclosed and included herein. For example, the ethylene/ α -olefin multi-block interpolymer can have a melting point in the range of from 115 to 124°C, from 115 to 122°C, from 115 to 120°C, from 115 to 119°C, from 116 to 125°C, from 116 to 123°C, from 116 to 121°C, from 116 to 119°C, from 117 to 125°C, from 117 to 123°C, from 117 to 122°C. Melting point can be measured in accordance with the DSC test method described below.

[0034] Suitable ethylene/ α -olefin multi-block interpolymers that can be used in embodiments include those under the name INFUSE™ (commercially available from the Dow Chemical Company), including, for example, INFUSE™ 9817.

[0035] In some embodiments, the first fiber is void of an ethylene-based random copolymer.

Second Fiber

[0036] The spunbond nonwoven according to embodiments disclosed herein comprises a mixture of a first fiber and a second fiber. The second fiber comprises an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and melt index (I_2) in the range of from 10 to 100 g/10 min; wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C.

[0037] In some embodiments, the ethylene-based polymer has a density of from 0.930 to 0.970 g/cc. All individual values and subranges of from 0.930 to 0.970 g/cc are disclosed and included herein. For example, the ethylene-based polymer can have a density of from 0.930 to 0.960 g/cc, from 0.930 to 0.955 g/cc, from 0.930 to 0.950 g/cc, from 0.930 to 0.945 g/cc, or from 0.930 to 0.940 g/cc.

[0038] In some embodiments, the ethylene-based polymer has a melt index (I_2) in the range of from 10 to 100 g/10 min. All individual values and subranges of from 10 to 100 g/10 min are disclosed and included herein. For example, the ethylene-based polymer can have a melt index (I_2) in the range of from 10 to 100 g/10 min, from 10 to 90 g/10 min, from 10 to 80 g/10 min, from 10 to 70 g/10 min, from 10 to 60 g/10 min, from 10 to 50 g/10 min, from 10 to 40 g/10 min, from 10 to 30 g/10 min, or from 10 to 20 g/10 min.

[0039] In some embodiments, the ethylene-based polymer has a melting point from 120°C to 135°C, or from 122°C to 133°C, or from 123°C to 130°C.

[0040] In some embodiments, the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C. All individual values and subranges of less than 20°C are disclosed and included herein. For example, the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer can be less than 18°C, less than 16°C, less than 15°C, less than 14°C, less than 12°C, less than 10°C, less than 8°C, less than 6°C or can be in the range of from 0 to 20°C, from 1 to 15°C, from 2 to 12°C, or from 3 to 10°C. Melting point can be measured in accordance with the DSC test method described below.

[0041] In some embodiments, the difference between the crystallization temperature (T_c) of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C. All individual values and subranges of less than 20°C are disclosed and included herein. For example, the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer can be less than 20°C, less than 16°C, less than 12°C, less than 10°C, or can be in the range of from 0 to 15°C, from 1 to 14°C, from 2 to 12°C, or from 4 to 10°C. Crystallization temperature (T_c) can be measured in accordance with the DSC test method described below. Matching the temperatures at which the individual fibers set up and solidify by crystallization is advantageous for the present invention.

[0042] Suitable ethylene-based polymers that can be used in embodiments include those under the name ASPUNTM (commercially available from the Dow Chemical Company), including for example, ASPUNTM 6000.

[0043] Without being bound by theory, it has been found that block segments of the ethylene/ α -olefin multi-block interpolymer disclosed herein works as a crosslinking point and contributes to better elastic properties than olefin random copolymers, and with this, the segments can display higher melting points and provides higher heat resistance (e.g., higher use temperature, better body and temperature creep resistance) compared to olefin random copolymers, which likewise contributes to better elastic properties when mixed with ethylene-based fibers as disclosed herein.

Nonwoven

[0044] The spunbond nonwoven disclosed herein can be formed by methods known to those skilled in the art, based upon the teachings disclosed herein. See, for example, US Patent No. 7700504 and US Patent No. 8053074, both of which are incorporated by reference herein in their entirety, and both of which describe nonwovens comprising a mixture of fibers. A spinneret as shown in FIG. 1 of US Patent No. 7700504 can be used to form the spunbond nonwoven. The spinneret can have spinning holes for different resins arranged in a staggered manner. The content of the first fiber and the second fiber in the spunbond nonwoven can be modified by changing the number of holes in the spinneret allocated to the resins of the first fiber or second fiber or by controlling the extrusion rate of each resin. A mixture of fibers with different fineness can be manufactured by spinning each resin at different extrusion rates

through the spinning holes allocated, or by spinning through spinnerets with different opening shapes or diameters.

