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(54) **CRIMPED FIBERS AND NONWOVEN CLOTH**

(57) The present invention relates to a crimped fiber including one component thereof containing a thermoplastic resin (A) and another component thereof containing a thermoplastic resin (B) and a thermoplastic resin (C), wherein a half-crystallization time at 25°C of the ther-

moplastic resin (A) is shorter than a half-crystallization time at 25°C of the thermoplastic resin (B), and a half-crystallization time at 25°C of the thermoplastic resin (C) is longer than the half-crystallization time at 25°C of the thermoplastic resin (B).

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Description

Technical Field

5 **[0001]** The present invention relates to a crimped fiber and a nonwoven fabric.

Background Art

10 **[0002]** For example, there is proposed a thermally fusible conjugate fiber in which three kinds of resin components having a different melting point or softening point from each other are disposed at a specified position in a short-direction cross section of the fiber so as to have high bulkiness, high nonwoven fabric strength, and stretchability when used for a nonwoven fabric (see PTL 1). In addition, there is also proposed a latently crimpable conjugate fiber using a core-sheath type composite material using polyolefins having a different melting point from each other (see PTL 2).

15 Citation List

Patent Literature

[0003]

20

PTL 1: JP 2012-251254 A

PTL 2: JP 2012-158861 A

Summary of Invention

25

Technical Problem

[0004] However, the conjugate fibers described in PTLs 1 and 2 were not satisfactory in terms of crimping properties.

30 **[0005]** In view of the foregoing circumstances, the present invention has been made, and an object thereof is to provide a crimped fiber having high crimping properties and a nonwoven fabric including the crimped fiber.

Solution to Problem

35 **[0006]** In order to solve the aforementioned problem, the present inventors made extensive and intensive investigations. As a result, it has been found that the foregoing problem can be solved by the following inventions.

[0007] Specifically, the disclosures of the present application are concerned with the following.

40 [1] A crimped fiber including one component thereof containing a thermoplastic resin (A) and another component thereof containing a thermoplastic resin (B) and a thermoplastic resin (C), wherein a half-crystallization time at 25°C of the thermoplastic resin (A) is shorter than a half-crystallization time at 25°C of the thermoplastic resin (B), and a half-crystallization time at 25°C of the thermoplastic resin (C) is longer than the half-crystallization time at 25°C of the thermoplastic resin (B).

[2] The crimped fiber as set forth in the above [1], wherein the half-crystallization time at 25°C of the thermoplastic resin (A) is 0.01 seconds or less.

45 [3] The crimped fiber as set forth in the above [1] or [2], wherein the half-crystallization time at 25°C of the thermoplastic resin (B) is more than 0.01 seconds and 0.06 seconds or less.

[4] The crimped fiber as set forth in any of the above [1] to [3], wherein the half-crystallization time at 25°C of the thermoplastic resin (C) is more than 0.06 seconds.

50 [5] The crimped fiber as set forth in any of the above [1] to [4], wherein a melt flow rate (MFR) of the thermoplastic resin (A) measured under a condition at a temperature of 190°C and a load of 2.16 kg in conformity with JIS K7210 is 1 g/10 min or more and 70 g/10 min or less.

[6] The crimped fiber as set forth in any of the above [1] to [5], wherein a melt flow rate (MFR) of the thermoplastic resin (B) measured under a condition at a temperature of 230°C and a load of 2.16 kg in conformity with JIS K7210 is 10 g/10 min or more and 500 g/10 min or less.

55 [7] The crimped fiber as set forth in any of the above [1] to [6], wherein a melt flow rate (MFR) of the thermoplastic resin (C) measured under a condition at a temperature of 230°C and a load of 2.16 kg in conformity with JIS K7210 is 10 g/10 min or more and 5,000 g/10 min or less.

[8] The crimped fiber as set forth in any of the above [1] to [7], wherein a melting point (T_m-D) of the thermoplastic

resin (A) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 90°C or higher and 135°C or lower.

[9] The crimped fiber as set forth in any of the above [1] to [8], wherein a melting point (T_m-D) of the thermoplastic resin (B) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 120°C or higher and 200°C or lower.

[10] The crimped fiber as set forth in any of the above [1] to [9], wherein a melting point (T_m-D) of the thermoplastic resin (C) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 50°C or higher and 100°C or lower.

[11] The crimped fiber as set forth in any of the above [1] to [10], wherein the thermoplastic resin (A) is a polyethylene-based resin.

[12] The crimped fiber as set forth in any of the above [1] to [11], wherein the thermoplastic resin (B) is a polypropylene-based resin.

[13] The crimped fiber as set forth in the above [12], wherein the thermoplastic resin (B) is a propylene homopolymer.

[14] The crimped fiber as set forth in any of the above [1] to [13], wherein in the thermoplastic resin (C), a melting endotherm (ΔH -D) obtained from a melting endothermic curve obtained by holding a sample under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 0 J/g or more and 80 J/g or less.

[15] The crimped fiber as set forth in any of the above [1] to [14], wherein a molecular weight distribution (M_w/M_n) of the thermoplastic resin (C) is less than 3.0.

[16] The crimped fiber as set forth in any of the above [1] to [15], wherein the content of the thermoplastic resin (C) occupying in the sum total of the thermoplastic resin (A), the thermoplastic resin (B), and the thermoplastic resin (C) is 1% or more and 50% or less.

