

A POLYETHYLENE BLEND USED ON ITS OWN AS A CARRIER FOR MICROFIBER FABRICATION PROCESS

FIELD OF INVENTION

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This invention relates to a blended polyethylene, where the constituent polyethylenes are produced by the tubular process of manufacturing polyethylene. In addition, the invention relates to the use of said polyethylene blend as a carrier for a polyamide microfiber fabrication process showing improvement in fiber stability and maximum take-up velocity
10 when compared to an unblended polyethylene produced by the tubular process.

BACKGROUND

The listing or discussion of a prior-published document in this specification should not
15 necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge.

Despite ethylene's simple structure, the field of polyethylene is a complex one with a wide variety of polyethylenes and many different manufacturing processes. The autoclave
20 process and the tubular process are two particularly important manufacturing processes for polyethylene, involving the reaction of ethylene at high pressures (150-350 MPa) to generate polyethylene.

The autoclave process (typically conducted at 150-200 MPa) generally uses a cylindrical
25 autoclave, which functions as an adiabatic continuous stirred-tank reactor (CSTR). A tubular reactor typically consists of several hundred meters of jacketted high-pressure tubing arranged as a series of straight sections connected by 180° bends and involves the reaction of polyethylene at high pressures (200-250 MPa). Further details of the autoclave and tubular processes may be found in the Polyethylene chapter of Ullmann's Encyclopedia of
30 Industrial Chemistry, Vol. 29, (2012), Wiley-VCH.

Polyethylene produced by the tubular process is cheaper than polyethylene made by the autoclave process, which makes it attractive for use in industrial processes. However, the properties and applications of polyethylene made by the tubular and autoclave processes
35 differ.

Polyethylene homopolymers produced by autoclave reactors have a high degree of long-chain branching. This allows easy processing of polyethylene having high molecular weight and makes the polyethylene especially useful for extrusion coating. In contrast, tubular reactors produce polyethylene homopolymers that contain a much lower degree of long chain branching. These resins are well suited for wire and cable insulation and certain packaging film markets, but are not considered to be suitable for use as a carrier in the manufacture of microfibers.

Polyethylene has been used as a carrier for microfiber fabrication (e.g. the manufacture of polyamide microfibers). Microfibers are fibres with a diameter of less than 12 microns (e.g. 0.1-10 microns).

Conjugate-spinning methods can be employed to produce microfibres. This can either be accomplished by a separation or a dissolution technique. The separation technique involves the spinning of a bicomponent filament, typically one comprising nylon 6 and polyester, though other conjugates can be used (such as polyethylene). After being woven, the fabric is exposed to solvent/alkali swelling or thermal/mechanical treatment, such that the two immiscible components separate, resulting in individual polyamide/polyester microfilaments.

In the dissolution technique, two polymers are extruded through a suitable spinneret to produce a bicomponent filament that comprises either several individual "islands" of one component embedded in a "sea" of the other component or several sectors of one component embedded in a radial type of the other component. After weaving, knitting or formation of a non-woven material, one of the components is removed by dissolution using a suitable solvent to produce the microfibers. This method can be accomplished by mixed-spinning of the island polymer and sea polymer, that is mixing the sea polymer and island polymer, melting the polymers in the same extruder, and extruding the polymers through a spinneret to produce yarns, or by conjugate spinning, where the sea polymer and island polymer are melted in different extruders and then combining the two polymers at a spinneret as yarns. Without wishing to be bound by theory, the melt spinning technique may work because the polymers are thermodynamically immiscible, leading to the formation of a sea and island yarn from the extruder.

With the sea and island technique, when the sea is dissolved with a solvent, the polymer that is the island remains and forms the finest fibres. The number of islands, the ratio of island components to sea components, and the cross-sectional shape of the resulting

microfilaments can be varied, as this method is capable of producing super microfibers, as well as hollow microfibres.

Currently, polyethylene produced by the autoclave process is used as a carrier for polyamide microfiber fabrication in the dissolution technique described above. Despite being cheaper, it has been found that polyethylene produced by the tubular process is not suitable for use in the dissolution technique, due to poor fiber stability. Fiber stability means the evenness of the fiber thickness during processing (polyethylene and polyamide). Poor stability means that the fiber thickness fluctuates during processing, leading to breakage of the fiber during extrusion and production delays.

SUMMARY OF INVENTION

It has been surprisingly found that blending two polyethylenes, having defined properties, manufactured using the tubular process results in a polyethylene blend that does not suffer from the poor fiber stability associated with unblended polyethylenes derived from the tubular process.

A first aspect of the invention relates to a polymer blend comprising:

a first polyethylene; and

a second polyethylene, wherein

the blend has a melt flow rate of from 45 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a molecular weight distribution (Mw/Mn) of from 4 to 7.