[0045] A process for making a nonwoven according to embodiments disclosed herein is also disclosed. The process comprising providing an ethylene/ α -olefin multi-block interpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C and an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and a melt index (I_2) in the range of from 10 to 100 g/10 min (as disclosed above), wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C; extruding each of the ethylene/ α -olefin multi-block interpolymer and the ethylene-based polymer through a spinneret having corresponding holes for extrusion of the ethylene/ α -olefin multi-block interpolymer and the ethylene-based polymer to form a mixture of at least a first fiber corresponding to the ethylene/ α -olefin multi-block interpolymer and a second fiber corresponding to the ethylene-based polymer; and forming a nonwoven. In some embodiments, the process comprises one or more of the following steps: quenching the mixture of fibers with a flow of air; attenuating the mixture of fibers by advancing them through a quench zone with a draw tension; collecting an attenuated mixture of fibers into a web on a foraminous surface; and bonding the mixture of fibers into a nonwoven fabric. Bonding can be achieved by a variety of means including, but not limited to, thermo-calendaring process, adhesive bonding process, hot air bonding process, needle punch process, hydroentangling process, and combinations thereof.

[0046] In some embodiments, the ratio of the first fiber to the second fiber in the nonwoven is in the range of from 95/5 to 5/95, or 90/10 to 10/90, 80/20 to 20/80, or from 70/30 to 30/70, or from 60/40 to 40/60.

[0047] In some embodiments, the first fiber and the second fiber have a fiber diameter in the range of from 10 to 50 micron (also referred to as micrometer or μm). All individual values of from 10 to 50 micron are disclosed and included herein. For example, the first fiber and the second fiber in the nonwoven can have a fiber diameter in the range of from 10 to 50 micron, from 15 to 45 micron, from 20 to 40 micron, or from 20 to 35 micron.

[0048] In some embodiments, the nonwoven has a basis weight in the range of from 15 to 250 grams per square meter (gsm). All individual values and subranges of from 15 to 250 gsm

are included and disclosed herein. For example, the nonwoven can have a basis weight in the range of from 15 to 250 gsm, from 25 to 225 gsm, from 40 to 200 gsm, or from 50 to 175 gsm.

[0049] In some embodiments, the nonwoven comprises at least 95 wt.% ethylene-based polymers, or at least 97 wt.% ethylene-based polymers, or at least 99 wt.% ethylene-based polymers, or at least 99 wt.% ethylene-based polymers or at least 99.9 wt.% ethylene-based polymer, based on the total weight of the polymers in the nonwoven. In some embodiments, the nonwoven consists of ethylene-based polymers. The nonwoven comprising a ethylene-based polymers makes it so it can be more suitable for recyclability in polyethylene recycling streams. In some embodiments, the nonwoven is void of polymers other than polyethylene, or void of polypropylene based polymers. The nonwoven disclosed here in can exhibit improved or maintained properties while being formed from a majority or nearly all ethylene-based polymers.

[0050] In some embodiments, the nonwoven has a stretch ratio between 2:1 and 5:1, or between 2:1 and 4:1.

Laminates

[0051] Spunbond nonwovens of various embodiments described herein can be used to form laminates. Such laminates can be formed from any of the nonwovens described herein.

[0052] Laminates may include the nonwovens of various embodiments in adhering contact with one or more additional nonwovens or one or more films. For example, a nonwoven of one or more embodiments described hereinabove may be adhered to a film. The film may include, for example, polyethylene, polyamide, polyethylene terephthalate, polypropylene, or combinations thereof.

Articles

[0053] Nonwovens or laminates of the present invention can be used to form articles, such as bandages, garments, and disposable hygiene products. Such articles can be formed from any

of the nonwovens or laminates described herein and can be formed using techniques known to those of skill in the art based on the teachings herein.

TEST METHODS

Density

[0054] Density is measured in accordance with ASTM D-792, and expressed in grams/cc (g/cm^3).