[17] The crimped fiber as set forth in any of the above [1] to [16], wherein the crimped fiber is a side-by-side type fiber.

[18] The crimped fiber as set forth in the above [17], wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber contains the thermoplastic resin (A).

[19] The crimped fiber as set forth in the above [17], wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber is composed of the thermoplastic resin (A).

[20] The crimped fiber as set forth in the above [17], wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber contains the thermoplastic resin (B).

[21] The crimped fiber as set forth in the above [17], wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber is composed of the thermoplastic resin (B).

[22] A nonwoven fabric including the crimped fiber as set forth in any of the above [1] to [21].

[23] A multilayered nonwoven fabric including a laminate of two or more layers, wherein at least one layer thereof is the nonwoven fabric as set forth in the above [22].

Advantageous Effects of Invention

[0008] In accordance with the present invention, it is possible to provide a crimped fiber having high crimping properties and a nonwoven fabric including the foregoing crimped fiber.

Brief Description of Drawings

[0009]

Fig. 1 is an image when observing a side-by-side type crimped fiber obtained in Example 16 with an optical microscope (magnification: 200 times).

Fig. 2 is an image when observing a side-by-side type crimped fiber obtained in Example 17 with an optical microscope (magnification: 200 times).

Fig. 3 is an image when observing a side-by-side type crimped fiber obtained in Example 18 with an optical microscope (magnification: 200 times).

Fig. 4 is an image when observing a side-by-side type crimped fiber obtained in Example 19 with an optical microscope (magnification: 200 times).

Fig. 5 is an image when observing a side-by-side type crimped fiber obtained in Example 20 with an optical microscope (magnification: 200 times).

Fig. 6 is an image when observing a side-by-side type crimped fiber obtained in Example 21 with an optical microscope

(magnification: 200 times).

Description of Embodiments

[0010] The present invention is hereunder described in detail.

[0011] In the present specification, the "crimped fiber" is used in a meaning including a conjugated spun fiber of a combination of different thermoplastic resins made using a side-by-side type nozzle, an eccentric core-sheath type nozzle, a deformed nozzle, or a divided nozzle. In addition, the core-sheath type fiber refers to a fiber whose cross section is composed of a "core" as an inner layer and a "sheath" as an outer layer, and the eccentric core-sheath type fiber refers to a fiber in which in the cross-sectional shape thereof, the center of gravity of an inner layer part is different from the center of gravity of the whole of the fiber.

[0012] In the present specification, among the components constituting the crimped fiber, the component containing the thermoplastic resin (A) is referred to as a "first component", and the component containing the thermoplastic resin (B) and the thermoplastic resin (C) is referred to as a "second component". In the present specification, in the case where the crimped fiber is a side-by-side type fiber, one of the components constituting the side-by-side type fiber is referred to as the "first component", and the other component is referred to as the "second component". In addition, in the case where the crimped fiber is a core-sheath type fiber, either one of the component to be used for the core layer composition and the component to be used for the sheath layer composition of the core-sheath type fiber is referred to as the "first component", with the other being referred to as the "second component".

<Crimped Fiber>

[0013] The crimped fiber of the present embodiment is a crimped fiber including one component thereof containing a thermoplastic resin (A) and another component thereof containing a thermoplastic resin (B) and a thermoplastic resin (C), wherein a half-crystallization time at 25°C of the thermoplastic resin (A) is shorter than a half-crystallization time at 25°C of the thermoplastic resin (B), and a half-crystallization time at 25°C of the thermoplastic resin (C) is longer than the half-crystallization time at 25°C of the thermoplastic resin (B).

[0014] In the present embodiment, when the thermoplastic resin (A), the thermoplastic resin (B), and the thermoplastic resin (C) satisfy the aforementioned relations, a difference between the half-crystallization time at 25°C of the first component containing the thermoplastic resin (A) and the half-crystallization time at 25°C of the second component containing the thermoplastic resin (B) and the thermoplastic resin (C) becomes larger, so that a crimped fiber having higher crimping properties can be provided.

[0015] In the present embodiment, the half-crystallization time was measured by the following method.

[0016] Using FLASH DSC (manufactured by Mettler Toledo International Inc.), a sample was heated and melted at 230°C for 2 minutes and then cooled to 25°C at a rate of 2,000°C/sec, thereby measuring a change in calorific value with time in an isothermal crystallization process at 25°C. When an integrated value of the calorific value from the start of isothermal crystallization until the completion of crystallization was defined as 100%, a time from the start of isothermal crystallization until the integrated value of the calorific value became 50% was defined as the half-crystallization time.

[0017] From the viewpoint of enhancing the crimping properties of the crimped fiber, it is preferred that a melt flow rate (MFR) of the thermoplastic resin (A) is smaller than an MFR of the thermoplastic resin (B); and that the MFR of the thermoplastic resin (B) is smaller than an MFR of the thermoplastic resin (C).

[0018] The melt flow rate (MFR) is measured by the measurement method prescribed in JIS K7210, and it is measured under a condition at a temperature of 190°C and a load of 2.16 g with respect to the thermoplastic resin (A) and under a condition at a temperature of 230°C and a load of 2.16 g with respect to the thermoplastic resin (B) and the thermoplastic resin (C), respectively.