In embodiments of the invention, the first polyethylene may have a density of from 0.910 g/cm³ to 0.930 g/cm³ and a melt flow rate of from 1 g/10min to 10 g/10min; and the second polyethylene may have a density of from 0.910 g/cm³ to 0.920 g/cm³ and a melt flow rate of from 45 g/10min to 60 g/10min.

In further embodiments of the invention, the polymer blend may have a maximum take-up velocity of from 95 to 200 m/min when mixed in a 1:1 weight ratio with a polyamide to form a second polymer blend and the maximum take-up velocity is measured using a Toyoseki MT/MTV machine with waterbath, with a melt-mixing temperature of 260°C, a load of 224 g and a waterbath temperature of 23°C.

In embodiments of the invention, the melt flow rate of the second polyethylene may be greater than the melt flow rate of the first polyethylene and/or the density of the first polyethylene may be greater than the density of the second polyethylene.

- 5 In yet further embodiments of the invention, the first and second polyethylenes may be homopolymers.

In certain embodiments, the polymer blend may have:

- 10 (a) a melt flow rate of from 50 g/10min to 55 g/10min; and/or
(b) a density of from 0.915 g/cm³ to 0.918 g/cm³; and/or
(c) a molecular weight distribution (Mw/Mn) of from 5 to 6.

15 In further embodiments of the invention, the first polyethylene may be from 1 and 20 wt% of the polymer blend and/or the second polyethylene may be from 80 to 99 wt% of the polymer blend.

In further embodiments of the invention, the first and second polyethylene may be produced by the tubular process for manufacturing polyethylene.

- 20 In yet further embodiments of the invention, the first polyethylene may have:

- (a) a swelling ratio of from 1.50 to 1.90 (e.g. the swelling ratio is from 1.60 to 1.80); and/or
(b) a molecular weight distribution (Mw/Mn) of from 5 to 8 (e.g. the molecular weight distribution (Mw/Mn) is from 6 to 8); and/or
25 (c) a melt flow rate of from 3 g/10min to 5 g/10min; and/or
(d) a density of from 0.915 g/cm³ to 0.918 g/cm³.

In yet further embodiments of the invention, the second polyethylene may have:

- 30 (a) a melt flow rate of from 50 g/10min to 55 g/10min; and/or
(b) a density of from 0.915 g/cm³ to 0.918 g/cm³; and/or
(c) a molecular weight distribution (Mw/Mn) of from 4 to 7 (e.g. the molecular weight distribution (Mw/Mn) is from 5 to 6)

35 In a second aspect of the invention, there is provided a process for preparing a polymer blend according to the first aspect of the invention.

In a third aspect of the invention, there is provided a use of a polymer blend according to the first aspect of the invention as a carrier material for the production of a polyamide microfiber material.

5 In a fourth aspect of the invention, there is provided a process to prepare a polyamide microfiber material, comprising the steps of:

- 10 (a) providing a polymer extrusion device configured to extrude at least a primary polymer and a secondary polymer in the form of a fiber in a sea and island configuration, wherein the primary polymer supplies the sea component and the secondary polymer supplies the island component of the fiber; and
- (b) providing the primary and secondary polymer to the polymer extrusion device;
- 15 (c) melting and extruding the primary and secondary polymers to form a fiber having a sea and island configuration;

wherein:

- the primary polymer is a polyethylene blend having a melt flow rate of from 45 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a molecular weight distribution (Mw/Mn) of from 4 to 7; and
- 20 the secondary polymer is a polyamide.

In embodiments of the invention, the primary polymer may be a polyethylene blend according to the first aspect of the invention.

25 In yet further embodiments of the invention, the polyamide microfiber material may be formed into a non-woven material.

In still further embodiments of the invention, the primary polymer may be dissolved to form microfibers of the second polymer.

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In yet still further embodiments, the primary polymer and secondary polymer may be blended in a weight ratio of from 10:1 to 1:10, such as from 5:1 to 2:1, e.g. 1:1.

FIGURES

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The invention will now be described in further detail below, with the aid of the following figure.

FIG. 1 A schematic diagram, depicting a typical process used to make microfibers from the LDPE/Polyamide material.

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DETAILED DESCRIPTION OF INVENTION

As used herein, the term “polymeric blend” means a mixture of polymeric resins which includes, but is not limited to, homopolymers, copolymers (e.g., block, graft, random and alternating copolymers), terpolymers, etc., and blends and modifications thereof which is in the form of a solid solution, considered to form a substantially homogeneous mixture. Optional adjuncts may be added to the polymeric blend and, if the blend remains a solid solution, such blends are also considered polymeric blends. In aspects and embodiments that may be mentioned herein, the “polymeric blend” is a mixture of at least two homopolymers.