Melt Index (I_2)

[0055] Melt Index is measured in accordance with ASTM D 1238 at 190° Celsius and 2.16 kg, and is expressed in grams eluted/10 minutes (g/10 min).

Differential Scanning Calorimetry (DSC) / Crystallization and Melting Point

[0056] Differential Scanning Calorimetry (DSC) is used to measure the melting and crystallization behavior of a polymer over a wide range of temperatures. For example, the TA Instruments Q1000 DSC, equipped with an RCS (refrigerated cooling system) and an autosampler is used to perform this analysis. The instrument is first calibrated using the software calibration wizard. A baseline is obtained by heating a cell from -80°C to 280°C without any sample in an aluminum DSC pan. Sapphire standards are then used as instructed by the calibration wizard. Next, 1 to 2 milligrams (mg) of a fresh indium sample are analyzed by heating the standards sample to 180°C, cooling to 120°C at a cooling rate of 10°C/minute, and then keeping the standards sample isothermally at 120°C for 1 minute. The standards sample is then heated from 120°C to 180°C at a heating rate of 10°C/minute. Then, it is determined that indium standards sample has heat of fusion (H_f) = 28.71 ± 0.50 Joules per gram (J/g) and onset of melting = $156.6^\circ\text{C} \pm 0.5^\circ\text{C}$. Test samples are then analyzed on the DSC instrument.

[0057] During testing, a nitrogen purge gas flow of 50 ml/min is used. Each sample is melt pressed into a thin film at about 175°C; the melted sample is then air-cooled to room temperature (approx. 25°C). The film sample is formed by pressing a “0.1 to 0.2 gram” sample at 175°C at 1,500 psi, and 30 seconds, to form a “0.1 to 0.2 mil thick” film. A 3-10 mg, 6 mm diameter specimen is extracted from the cooled polymer, weighed, placed in a light aluminum

pan (ca 50 mg), and crimped shut. Analysis is then performed to determine its thermal properties.

[0058] The thermal behavior of the sample is determined by ramping the sample temperature up and down to create a heat flow versus temperature profile. First, the sample is rapidly heated to 180°C, and held isothermal for five minutes, in order to remove its thermal history. Next, the sample is cooled to -40°C, at a 10°C/minute cooling rate, and held isothermal at -40°C for five minutes. The sample is then heated to 150°C (this is the “second heat” ramp) at a 10°C/minute heating rate. The cooling and second heating curves are recorded. The cool curve is analyzed by setting baseline endpoints from the beginning of crystallization to -20°C. The heat curve is analyzed by setting baseline endpoints from -20°C to the end of melt. The values determined are highest peak melting temperature (T_m), highest peak crystallization temperature (T_c), onset crystallization temperature ($T_{c\text{ onset}}$), heat of fusion (H_f) (in Joules per gram), and the calculated % crystallinity for polyethylene samples using: % Crystallinity for PE = $((H_f)/(292 \text{ J/g})) \times 100$, and the calculated % crystallinity for polypropylene samples using: % Crystallinity for PP = $((H_f)/(165 \text{ J/g})) \times 100$. The heat of fusion (H_f) and the highest peak melting temperature are reported from the second heat curve. Highest peak crystallization temperature and onset crystallization temperature are determined from the cooling curve. The highest peak melting temperature (T_m) is the “melting point” (as that term is used herein) of the sample.

[0059] Tensile properties of the spunbond non-wovens

[0060] The tensile properties of the non-wovens are measured on an extensometer with a load cell of 100N on 50 x 250 mm specimen, with a grip distance of 100mm, at a test speed of 200 mm/min, in machine and cross direction. Maximum tensile strength in the machine direction (MD) and traverse direction (TD) in Newtons (N) is reported, as well as strain at break in the MD and TD, reported in percentage (%).

[0061] Elastic properties of the spunbond non-wovens

[0062] The elastic properties of the spunbond non-wovens are measured on an extensometer with a load cell of 100 N on 100 x 25 mm specimen, with a grip distance of 25 mm, at a test speed of 125 mm/min in MD. The hysteresis cycle is measured as following:

[0063] First cycle: stretch to 100% extension, 30 sec holding time at 100% extension, return at 0% extension, 60 sec holding time at 0% extension. The permanent set is measured when reaching a 0.1N tensile strength after the holding time at 0%.