[0019] From the viewpoint of enhancing the crimping properties of the crimped fiber, it is preferred that a melting point (T_m-D) of the thermoplastic resin (A) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is lower than a melting point (T_m-D) of the thermoplastic resin (B) defined under the aforementioned condition; and that the melting point (T_m-D) of the thermoplastic resin (B) is higher than a melting point (T_m-D) of the thermoplastic resin (C) defined under the aforementioned condition.

[Thermoplastic Resin (A)]

[0020] In the thermoplastic resin (A) which is used in the present embodiment, the half-crystallization time at 25°C is shorter than the half-crystallization time at 25°C of the thermoplastic resin (B) as mentioned later, and is preferably 0.01 seconds or less. When the half-crystallization time at 25°C of the thermoplastic resin (A) is 0.01 seconds or less, a

crimped fiber having higher crimping properties is obtained.

[0021] The melt flow rate (MFR) of the thermoplastic resin (A) is preferably 1 g/10 min or more, more preferably 5 g/10 min or more, still more preferably 10 g/10 min or more, and yet still more preferably 15 g/10 min or more, and it is preferably 70 g/10 min or less, more preferably 45 g/10 min or less, still more preferably 30 g/10 min or less, and yet still more preferably 20 g/10 min or less.

[0022] The melt flow rate (MFR) is measured by the measurement method prescribed in JIS K7210, and it is measured under a condition at a temperature of 190°C and a load of 2.16 kg.

[0023] The melting point (T_m-D) of the thermoplastic resin (A) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is preferably 90°C or higher, more preferably 100°C or higher, and still more preferably 115°C or higher, and it is preferably 135°C or lower, and more preferably 130°C or lower.

[0024] Although the thermoplastic resin (A) is not particularly limited so long as it satisfies the aforementioned requirements, it is preferably a polyethylene-based resin using a so-called metallocene catalyst having a narrow molecular weight distribution. The polyethylene-based resin may be either an ethylene homopolymer or a copolymer. In the case of a copolymer, a copolymerization ratio of an ethylene unit is more than 50 mol%, preferably 60 mol% or more, more preferably 70 mol% or more, still more preferably 90 mol% or more, and yet still more preferably 95 mol% or more. A copolymerizable monomer is, for example, an α -olefin having 3 to 30 carbon atoms, and specific examples thereof include 1-butene, 1-pentene, 1-hexene, 1-octene, and 1-decene.

[0025] Examples of commercially available products of the ethylene homopolymer include "ASPUN™" Series (for example, "ASPUN XUS 61800.52 LE" and "ASPUN 6834E" (manufactured by The Dow Chemical Company). In addition, examples of commercially available products of a copolymer of ethylene and octene include "AFFINITY GA1900", "AFFINITY GA1950", "AFFINITY EG8185", "AFFINITY EG8200", "ENGAGE 8137", "ENGAGE 8180", and "ENGAGE 8400", all of which are manufactured by The Dow Chemical Company (all of them are a trade name).

[0026] In the polyethylene-based resin, as its weight average molecular weight (M_w) is large, the crimping properties of the resulting crimped fiber can be enhanced; however, end breakage is liable to occur, and spinnability is lowered. In addition, as a density of the polyethylene-based resin is high, the crimping properties of the resulting crimped fiber can be enhanced; however, end breakage is liable to occur, and spinnability is lowered. On the other hand, in the crimped fiber of the present embodiment, by using, as the second component, the component having the thermoplastic resin (C) added to the thermoplastic resin (B) as mentioned later, the end breakage can be suppressed, the spinnability can be enhanced, and furthermore, the crimping properties can be enhanced.

[0027] When the amount of the first component is defined as 100% by mass, the content of the thermoplastic resin (A) in the first component is preferably 80% by mass or more, more preferably 85% by mass or more, and still more preferably 90% by mass or more, and its upper limit value is 100% by mass.

[Thermoplastic Resin (B)]

[0028] The half-crystallization time at 25°C of the thermoplastic resin (B) which is used in the present embodiment is shorter than the half-crystallization temperature at 25°C of the thermoplastic resin (C) as mentioned later, and it is preferably more than 0.01 seconds, more preferably 0.02 seconds or more, still more preferably 0.03 seconds or more, and yet still more preferably 0.04 seconds or more, and it is preferably 0.06 seconds or less, more preferably less than 0.06 seconds, and still more preferably 0.05 seconds or less. When the half-crystallization time at 25°C of the thermoplastic resin (B) is more than 0.01 seconds, a difference from the half-crystallization time at 25°C of the thermoplastic resin (A) is generated, so that the crimping properties of the crimped fiber can be enhanced.

[0029] The melt flow rate (MFR) of the thermoplastic resin (B) is preferably 10 g/10 min or more, and more preferably 30 g/10 min or more, and it is preferably 500 g/10 min or less.

[0030] The melt flow rate (MFR) is measured by the measurement method prescribed in JIS K7210, and it is measured under a condition at a temperature of 230°C and a load of 2.16 kg.

[0031] The melting point (T_m-D) of the thermoplastic resin (B) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is preferably 120°C or higher, more preferably 130°C or higher, and still more preferably 140°C or higher, and it is preferably 200°C or lower, more preferably 180°C or lower, and still more preferably 170°C or less.