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As used herein, the term “spunbonded fibers” refers to small diameter substantially continuous fibers that are formed by extruding a molten thermoplastic material as filaments from a plurality of fine, usually circular, capillaries of a spinneret with the diameter of the extruded filaments then being rapidly attenuated by drawing using conventional godet winding systems or through air drag attenuation devices. If a godet system is used, the fiber diameter can be further reduced through post extrusion drawing.

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As used herein, the term “extensible” refers to any fiber, which, upon application of a biasing force, is elongatable to at least about 200 percent without experiencing catastrophic failure, preferably to at least 400 percent elongation without experiencing catastrophic failure, and more preferably to at least 600 percent elongation without experiencing catastrophic failure and most preferably to at least 800 percent elongation without experiencing catastrophic failure.

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As used herein, the “equivalent diameter” of a non-circular cross section fiber is the diameter of a circle having the same cross-sectional area as the fiber.

As used herein, the term “nonwoven web”, or “nonwoven material” refers to a web that has a structure of individual fibers or threads which are interlaid, but not in any regular, repeating manner. Nonwoven webs have been, in the past, formed by a variety of processes, including,

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but not limited to, air laying processes, meltblowing processes, spunbonding processes and carding processes.

When used herein, the terms “comprises” and “comprising” and equivalents thereof are intended to be non-limiting in nature. Said terms are intended to encompass the terms “consists essentially of” and “consists of” and equivalents thereof. It is intended that the terms “comprises” and “comprising” and equivalents thereof may be replaced by the terms “consists essentially of” and “consists of” and equivalents thereof.

10 The polymer blends described herein include at least a first polyethylene and a second polyethylene, wherein the resulting blended material has a melt flow rate of from 45 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a molecular weight distribution (Mw/Mn) of from 4 to 7.

15 The polyethylene (or polymer) blend may have a density of from 0.910 g/cm³ to 0.930 g/cm³, such as a density of from 0.912 g/cm³ to 0.925 g/cm³, such as from 0.914 g/cm³ to 0.920 g/cm³ or, more particularly, a density of from 0.915 g/cm³ to 0.918 g/cm³. A method for measuring density is provided in the methods section below.

20 The polyethylene blend may have a melt flow rate of from 45 g/10min to 60 g/10min, such as from 48 g/10min to 57 g/10min or, more particularly, 50 g/10min to 55 g/10min. A method for measuring the melt flow rate is provided in the methods section below. Alternatively, if there is not enough sample for melt index determinations or if it is necessary to determine melt flow rate of fractions of a blend, an alternative molecular weight measure, such as gel
25 permeation chromatography, can be used and known correlations between molecular weight and melt flow rate can be used to determine the melt flow rate for the blend (see, for example, A. Gijssels, Ind. Polym. Process, 9, 252 (1994)).

The polyethylene blend may have a molecular weight distribution (Mw/Mn) of from 4 to 7,
30 such as from 5 to 6. The molecular weight distribution is determined by measuring the weight average and number average molecular weight of the polymer in question and then dividing the former by the latter. The weight average molecular weight is measured by ISO16014, as is the number average molecular weight.

35 The polyethylene blend may comprise from 1 to 20 wt% (e.g. from 1.5 to 5 wt%) of the polyethylene blend of the first polyethylene and from 80 to 99 wt% (e.g. from 95 to 98.5 wt%)

of the second polyethylene. When the amount of the first polyethylene is lower than 1 wt% of the polyethylene blend, the blend does not provide the desired effects, while if there is more than 20 wt% of the first polyethylene, the polymer blend will have a lower melt flow rate, reducing the take-up velocity.

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The polymeric blends of the present invention may be prepared in any suitable fashion, including, but not limited to, blending the desired components in the desired proportions using conventional blending techniques and apparatus, including a Banbury mixer (available from Farrel Corp., Ansonia, Conn.) or laboratory extruders, such as the PolyLab Twin Screw Extruder (available from Thermo Electron (Karlsruhe), Karlsruhe, Germany) which are suitable for preparing small batches of material. Commercial scale pelletizing extruders may also be used for preparing larger blend quantities, and the like. It is even possible to prepare a premixture of pellets comprising pellets of the first polyethylene and pellets of the second polyethylene relying on intimately mixing the pellet premixture in the fiber extrusion apparatus for final mixing into the polymeric blend of the present invention (dry blending). As will be recognized, such reliance on the fiber extrusion apparatus requires careful design of extruder length, temperature profile and flight geometry to ensure adequate mixing of the pellets before fiber extrusion.