[0064] Second cycle: stretch to 100% extension, 30 sec holding time at 100% extension, return at 0% extension, 60 sec holding time at 0% extension. The permanent set is measured when reaching a 0.1N tensile strength after the holding time at 0%.

[0065] Pre-stretching of the nonwovens at 2:1 in machine direction: 150mm x 50mm specimens are stretched to 100% elongation in machine direction (100mm grip distance extend to 200mm) at 125 mm/min extension speed and hold at the position for 30 sec. The specimens then return to original length at 125 mm/min speed. The specimen of 100 mm x 25 mm are cut out from these samples for hysteresis measurements. The different parameters reported from the hysteresis curve from the first and second cycle are:

- Force at 50% of extension (N)
 - Maximum force at 100% extension (N)
 - Force at 50% of retraction (N)
 - Ratio of Force at 50% of extension / Force at 50% of retraction (50%E/50%R)
- Permanent set at 0.1N after 60s of holding time at 0% extension (%)

EXAMPLES

[0066] Examples of spunbond nonwovens according to the embodiments disclosed herein are formed and tested as described herein.

[0067] INFUSE™ 9817 (“INFUSE”) – is an ethylene/ α -olefin multi-block interpolymer having a density of 877 g/cc, a melt index (I_2) of 15 g/10 min, a melting point of 120°C, and a crystallization temperature (T_c) of 103°C.

[0068] ASPUN™ 6000 (“ASPUN”) – is an ethylene-based polymer having a density of 0.935 g/cc, and a melt index (I_2) of 19 g/10 min, a melting point of 125°C, and a crystallization temperature (T_c) of 113 °C.

[0069] PP 511A from Sabic is a homopolypropylene with a melt flow rate of 25 g/10 min (measured at 230 °C), a melting point of around 160°C, and 0.900 g/cc density is used in Comparative Example 3.

[0070] Composition of the spunbond non-wovens

[0071] Inventive Example 1 (IE1) is a spunbond nonwoven formed from a mixture of two fibers (75 wt.% of INFUSE™ 9817 and 25 wt.% of ASPUN™ 6000 - 75/25 ratio). IE1 has a basis weight of 60 gsm.

[0072] Comparative Example 1 (CE1) is a spunbond nonwoven formed from a core/sheath bicomponent fiber having a core of 75 wt.% INFUSE™ 9817 and sheath of 25 wt.% ASPUN™ 6000.

[0073] Inventive Example 2 (IE2) is a spunbond nonwoven formed from a mixture of two fibers (90 wt.% of INFUSE™ 9817 and 10 wt.% of ASPUN™ 6000 - 90/10 ratio). IE2 has a basis weight of 100 gsm.

[0074] Comparative Example 2 (CE2) is a spunbond nonwoven formed from a core/sheath bicomponent fiber having a core of 90 wt.% INFUSE™ 9817 and sheath of 10 wt.% ASPUN™ 6000.

[0075] Inventive Example 3 (IE3) is a spunbond nonwoven formed from a mixture of two fibers (60 wt.% of INFUSE™ 9817 and 40 wt.% of ASPUN™ 6000 - 60/40 ratio). IE3 has a basis weight of 60 gsm.

[0076] Comparative Example 3 (CE3) is a spunbond nonwoven formed from a mixture of fibers (60 wt.% of INFUSE™ 9817 and 40 wt.% of Sabic PP 511A Polypropylene - 60/40 ratio).

[0077] Table 1. Composition of the spunbond non-wovens

	CE 1	CE 2	CE 3	IE 1	IE 2	IE 3
Material A	INFUSE™ 9817	INFUSE™ 9817	INFUSE™ 9817	INFUSE™ 9817	INFUSE™ 9817	INFUSE™ 9817
Material B	ASPUN™ 6000	ASPUN™ 6000	Sabic PP 511A	ASPUN™ 6000	ASPUN™ 6000	ASPUN™ 6000
Ratio A/B	75/25	90/10	60/40	75/25	90/10	60/40
Configuration	Core/Sheath fiber	Core/Sheath fiber	Mixed Fiber	Mixed fiber	Mixed fiber	Mixed fiber
Basis weight	60	100	60	60	100	60

[0078] Production of the spunbond non-wovens

[0079] Material A – INFUSE™ 9817 for example – and Material B - ASPUN™ 6000 for example are independently melted using extruders of 2.5 inches and 2 inches respectively and with L/D ratio of 30:1. The melt temperatures of the resins are of 230°C, with quench air temperature of 16°C and air pressure of 0.5 bars. The spinneret is composed of two circuits, circuit A with 672 holes with 0.40 mm diameter and L/D capillary ratio of 4/1, and circuit B with 252 holes with 0.40 mm diameter and L/D capillary ratio of 4/1. The throughput per holes for each sample is reported in Table 2.