[0032] Although the thermoplastic resin (B) is not particularly limited so long as it satisfies the aforementioned requirements, it is preferably a polypropylene-based resin. The polypropylene-based resin may be a propylene homopolymer or may also be a copolymer; however, it is preferably a propylene homopolymer using a so-called metallocene catalyst having a narrow molecular weight distribution. In addition, in the case of a copolymer, a copolymerization ratio of a propylene unit is 50 mol% or more, preferably 60 mol% or more, more preferably 70 mol% or more, still more preferably

90 mol% or more, and especially preferably 95 mol% or more. Examples of a copolymerizable monomer include α -olefins having 2 carbon atoms or 4 to 20 carbon atoms, such as ethylene, 1-butene, 1-pentene, 1-hexene, 1-octene, and 1-decene; acrylic acid esters, such as methyl acrylate; and vinyl acetate. From the viewpoint of spinnability, a propylene homopolymer is preferred.

[0033] In the thermoplastic resin (B), a polypropylene-based resin resulting from polymerization using a catalyst other than the metallocene-based catalyst (for example, a Ziegler-Natta catalyst) may be contained. These may be used alone or may be used in combination of two or more thereof.

[0034] Specific examples thereof include a peroxide-containing propylene-based resin.

[0035] Examples of commercially available products of the propylene homopolymer include "NOVATEC™ PP" Series (for example, "NOVATEC SA03") (manufactured by Japan Polypropylene Corporation). In addition, examples of commercially available products of the peroxide-containing propylene homopolymer resulting from polymerization using a catalyst other than the metallocene-based catalyst include "Moplen" Series (for example, "Moplen HP461Y") (manufactured by Lyondell Basell); and PP3155 (a trade name, manufactured by ExxonMobil Chemical Corporation).

[0036] Examples of commercially available products of the polypropylene-based resin resulting from polymerization using a metallocene-based catalyst include "Metocene" Series (for example, "Metocene MF650Y") (manufactured by Lyondell Basell).

[0037] From the viewpoint of performing the viscosity control, a polypropylene-based resin resulting from polymerization using a metallocene-based catalyst is preferred.

[0038] When the amount of the second component is defined as 100% by mass, the content of the thermoplastic resin (B) in the second component is preferably 50% by mass or more, more preferably 60% by mass or more, still more preferably 70% by mass or more, and yet still more preferably 80% by mass or more, and it is preferably 99% by mass or less, more preferably 97% by mass or less, and still more preferably 95% by mass or less.

[Thermoplastic Resin (C)]

[0039] The half-crystallization time at 25°C of the thermoplastic resin (C) which is used in the present embodiment is longer than that of the thermoplastic resin (B), and it is preferably 0.06 seconds or more, and more preferably more than 0.06 seconds.

[0040] When the half-crystallization time at 25°C of the thermoplastic resin (C) is 0.06 seconds or more, a difference between the half-crystallization time at 25°C of the first component and the half-crystallization time at 25°C of the second component can be made larger, and the crimping properties of the crimped fiber can be more enhanced.

[0041] The melt flow rate (MFR) of the thermoplastic resin (C) is preferably 10 g/10 min or more, and more preferably 500 g/10 min or more, and it is preferably 5,000 g/10 min or less. When the MFR is 10 g/10 min or more, a difference between the MFR of the first component and the MFR of the second component can be made larger, and the crimping properties of the crimped fiber can be more enhanced.

[0042] The melt flow rate (MFR) is measured by the measurement method prescribed in JIS K7210, and it is measured under a condition at a temperature of 230°C and a load of 2.16 kg.

[0043] The melting point (Tm-D) of the thermoplastic resin (C) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is preferably 50°C or higher, and more preferably 60°C or higher, and it is preferably 100°C or lower. When the melting point (Tm-D) of the thermoplastic resin (C) is 50°C or more, a difference between the melting point (Tm-D) of the first component and the melting point (Tm-D) of the second component can be made larger.

[0044] A weight average molecular weight (Mw) of the thermoplastic resin (C) is preferably 30,000 or more, and it is preferably 150,000 or less, and more preferably 60,000 or less.

[0045] A molecular weight distribution (Mw/Mn) of the thermoplastic resin (C) is preferably less than 3.0, more preferably 2.5 or less, and still more preferably 2.3 or less. When the molecular weight distribution of the thermoplastic resin (C) falls within the aforementioned range, the generation of stickiness in the fiber obtained by spinning is suppressed.

[0046] The aforementioned weight average molecular weight (Mw) and the molecular weight distribution (Mw/Mn) are determined by means of a gel permeation chromatography (GPC) measurement. The weight average molecular weight is a weight average molecular weight expressed in terms of polystyrene, as measured by using the following device under the following condition, and the molecular weight distribution is a value calculated from a number average molecular weight (Mn) as measured similarly and the aforementioned weight average molecular weight.