20 The polyethylene blend is intended to be used as a carrier for polyamide microfiber fabrication. This polyethylene blend has better processing performance (such as fiber stability and take-up velocity properties) than non-blended polyethylene made by the tubular process.

25 The polyethylene blend may have a maximum take-up velocity of from 95 to 200 m/min when mixed in 1:1 weight ratio with a polyamide to form a second polymer blend and the maximum take-up velocity is measured using a Toyoseki MT/MTV machine with waterbath, with a melt-mixing temperature of 260°C, a load of 224 g and a waterbath temperature of 23°C.

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In certain embodiments, both the first and the second polyethylenes are prepared using the tubular process for the manufacture of polyethylenes.

It will be appreciated that the first polyethylene has a separate density and a melt flow rate.

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The density of the first polyethylene may be from 0.910 g/cm³ to 0.930 g/cm³ (e.g. from 0.912 g/cm³ to 0.925 g/cm³, such as 0.915 g/cm³ to 0.918 g/cm³). The density of the first polyethylene may be greater than the density of the second polyethylene. The melt flow rate of the first polyethylene may be from 1 g/10min to 10 g/10min (e.g. 2 g/10min to 7 g/10min or, more particularly, from 3 g/10min to 5 g/10min).

In certain embodiments, the molecular weight distribution of the first polyethylene (Mw/Mn) may be from 5 to 8 (e.g. the molecular weight distribution (Mw/Mn) is from 6 to 8). In certain embodiments, the swelling ratio of the first polyethylene may be from 1.50 to 1.90 (e.g. the swelling ratio is from 1.60 to 1.80).

It is preferred that the first polyethylene is a homopolymer. Suitable first polyethylenes are described in the Examples section below. In certain embodiments, the first polyethylene does not contain any adjuvants or adjunct materials.

The second polyethylene also has an individual density and a melt flow rate properties.

The density of the second polyethylene may be from 0.910 g/cm³ to 0.920 g/cm³ (e.g. from 0.913 g/cm³ to 0.919 g/cm³ or, more particularly, from 0.915 g/cm³ to 0.918 g/cm³). The melt flow rate of the second polyethylene may be from 45 g/10min to 60 g/10min (e.g. from 50 g/10min to 55 g/10min). In certain embodiments of the invention, the melt flow rate of the second polyethylene may be greater than the melt flow rate of the first polyethylene.

In certain embodiments, the molecular weight distribution of the second polyethylene (Mw/Mn) may be from 4 to 7 (e.g. the molecular weight distribution (Mw/Mn) is from 5 to 6).

It is preferred that the second polyethylene is a homopolymer. A suitable second polyethylene is described in the Examples section below. In certain embodiments, the second polyethylene does not contain any adjuvants or adjunct materials.

When discussed herein, the "tubular process" refers to the high-pressure process for the manufacture of polyethylene. Non-limiting examples of this process are described in the Polyethylene chapter of Ullmann's Encyclopedia of Industrial Chemistry, Vol. 29, (2012), Wiley-VCH.

The process to prepare a polyamide microfiber material, may comprise the steps of:

- 5 (a) providing a polymer extrusion device configured to extrude at least a primary polymer and a secondary polymer in the form of a fiber in a sea and island configuration, wherein the primary polymer supplies the sea component and the secondary polymer supplies the island component of the fiber;
- (b) providing the primary and secondary polymer to the polymer extrusion device;
- (c) melting and extruding the primary and secondary polymers to form a fiber having a sea and island configuration; and
- 10 (d) dissolving the primary polymer to form microfibers of the secondary polymer,

wherein:

the primary polymer is a polyethylene blend having a melt flow rate of from 45 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a
15 molecular weight distribution (Mw/Mn) of from 4 to 7; and
the secondary polymer is a polyamide.

It will be appreciated that the primary polymer is the polyethylene blend described hereinbefore.

20 The polyamide microfiber material may be formed into a non-woven material and/or the polyamide microfiber may be released by dissolving the polyethylene blend to form microfibers of polyamide.

25 As noted above, the fibers described herein are typically consolidated into a nonwoven material. Consolidation can be achieved by methods that apply heat and/or pressure to the fibrous web, such as thermal spot (i.e., point) bonding. Thermal point bonding can be accomplished by passing the fibrous web through a pressure nip formed by two rolls, one of which is heated and contains a plurality of raised points on its surface, as is described in U.S.
30 Pat. No. 3,855,046. Consolidation methods can also include, but are not limited to, ultrasonic bonding, through-air bonding, resin bonding, and hydroentanglement. Hydroentanglement typically involves treatment of the fibrous web with high pressure water jets to consolidate the web via mechanical fiber entanglement (friction) in the region desired to be consolidated, with the sites being formed in the area of fiber entanglement. The fibers
35 can be hydroentangled as taught in U.S. Pat. Nos. 4,021,284 and 4,024,612.