[0080] Table 2. Throughput per holes of the spunbond non-wovens

	Throughput per hole Circuit A – Mixed Fiber g/min	Throughput per hole Circuit B - Mixed Fiber g/min	Throughput per hole – Core/Sheath g/min
CE 1	-	-	0.8
CE 2			0.8
CE 3	0.8	1.42	-
IE 1	0.8	0.71	-
IE 2	0.8	0.24	-
IE 3	0.8	1.42	-

[0081] A core/sheath configuration is also used for Comparative Example 1 and 2 using the same extruders configuration with a 1003 holes spin pack with 0.35 mm diameter and L/D 4/1 capillary ratio. The web of the mixed long fibers deposited is deposited on a moving belt. The web is released from the moving belt and subjected to heat embossing with an ovoid embossing pattern such that the bonding area was 18.1 % at an average contact temperature of 96°C on the embossed and smooth rolls at pressure of 50 N/mm to prepare a spunbonded non-woven fabric. The resulting spunbonded non-woven fabric is evaluated in accordance with the above methods.

[0082] Results are reported in the below tables. As can be seen from the tables below, the inventive examples exhibit a surprising decrease in the maximum tensile strength, resulting in a desirable soft stretch for the elastic non-wovens. In a similar way, the inventive examples present a decrease in extension force at 50% and 100% elongation (soft stretch) for similar permanent set. Without being bound by theory, the present invention reveals that a mixture of fibers including particular polyethylene and ethylene alpha-olefin block copolymers results in

superior properties in elastic nonwovens. For instance, it has been found that block copolymers can work similarly as a crosslinking point and retain original structures, even under elevated temperature, which in turn helps provide improved or maintained permanent set, hysteresis (e.g., 50% extension force/50% retraction force), and extension force.

[0083] Table 3. Tensile properties of the non-wovens

	Maximum tensile strength, TD	Maximum tensile strength, MD	Strain at Break, TD	Strain at Break, MD
	N	N	%	%
CE 1	15.4	22.4	225	192
CE 2	23.7	28.5	320	242
CE 3	4.6	6.9	265	160
IE 1	6.2	10.4	246	234
IE 2	10.4	13.0	279	225
IE 3	5.4	8.2	261	202

[0084] Table 4. Elastic properties of IE 1 and CE 1

		IE1		CE1	
		No activation	Prestretched at 2:1 in Machine direction	No activation	Prestretched at 2:1 in Machine direction
1 st cycle	Force at 50% extension	3.1	1.8	6.1	4.7
	Force at 100% extension	4.6	4.7	8.0	8.9
	Force at 50% retraction	0.2	0.2	0.3	0.4
	1st 50% E/50% R	20.7	11.3	23.5	11.8
	Permanent set at 0.1 N	22.9	21.3	25.9	19.9
2 nd cycle	Force at 50% extension	0.5	0.5	2.4	2.6
	Force at 100% extension	3.7	3.9	7.1	7.8
	Force at 50% retraction	0.1	0.1	0.2	0.3
	permanent set at 0.1N	26.4	24.7	29.7	23.5
	2nd 50% E/50% R	4.2	3.6	14.1	8.7

[0085] Table 5. Elastic properties of IE 2 and CE 2

		IE2		CE2	
		No activation	Prestretched at 2:1 in Machine direction	No activation	Prestretched at 2:1 in Machine direction
1 st cycle	Force at 50%extension	2.6	1.3	6.2	4.6
	Force at 100% extension	4.5	3.6	8.6	8.1
	Force at 50% retraction	0.3	0.3	1.0	1.0
	1st 50%E/50%R	8.7	4.3	6.2	4.6
	Permanent set at 0.1 N	15.5	15.3	17.5	13.2
2 nd cycle	Force at 50%extension	0.9	0.8	3.2	3.1
	Force at 100% extension	3.7	3.1	7.7	7.4
	Force at 50% retraction	0.3	0.2	0.9	0.6
	Permanent set at 0.1N	18.0	18.0	19.4	15.0
	2nd 50%E/50%R	3.0	4.0	3.6	5.2