<GPC Measuring Device>

[0047]

Column: "TOSO GMHHR-H(S)HT", manufactured by Tosoh Corporation

Detector: RI detector for liquid chromatogram, "WATERS 150C", manufactured by Waters Corporation

<Measurement Condition>

[0048]

Solvent: 1,2,4-Trichlorobenzene

Measurement temperature: 145°C

Flow rate: 1.0 mL/min

Sample concentration: 2.2 mg/mL

Injection amount: 160 µL

Calibration curve: Universal Calibration

Analysis program: HT-GPC (Ver. 1.0)

[0049] In the thermoplastic resin (C), a melting endotherm ($\Delta H-D$) obtained from a melting endothermic curve obtained by holding a sample under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is preferably 0 J/g or more, more preferably 10 J/g or more, and still more preferably 20 J/g or more, and it is preferably 80 J/g or less, more preferably 60 J/g or less, and still more preferably 40 J/g or less.

[0050] In the present embodiment, the melting endotherm ($\Delta H-D$) is calculated by determining an area surrounded by a line containing a peak of a melting endothermic curve obtained by holding a sample under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) and a line connecting a point on the low-temperature side free from a change of the amount of heat with a point on the high-temperature side free from a change of the amount of heat (this line is referred to as a baseline).

[0051] Although the thermoplastic resin (C) is not particularly limited so long as it satisfies the aforementioned requirements, it is preferably a polypropylene-based resin. The polypropylene-based resin may be either a propylene homopolymer or a copolymer. From the viewpoint of suppressing stickiness, a polypropylene-based resin resulting from polymerization using a metallocene-based catalyst is performed.

[0052] Examples of the propylene homopolymer include low-molecular weight polypropylene, and preferably L-MODU (manufactured by Idemitsu Kosan Co., Ltd.) and Moplen (manufactured by Lyondell Basell), each being synthesized using a metallocene-based catalyst. These may be used alone or may be used in admixture of two or more thereof.

[0053] In the case where the polypropylene-based resin is a copolymer, a copolymerization ratio of a propylene unit is more than 50 mol%, preferably 60 mol% or more, more preferably 70 mol% or more, still more preferably 90 mol% or more, and yet still more preferably 95 mol% or more. A copolymerizable monomer is at least one selected from the group consisting of ethylene and an α -olefin having 4 to 30 carbon atoms, and specific examples thereof include ethylene, 1-butene, 1-pentene, 1-hexene, 1-octene, and 1-decene.

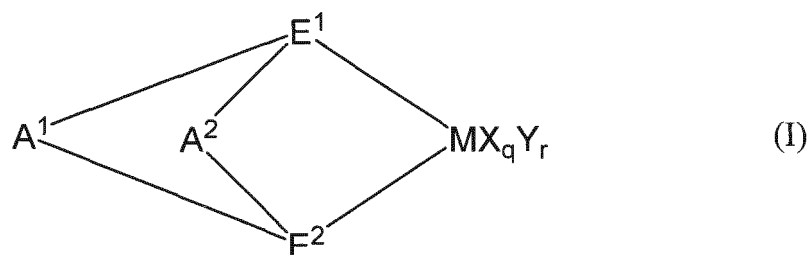
[0054] In the case where the polypropylene-based resin is a copolymer, the polypropylene-based resin preferably contains at least one structural unit selected from the group consisting of ethylene and an α -olefin having 4 to 30 carbon atoms in an amount of more than 0 mol% and 20 mol% or less.

(Production Method of Thermoplastic Resin (C))

[0055] In the case where the thermoplastic resin (C) is a polypropylene-based resin, the polypropylene-based resin can be produced using a metallocene-based catalyst described in, for example, WO 2003/087172 A. In particular, a metallocene-based catalyst using a transition metal compound in which a ligand forms a crosslinked structure via a crosslinking group is preferred. Above all, a metallocene-based catalyst obtained by combining a transition metal compound in which a crosslinked structure is formed via two crosslinking groups with a cocatalyst is preferred.

[0056] Specifically, examples thereof include a polymerization catalyst containing

(i) a transition metal compound represented by the general formula (I):



wherein,

M represents a metal element belonging to any one of the Groups 3 to 10 or the lanthanoid series in the periodic table; E¹ and E² each represent a ligand selected from a substituted cyclopentadienyl group, an indenyl group, a substituted indenyl group, a heterocyclopentadienyl group, a substituted heterocyclopentadienyl group, an amide group, a phosphide group, a hydrocarbon group, and a silicon-containing group, and forms a crosslinked structure via A¹ and A², and may be the same as or different from each other; X represents a σ -bonding ligand, and when plural X's are present, the plural X's may be the same as or different from each other, and each X may crosslink with any other X, E¹, E², or Y; Y represents a Lewis base, and when plural Y's are present, the plural Y's may be the same as or different from each other, and each Y may crosslink with any other Y, E¹, E², or X; A¹ and A² each represent a divalent crosslinking group that bonds two ligands and represent a hydrocarbon group having 1 to 20 carbon atoms, a halogen-containing hydrocarbon group having 1 to 20 carbon atoms, a silicon-containing group, a germanium-containing group, a tin-containing group, -O-, -CO-, -S-, -SO₂-, -Se-, -NR¹-, -PR¹-, -P(O)R¹-, -BR¹-, or -AlR¹-, wherein R¹ represents a hydrogen atom, a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms, or a halogen-containing hydrocarbon group having 1 to 20 carbon atoms, and may be the same as or different from each other; q represents an integer of 1 to 5 and corresponds to [(valence of M) - 2]; and r represents an integer of 0 to 3, and

(ii) at least one component selected from the group consisting of (ii-1) a compound capable of reacting with the transition metal compound that is the component (i) or a derivative thereof to form an ionic complex and (ii-2) an aluminoxane.