The primary polymer and secondary polymer may be blended in a weight ratio of from 10:1 to 1:10, such as from 5:1 to 2:1, e.g. 1:1.

EXAMPLES

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Materials

Polyethylene 1 (PE1) and polyethylene 2 (PE2) were obtained from The Polyolefin Company (Singapore) Pte. Ltd using the processes described below, and both have properties that are
10 in line with that reported for the first polyethylene.

Polyethylene 3 (PE3) was obtained from The Polyolefin Company (Singapore) Pte. Ltd and is produced by the tubular process. PE3 has properties that are in line with that reported for the second polyethylene and was obtained as described below.

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The polyamide used in these experiments was obtained from Guangdong Xinhui Meida Nylon Co (Grade: M32800 (PA6)).

Further details of the processes used to make PE1-PE3 are provided below.

20

Polyethylene 1

PE1 was prepared by dissolving an initiator in isoparaffin and subsequently injected into the tubular reactor at four points, in keeping with the Polyethylene chapter of Ullmann's
25 Encyclopedia of Industrial Chemistry, Vol. 29, (2012), Wiley-VCH. Further conditions, are listed below.

Temperature of Feed Ethylene Gas: 170°C

Average Reaction Temperature: 290°C

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Pressure of Reactor Entrance: 170MPa

Temperature of Refrigerant in Outer Wall of Reactor: 160°C

Temperature of High Pressure Separator: 200°C

Chain Transfer Agent: Propylene

35 PE1 has a Melt Flow Rate of 3.4 g/10 min, a Swelling Ratio of 1.72, a density of 0.918 g/cm³ and a Molecular Weight Distribution of 7.2. All properties are measured as discussed herein.

Polyethylene 2

PE2 was prepared by dissolving an initiator in isoparaffin and subsequently injected into the tubular reactor at four points, in keeping with the Polyethylene chapter of Ullmann's Encyclopedia of Industrial Chemistry, Vol. 29, (2012), Wiley-VCH. Further conditions, are listed below.

Temperature of Feed Ethylene Gas: 170°C

Average Reaction Temperature: 300°C

Pressure of Reactor Entrance: 230MPa

Temperature of Refrigerant in Outer Wall of Reactor: 155°C

Temperature of High Pressure Separator: 180°C

Chain Transfer Agent: Propylene

PE2 has a Melt Flow Rate of 1.2 g/10 min, a Swelling Ratio of 1.58, a density of 0.920 g/cm³ and a Molecular Weight Distribution of 6.9. All properties are measured as discussed herein.

Polyethylene 3

PE3 was prepared by dissolving an initiator in isoparaffin and subsequently injected into the tubular reactor at four points, in keeping with the Polyethylene chapter of Ullmann's Encyclopedia of Industrial Chemistry, Vol. 29, (2012), Wiley-VCH. Further conditions, are listed below.

Temperature of Feed Ethylene Gas: 170°C

Average Reaction Temperature: 300°C

Pressure of Reactor Entrance: 180MPa

Temperature of Refrigerant in Outer Wall of Reactor: 175°C

Temperature of High Pressure Separator: 180°C

Chain Transfer Agent: Propylene

PE3 has a Melt Flow Rate of 50 g/10 min, a density of 0.917 g/cm³ and a Molecular Weight Distribution of 5.3. All properties are measured as discussed herein.

Methods of Analysis

Melt Flow Rate

- 5 The Melt Flow Rate was determined using ASTM D1238, Procedure A – Standard Test Method for Melt Flow Rates of thermoplastics by Extrusion Plastometer using a Toyoseiki Melt Indexer F-B01 a temperature of 190°C and a load of 2.16 kg. The conditioning time used was 6 minutes and the orifice dimensions were 2.095 mm inner diameter and 8.0 mm length.

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Swelling Ratio

- The Swelling ratio measurements were carried out using the same conditions given for the Melt Flow Rate above, except that the extrudate is collected when the extrudate length
15 measures 20 mm. To calculate the swelling ratio, the diameter of the midpoint of the extrudate is measured and divided by the inner diameter of the orifice (in this case, the inner diameter of the orifice is 2.095 mm).

- For example, diameter of the midpoint of extrudate is 3.25 mm measured by a micrometer.
20 Therefore, the swelling ratio = $3.25/2.095 = 1.55$.

The Melt Flow Rate level of PE3 was too high, so it was not possible for the operator to cut off the extrudate when its length is 20mm for swelling ratio measurement.