[0086] Table 6 Elastic properties of IE 3 and CE 3

		CE3		IE3	
		No activation	Prestretched at 2:1 in Machine direction	No activation	Prestretched at 2:1 in Machine direction
1 st cycle	Force at 50%extension	3.8	1.1	3.0	1.5
	Force at 100% extension	5.1	5.5	3.9	3.7
	Force at 50% retraction	0.0	0.04	0.1	0.1
	1st 50%E/50%R	126.7	27.5	50.0	21.4
	Permanent set at 0.1 N	42.3	40.6	31.8	31.1
2 nd cycle	Force at 50%extension	0.2	0.2	0.4	0.4
	Force at 100% extension	3.3	3.6	3.2	3.1
	Force at 50% retraction	0.0	0.0	0.1	0.1
	Permanent set at 0.1N	49.9	47.9	37.7	36.2
	2nd 50%E/50%R	7.5	10.0	8.0	7.0

We Claim:

1. A spunbond nonwoven comprising:
a mixture of a first fiber and a second fiber;
the first fiber comprising an ethylene/ α -olefin multi-block interpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C;
the second fiber comprising an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and a melt index (I_2) in the range of from 10 to 100 g/10 min;
wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C.
2. The nonwoven of claim 1, wherein the difference between crystallization temperature (T_c) of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 20°C.
3. The nonwoven of claim 1, wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolymer is less than 15°C.
4. The nonwoven of any preceding claim, wherein the ratio of the first fiber to the second fiber in the nonwoven is in the range of from 95/5 to 5/95.
5. The nonwoven of any preceding claim, wherein the first fiber and the second fiber have a fiber diameter in the range of from 10 to 50 micron.
6. The nonwoven of any preceding claim, wherein the nonwoven has a basis weight in the range of from 15 to 250 gsm.
7. The nonwoven of any preceding claim, wherein the nonwoven has a stretch ratio between 2:1 and 5:1.
8. The nonwoven of any preceding claim, wherein the nonwoven comprises at least 99 wt.% ethylene-based polymer, based on the total weight of the polymers in the nonwoven.
9. A laminate comprising a nonwoven according to any of the preceding claims.

10. An article comprising a nonwoven according to any one of claims 1-8.
11. A process for making a nonwoven, the process comprising providing an ethylene/ α -olefin multi-block interpolpolymer having a density of from 0.860 to 0.885 g/cc, a melt index (I_2) in the range of from 10 to 50 g/10 min, and a melting point in the range of from 115 to 125°C and an ethylene-based polymer having a density of from 0.930 to 0.970 g/cc, and a melt index (I_2) in the range of from 10 to 100 g/10 min (as disclosed above), wherein the difference between the melting point of the ethylene-based polymer and the ethylene/ α -olefin multi-block interpolpolymer is less than 20°C; extruding each of the ethylene/ α -olefin multi-block interpolpolymer and the ethylene-based polymer through a spinneret having corresponding holes for extrusion of the ethylene/ α -olefin multi-block interpolpolymer and the ethylene-based polymer to form a mixture of at least a first fiber corresponding to the ethylene/ α -olefin multi-block interpolpolymer and a second fiber corresponding to the ethylene-based polymer; and forming the nonwoven.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/035021

A. CLASSIFICATION OF SUBJECT MATTER INV. D04H3/007 B32B5/02 B32B5/26 D04H3/153 D04H3/16 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) D04H B32B D01F 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		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/248347 A1 (NOVARINO ELENA [DE] ET AL) 6 August 2020 (2020-08-06) paragraphs [0136] - [0137] example 1 table 1 paragraph [0115] paragraphs [0130] - [0131]; claims 14-15 -----	1 - 11
A	US 11 161 321 B2 (AVINTIV SPECIALTY MATERIALS INC [US]) 2 November 2021 (2021-11-02) claim 1; figure 3 column 15, lines 4-30 -----	1 - 11
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☒ 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 24 September 2024		Date of mailing of the international search report 07/10/2024
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 Beckert, Audrey

INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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