[0057] The transition metal compound that is the aforementioned component (i) is preferably a transition metal compound in which the ligand is of a (1,2')(2,1') double crosslinking type, and examples thereof include (1,2'-dimethylsilylene)(2,1'-dimethylsilylene)-bis(3-trimethylsilylmethylindenyl)zirconium dichloride.

[0058] Specific examples of the compound that is the aforementioned component (ii-1) include triethylammonium tetraphenylborate, tri-n-butylammonium tetraphenylborate, trimethylammonium tetraphenylborate, tetraethylammonium tetraphenylborate, methyl(tri-n-butyl)ammonium tetraphenylborate, benzyl(tri-n-butyl)ammonium tetraphenylborate, dimethyldiphenylammonium tetraphenylborate, triphenyl(methyl)ammonium tetraphenylborate, trimethylanilinium tetraphenylborate, methylpyridinium tetraphenylborate, benzylpyridinium tetraphenylborate, methyl(2-cyanopyridinium) tetraphenylborate, triethylammonium tetrakis(pentafluorophenyl)borate, tri-n-butylammonium tetrakis(pentafluorophenyl)borate, triphenylammonium tetrakis(pentafluorophenyl)borate, tetra-n-butylammonium tetrakis(pentafluorophenyl)borate, tetraethylammonium tetrakis(pentafluorophenyl)borate, benzyl(tri-n-butyl)ammonium tetrakis(pentafluorophenyl)borate, methyldiphenylammonium tetrakis(pentafluorophenyl)borate, triphenyl(methyl)ammonium tetrakis(pentafluorophenyl)borate, methylanilinium tetrakis(pentafluorophenyl)borate, dimethylanilinium tetrakis(pentafluorophenyl)borate, methylpyridinium tetrakis(pentafluorophenyl)borate, benzylpyridinium tetrakis(pentafluorophenyl)borate, methyl(2-cyanopyridinium) tetrakis(pentafluorophenyl)borate, benzyl(2-cyanopyridinium) tetrakis(pentafluorophenyl)borate, methyl(4-cyanopyridinium) tetrakis(pentafluorophenyl)borate, triphenylphosphonium tetrakis(pentafluorophenyl)borate, dimethylanilinium tetrakis[bis(3, 5-difluoromethyl)phenyl]borate, ferrocenium tetraphenylborate, silver tetraphenylborate, trityl tetraphenylborate, tetraphenylporphyrinmanganese tetraphenylborate, ferrocenium tetrakis(pentafluorophenyl)borate, (1,1'-dimethylferrocenium) tetrakis(pentafluorophenyl)borate, decamethylferrocenium tetrakis(pentafluorophenyl)borate, silver tetrakis(pentafluorophenyl)borate, trityl tetrakis(pentafluorophenyl)borate, lithium tetrakis(pentafluorophenyl)borate, sodium tetrakis(pentafluorophenyl)borate, tetraphenylporphyrinmanganese tetrakis(pentafluorophenyl)borate, silver tetrafluoroborate, silver hexafluorophosphate, silver hexafluoroarsenate, silver perchlorate, silver trifluoroacetate, and silver trifluoromethanesulfonate.

[0059] Examples of the aluminoxane that is the aforementioned component (ii-2) include known chain aluminoxanes and cyclic aluminoxanes.

[0060] The polypropylene-based resin may also be produced by jointly using an organoaluminum compound, such as trimethylaluminum, triethylaluminum, triisopropylaluminum, triisobutylaluminum, dimethylaluminum chloride, diethylaluminum chloride, methylaluminum dichloride, ethylaluminum dichloride, dimethylaluminum fluoride, diisobutylalumi-

num hydride, diethylaluminum hydride, and ethylaluminum sesquichloride.

[0061] From the viewpoint of enhancing the crimping properties, when the amount of the second component is defined as 100% by mass, the content of the thermoplastic resin (C) in the second component is preferably 1% by mass or more, more preferably 3% by mass or more, and still more preferably 5% by mass or more, and it is preferably 50% by mass or less, more preferably 40% by mass or less, still more preferably 30% by mass or less, and yet still more preferably 20% by mass or less. When the content of the thermoplastic resin (C) in the second component is 1% by mass or more, it becomes possible to achieve reduction of the fiber diameter, and the flexibility of the nonwoven fabric is improved with a decrease of the elastic modulus of the fiber.

[0062] From the viewpoint of enhancing the crimping properties, the content of the thermoplastic resin (C) occupying in the sum total of the thermoplastic resin (A), the thermoplastic resin (B), and the thermoplastic resin (C) is preferably 1% or more, more preferably 2% or more, and still more preferably 5% or more, and it is preferably 50% or less, more preferably 30% or less, and still more preferably 20% or less.

[0063] In the crimped fiber of the present embodiment, at least one of the first component and the second component can be compounded with an arbitrary additive within a range where the effects of the present embodiment are not impaired. Specific examples of the additive include a foaming agent, a crystal nucleating agent, a weatherability stabilizer, a UV absorber, a light stabilizer, a heat resistance stabilizer, an antistatic agent, a release agent, a flame retardant, a synthetic oil, a wax, an electric property-improving agent, a slip inhibitor, an anti-blocking agent, a viscosity-controlling agent, a coloring inhibitor, a defogging agent, a lubricant, a pigment, a dye, a plasticizer, a softening agent, an age resistor, a hydrochloric acid-absorbing agent, a chlorine scavenger, an antioxidant, and an antitack agent.