25 *Density Testing*

- Samples for density testing were prepared by compression moulding. Before subjecting the specimens to compression, the specimen was pre-heated to 150°C and was then subjected to bumping to remove any gas bubbles. Each specimen had the dimensions of 30 mm x 25
30 mm x 1mm and was subjected to a moulding temperature of 150°C at a moulding pressure of 50 kg/cm³ for 5 minutes using Tester Sangyo Co. Ltd, Model: SA-303. The specimen was then subjected to a cooling temperature of 23°C and a cooling pressure of 20 kg/cm³ for 3 minutes using Tester Sangyo Co. Ltd, Model: SA-302. Subsequently, the specimen was annealed at 100°C for 1 hour in distilled water, after which the specimen was conditioned in
35 a standard laboratory atmosphere (23°C, 50% relative humidity) for 16 hours.

The density of the specimens produced by the procedure above were then tested using ASTM D792 – standard test methods for density and specific gravity (relative density) of plastics by displacement, using Test Method A – for testing solid plastics in water.

- 5 The tests were conducted using equipment from Ohaus Corporation, Model: DV215D (Balance) & 77402-00 (Density Kit).

Weight Average Molecular Weight and Molecular Weight Distribution

- 10 The Weight Average and Number Average Molecular Weight, and Molecular Weight Distribution were measured using:

- ISO16014-4, Part 4: High Temperature Method - Determination of Average Molecular Mass and Molecular Mass Distribution of Polymers using Size-Exclusion Chromatography (sample preparation and testing of the sample); and
- 15 • ISO16014-1, Part 1: General Principles - Determination of Average Molecular Mass and Molecular Mass Distribution of Polymers using Size-Exclusion Chromatography (steps for data processing and calculation of the results).

- 20 The analysis was conducted using Tosoh Corporation, Model: HLC-8121GPC/HT, TSK Gel GMH 6-HT and with a differential refractometer as the detector. The temperature used was 140°C, the carrier was ortho-dichlorobenzene and the flow rate was 1.0 mL/min.

Examples 1-4 and Comparative Example 1

- 25 *Preparation of Low Density Polyethylenes (LDPEs)*

- The blended LDPEs listed in Table 1 were prepared by dry blending pellets of the respective LDPEs in the ratios provided in said table. The dry-blended material was then fed into the hopper of the extruder and melt-mixed, the resulting blended polymer was then extruded to
- 30 generate the polymer blends of Examples 1 to 4 in pellet form, using a Labtech Engineering machine (Model: LBE 20-30/C (L/D: 32)) with an orifice diameter of 2 mm (the size of the die opening) and a screw diameter of 20 mm, operating at a temperature of 180°C and providing 2.0kg/hr of extruded pellets. A similar method was used for Comparative Example 1.

Polyamide Fiber Formation

Each of the blended LDPEs were dried in oven at 90°C for at least 3 hours and the polyamide was dried in oven at 120°C for at least 3 hours. The blended LDPE and polyamide were dry blended by hand at a weight ratio of 1:1. The dry blended LDPE/polyamide mixture is then poured into the hopper for extrusion into pellet form using Labtech Engineering, Model: LBE 20-30/C (L/D: 32) with a 2mm diameter orifice and a screw diameter of 20 mm, where the melt temperature of the hopper is 240°C and the blended LDPE is extruded at a rate of 2.5kg/hr.

The collected pellet was then dried in an oven at 100°C for at least 2 hours before being fed into a Toyoseiki MT/MTV Machine with Waterbath for fibre fabrication (orifice diameter 0.8 mm; temperature of 260°C; compression load of 224 grams and waterbath temperature of 23°C). The fibre is wound along the rollers to the winders for collection at low speed. The take-up velocity is then slowly increased (in increments of 54 m/min) until the fibre breaks. The maximum take-up velocity is the last take-up velocity reached before the fibre breaks (see Table 1).

Some of the pellets of each example were tested as described above to determine the MFR, the density and MWD of the blended polymer pellets of examples 1-4 and the non-blended polymer pellet of comparative example 1 (see Table 2).

Table 1:

	Composition of Blended LDPE (%)	Maximum Take-Up Velocity of LDPE/PA Fiber (m/min)
Example 1	PE1 / PE3 = 2.5/97.5	149
Example 2	PE2 / PE3 = 2.5/97.5	108
Example 3	PE2 / PE3 = 5/95	111
Example 4	PE2 / PE3 = 10/90	160
Comparative Example 1	PE1 / PE3 = 0/100	93

Testing Conditions (for take-up velocity):

Machine: Toyoseiki MT/MTV Machine with waterbath

Temperature: 260°C

Load: 224 g

Waterbath Temperature: 23°C

Table 2:

	MFR (g/10min)	Density (g/cm ³)	MWD
Example 1	45	0.916	6.0
Example 2	42	0.916	5.7
Example 3	37	0.916	6.0
Example 4	32	0.915	6.0
Comparative Example 1	49	0.917	5.8

5 Testing conditions are as defined hereinbefore.

Example 5 and Comparative Example 2

Formation of Blended LDPEs

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The following example makes use of industrial-scale equipment.