[0064] In the crimped fiber of the present embodiment, a mass ratio of the first component containing the thermoplastic resin (A) to the second component containing the thermoplastic resin (B) and the thermoplastic resin (C) is preferably 9/1 to 1/9, and more preferably 7/3 to 3/7. When the mass ratio of the first component to the second component falls within the aforementioned range, in the crimped nonwoven fabric, crimping properties and stretchability are revealed.

[0065] Although examples of the crimped fiber of the present embodiment include a side-by-side type fiber, a core-sheath type fiber, and an eccentric core-sheath type fiber, a side-by-side type fiber is preferred.

[0066] As a result of extensive and intensive analyses made by the present inventors, it has been found that the crimped fiber of the present embodiment is divided into the case where the component containing the thermoplastic resin (A), preferably the component containing a polyethylene-based resin, is located inside the crimp; and the case where the component containing the thermoplastic resin (B), preferably the component containing a polypropylene-based resin, is located inside the crimp, depending upon a spinning condition and the like.

[0067] Although the mechanism in which such a phenomenon is generated is not always elucidated yet, it may be conjectured as follows.

[0068] The mechanism is described by reference to the case where the thermoplastic resin (A) is a polyethylene-based resin, and the thermoplastic resin (B) is a polypropylene-based resin.

[0069] First of all, when the thermoplastic resin (C) is not added, since the spinning speed and spinnability are not improved, the spinning speed is not increased, so that the spinning is performed only at a low speed.

[0070] In the case where the spinning speed is low, on the occasion when the polyethylene-based resin is cooled to achieve solidification (crystallization), its density becomes higher than that of the polypropylene-based resin, and therefore, a difference in a shrinkage ratio from the polypropylene-based resin is generated. In this way, in the case where the difference in a shrinkage ratio between the two components becomes a control factor to undergo crimping of the fiber, the polyethylene-based resin having a higher shrinkage ratio is located inside the crimp.

[0071] On the other hand, under a condition under which the spinning speed is thoroughly fast, it may be conjectured that oriented crystallization also contributes as a control factor of crimping. In the case of a conjugate fiber of the polypropylene-based resin and the polyethylene-based resin, it is known that the oriented state of a molecule or crystal of the polypropylene-based resin is higher than the oriented state of a molecule or crystal of the polyethylene-based resin (Journal of the Textile Machinery Society of Japan: "Sen-i Kogaku", Vol. 55, No. 5 (2002), pp.236-242). This may be considered to be suggested such that when a strong molecular orientation of a constant value or higher is applied, a phenomenon in which the polypropylene-based resin is crystallized more fast than the polyethylene-based resin occurs.

[0072] In the case where the thermoplastic resin (C) is added, the spinnability is improved, and it is possible to increase the spinning speed. In the case where the spinning speed is fast, on the occasion when the polypropylene-based resin is cooled to achieve solidification (crystallization), the polypropylene-based resin is crystallized more fast than the polyethylene-based resin, and therefore, a difference in a solidification speed from the polyethylene-based resin is generated. In this way, in the case where the difference in a shrinkage ratio between the two components becomes a control factor to undergo crimping of the fiber, the polypropylene-based resin having a higher shrinkage ratio is located inside the crimp.

[0073] Such a phenomenon may exert a strong influence on the case where the resin in a semi-molten state immediately after being discharged from a die forms a crimped fiber. Namely, in the case where the spinning speed is thoroughly fast, when the polypropylene-based resin is solidified and immobilized in advance of the polyethylene-based resin, the polyethylene-based resin which is in a semi-molten state at that moment is solidified while refaxing, and therefore, there

is a possibility that the polyethylene-based resin is located outside the crimp. Conversely, in the case where the spinning speed is slow, only a molecular orientation of a constant value or lower is applied, and therefore, the speed of the original crystallization becomes a control factor. Thus, the polyethylene-based resin is located inside the crimp, whereas the polypropylene-based resin is located outside the crimp.

[0074] Not only in the case where the spinning speed is fast, but also in the case where the discharge amount is small, the case where the resin temperature is low, the case where the fluidity of the resin is low, and the case where the resin contains a lot of high-molecular weight components, during spinning, an environment where the molecular orientation on the resin is strongly applied is generated, and therefore, it may be said that the possibility in which the polypropylene-based resin is located inside the crimp becomes high.

[0075] The polypropylene-based resin is shrunk due to not only crystallization but also a force at which the molecular chains having been drawn in a tangled state on spinning are released from stretching to return back. In consequence, different from the polyethylene-based resin, in the case of the polypropylene-based resin, as a stretching force to be applied during spinning is strong, the shrinkage ratio becomes high. Even in the case where the foregoing shrinkage ratio excels the shrinkage ratio due to crystallization of the polyethylene-based resin, the control factor at which the fiber crimps changes, whereby the polypropylene-based resin having a higher shrinkage ratio is located inside the crimp.

[0076] In the case where the crimped fiber of the present embodiment is a side-by-side type fiber, the resin constituting the inside of the crimp in the crimped fiber may be any of the component containing the thermoplastic resin (A), the component composed of the thermoplastic resin (A), the component containing the thermoplastic resin (B), and the component composed of the thermoplastic resin (B).