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PE3 was polymerized in a tubular reactor and was then supplied to a downstream polymer separator and then to the main extruder. PE1 was fed into the main extruder at 180°C by way of a side extruder. The feed rate of the side extruder was adjusted until the target composition was achieved. In the main extruder, the two kinds of LDPE (PE1 and PE3) were blended at 120°C to provide the LDPE of Example 5. A similar process was used to make Comparative Example 2, without the inclusion of PE1.

20

The physical properties of Example 5 are as follows: MFR: 54 g/10min; Density: 0.917 g/cm³; and MWD: 5.6.

25

The physical properties of Comparative Example 2 are as follows: MFR: 50 g/10min; Density: 0.917 g/cm³; and MWD: 5.3.

Polyamide Fiber Formation

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The blended LDPE of Example 5 was dried in oven at 70°C for at least 24 hours and the polyamide was dried in a vacuum oven (66.67 P) at 120°C for at least 24 hours. The blended LDPE and polyamide were dry blended by hand at a weight ratio of 1:1. The dry

blended LDPE/polyamide mixture was then poured into the hopper for extrusion into fibers, using a Musashino Kikai Fibre Spinning Machine, with an orifice diameter of 0.8 mm, at a melt-temperature of 250°C, an output of 250 g/hr, an air gap of 15 mm and a waterbath temperature of 5°C.

5

The fibre was wound along the rollers to the winders for collection at low speed. The take-up velocity was then slowly increased (in increments of 10m/min) until the fibre breaks. The maximum take-up velocity is the last take-up velocity reached before the fibre broke. Fibre thickness is measured inline during processing at the point before the fibres are wound up (see Table 3).

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Table 3:

	Composition of Blended LDPE (%)	Maximum Take-Up Velocity of LDPE/PA Fiber (m/min)	Standard Error of Fiber Thickness (%)
Example 5	PE1/PE3 = 1.7/98.3	80	5.6
Comparative Example 2	PE1/PE3 = 0/100	50	5.9

Testing Conditions:

Machine: Musashino Kikai Fibre Spinning Machine

Temperature: 250°C

Output: 250 g/hr

Air Gap: 15mm

Waterbath Temperature: 5°C

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Example 6

A typical process used to make microfibers from the LDPE/Polyamide material is described below, with reference to Figure 1.

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- 1) LDPE (101) and Polyamide (102) are fed into a mixing silo (110) at a ratio of 1:1.
- 2) The mixture of LDPE and polyamide is then fed into an extruder (120/130) for melt mixing.
- 3) The extrudate is extruded through the dies (131) to form fibers (there are 8 dies connected to the extruder and each die has 42,000 orifices).

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- 4) The fibers extruded from each die are air cooled and wound onto a winder (160) that also coats the fibers with an antistatic agent.
- 5) The fibers are dried by air (by an air dryer; 140) and are then heated with water (in a water bath; 150) to enable further fiber stretching.
- 5 6) The fibers are then laid onto a conveyor (not shown) and dried in an oven (170).
- 7) After drying, the fibers are cut into shorter lengths (180) before entering a drying silo (190).
- 8) The cut and dried fibers are then fluffed in a chamber (195) before being packed (199).
- 10 9) The fluffed fibers are then laid out randomly on a conveyor before needle punching to form a non-woven cloth.
- 10) Polyurethane adhesive is added to the non-woven cloth to hold the cloth in place.
- 11) The LDPE is dissolved away using toluene leaving only the polyamide non-woven microfiber cloth behind.

CLAIMS

1. A polymer blend comprising:
a first polyethylene; and
a second polyethylene, wherein
the blend has a melt flow rate of from 32 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a molecular weight distribution (Mw/Mn) of from 4 to 7.
2. The polymer blend according to Claim 1, wherein the blend has a melt flow rate of 32 g/10min, or 37 g/10min or from 45 g/10min to 60 g/10min.
3. The polymer blend according to Claim 2, wherein the blend has a melt flow rate of from 45 g/10min to 60 g/10min.
4. The polymer blend according to any one of Claims 1 to 3, wherein:
the first polyethylene has a density of from 0.910 g/cm³ to 0.930 g/cm³,
a melt flow rate of from 1 g/10min to 10 g/10min and a molecular weight distribution from 5 to 8; and
the second polyethylene has a density of from 0.910 g/cm³ to 0.920 g/cm³, a melt flow rate of from 45 g/10min to 60 g/10min and a molecular weight distribution from 4 to 7.
5. The polymer blend according to any one of Claims 1 to 4, wherein the polymer blend has a maximum take-up velocity of from 95 to 200 m/min when mixed in 1:1 weight ratio with a polyamide to form a second polymer blend and the maximum take-up velocity is measured using a Toyoseki MT/MTV machine with waterbath, with a melt-mixing temperature of 260°C, a load of 224 g and a waterbath temperature of 23°C.
6. The polymer blend according to any one of the preceding claims, wherein:
 - (a) the melt flow rate of the second polyethylene is greater than the melt flow rate of the first polyethylene; and/or
 - (b) the density of the first polyethylene is greater than the density of the second polyethylene.
7. The polymer blend according to any one of the preceding claims, wherein the first and second polyethylenes are homopolymers.

8. The polymer blend according to any one of the preceding claims, wherein:
 - (a) the blended melt flow rate is from 50 g/10min to 55 g/10min; and/or
 - (b) the density of the polymer blend is from 0.915 g/cm³ to 0.918 g/cm³.
9. The polymer blend according to any one of the preceding claims, wherein the molecular weight distribution (Mw/Mn) of the polymer blend is from 5 to 6.
10. The polymer blend according to any one of the preceding claims, wherein:
 - (a) the first polyethylene is from 1 to 20 wt% of the composition; and/or
 - (b) the second polyethylene is from 80 to 99 wt% of the composition.
11. The polymer blend according to any one of the preceding claims, wherein the first and second polyethylene are produced by the tubular process for manufacturing polyethylene.
12. The polymer blend according to any one of the preceding claims, wherein the first polyethylene has:
 - (a) a swelling ratio of from 1.50 to 1.90; and/or
 - (b) a molecular weight distribution (Mw/Mn) of from 5 to 8, optionally wherein the first polyethylene has:
 - (a) swelling ratio is from 1.60 to 1.80; and/or
 - (b) molecular weight distribution (Mw/Mn) is from 6 to 8.
13. The polymer blend according to any one of the preceding claims, wherein the first polyethylene has:
 - (a) a melt flow rate is from 3 g/10min to 5 g/10min; and/or
 - (b) a density is from 0.915 g/cm³ to 0.918 g/cm³.
14. The polymer blend according to any one of the preceding claims, wherein the second polyethylene has:
 - (a) a melt flow rate from 50 g/10min to 55 g/10min; and/or
 - (b) a density from 0.915 g/cm³ to 0.918 g/cm³.

15. The polymer blend according to any one of the preceding claims, wherein the second polyethylene has a molecular weight distribution (Mw/Mn) of from 4 to 7, optionally wherein the second polyethylene has a molecular weight distribution (Mw/Mn) of from 5 to 6.
16. A process for preparing a polymer blend according to any one of Claims 1 to 15.
17. Use of a polymer blend according to any one of Claims 1 to 15 as a carrier material for the production of a polyamide microfiber material.
18. A process to prepare a polyamide composite material comprising polyamide microfibers, comprising the steps of:
- (a) providing a polymer extrusion device configured to extrude at least a primary polymer and a secondary polymer in the form of a fiber in a sea and island configuration, wherein the primary polymer supplies the sea component and the secondary polymer supplies the island component of the fiber; and
 - (b) providing the primary and secondary polymer to the polymer extrusion device;
 - (c) melting and extruding the primary and secondary polymers to form a fiber having a sea and island configuration;
- wherein:
- the primary polymer is a polyethylene blend having a melt flow rate of from 32 g/10min to 60 g/10min, a density of from 0.910 g/cm³ to 0.930 g/cm³ and a molecular weight distribution (Mw/Mn) of from 4 to 7; and
 - the secondary polymer is a polyamide.
19. The process according to Claim 18, wherein the blend has a melt flow rate of 32 g/10min, or 37 g/10min or from 45 g/10min to 60 g/10min.
20. The process according to Claim 19, wherein the blend has a melt flow rate of from 45 g/10min to 60 g/10min.
21. The process of any one of Claims 18 to 20, wherein the primary polymer is a polyethylene blend according to any one of Claims 1 to 15.

22. The process of any one of Claims 18 to 21, wherein the polyamide microfiber material is formed into a non-woven material.
23. The process of any one of Claims 18 to 22, wherein the primary polymer is dissolved to form microfibers of the secondary polymer.
24. The process of any one of Claims 18 to 23, wherein the primary polymer and secondary polymer are blended in a ratio of from 10:1 to 1:10.