[Production of Crimped Fiber]

[0077] As a production method of the crimped fiber of the present embodiment, an example of the production method of a side-by-side type crimped fiber is shown below.

[0078] The side-by-side type crimped fiber is produced by the melt spinning method in which the resins of at least two components are each separately melt extruded with an extruder and extruded from special spinning nozzles as disclosed in, for example, U.S. Patent 3,671,379, and the molten resins each separately melt extruded from the extruder are joined and discharged in a fiber form, followed by cooling for solidification. Here, in the aforementioned process, as the spinning speed is fast, the crimping properties of the resulting side-by-side type crimped fiber can be enhanced, and hence, such is preferred.

[0079] In the production method of a side-by-side type crimped fiber in the present embodiment, the desired fiber can be produced even without performing a post-treatment step, such as heating or stretching after spinning; however, the post-treatment step may be adopted, if desired. For example, a crimping degree of the fiber may be increased by heating at 100 to 150°C, stretching in a ratio of 1.2 to 5 times, or a combined condition thereof.

[0080] As for the crimped fiber of the present embodiment, from the viewpoint of a balance among texture of the nonwoven fabric, flexibility, and strength, a fineness as calculated by the following measuring method is preferably 0.5 deniers or more, and more preferably 0.8 deniers or more, and it is preferably 2.5 denies or less, and more preferably 2.0 deniers or less. The fineness of the crimped fiber is calculated by the following measurement method.

[Measurement of Fineness]

[0081] Fibers in a nonwoven fabric are observed with a polarizing microscope, an average value (d) of diameter of randomly selected 100 fibers is measured, and the fineness of the nonwoven fabric sample is calculated from a density of the resin ($\rho = 900,000 \text{ g/m}^3$) according to the following expression.

$$\text{Fineness (denier)} = \rho \times \pi \times (d/2)^2 \times 9,000$$

[0082] In the crimped fiber of the present embodiment, the number of crimps is preferably 2 or more per 25 mm, more preferably 5 or more per 25 mm, still more preferably 10 or more per 25 mm, yet still more preferably 13 or more per 25 mm, and even yet still more preferably 15 or more per 25 mm.

[0083] In the crimped fiber of the present embodiment, the crimping degree is preferably 1.5% or more, more preferably 3% or more, still more preferably 5% or more, yet still more preferably 7% or more, and even yet still more preferably 9% or more.

[0084] The number of crimps and the crimping degree can be measured by the methods described in the section of Examples.

<Nonwoven Fabric>

[0085] The nonwoven fabric of the present embodiment includes the aforementioned crimped fiber. The nonwoven fabric is small in terms of the fineness as mentioned above and is excellent in terms of spinning stability even under a forming condition under which end breakage likely occurs. In addition, the nonwoven fabric of the present embodiment may also be a multilayered nonwoven fabric including a laminate of two or more layers. In that case, from the viewpoint of smoothness of the surface, it is preferred that at least one layer of the nonwoven fabric constituting an outer layer of the multilayered nonwoven fabric is the nonwoven fabric including the aforementioned crimped fiber.

<Production Method of Nonwoven Fabric>

[0086] The production method of the nonwoven fabric of the present embodiment is not particularly limited, and a conventionally known method can be adopted. As an example thereof, the spunbonding method is shown below.

[0087] Generally, in the spunbonding method, a melt-kneaded resin composition is spun, stretched, and then opened to form a continuous long fiber, and subsequently, in the continuing step, the continuous long fiber is deposited on a moving collector surface and entangled to produce a nonwoven fabric. According to the foregoing method, the nonwoven fabric can be continuously produced, and the fibers constituting the nonwoven fabric are a stretched continuous long fiber, and therefore, the strength is high. As for the spunbonding method, a conventionally known method can be adopted, and the fibers can be produced by extruding a molten polymer from, for example, a group of large nozzle having several thousand holes, or for example, a group of small nozzles each having about 40 holes. After being ejected from the nozzle, the molten fiber is cooled by a cross-flow cold air system and then drawn away from the nozzle, followed by stretching by high-speed airflow. Generally, there are two kinds of air-damping methods, both of which use a venturi effect. In the first method, a filament is stretched using a suction slot (slot stretching), and this method is conducted with a width of the nozzle or a width of the machine. In the second method, a filament is stretched through a nozzle or a suction gun. A filament formed by this method is collected on a screen (wire) or a pore forming belt to form a web. Subsequently, the web passes through compression rolls and then between heating calendar rolls and are bounded at a part where the embossing part on one roll includes about 10% or more and about 40% or less of the area of the web to form a nonwoven fabric.

[Fiber Product]

[0088] Although the fiber product using the nonwoven fabric of the present embodiment is not particularly limited, for example, the following fiber products can be exemplified. That is, examples thereof include a member for a disposable diaper, a stretchable member for a diaper cover, a stretchable member for a sanitary product, a stretchable member for a hygienic product, a stretchable tape, an adhesive bandage, a stretchable member for clothing, an insulating material for clothing, a heat insulating material for clothing, a protective suit, a hat, a mask, a glove, a supporter, a stretchable bandage, a base fabric for a fomentation, a non-slip base fabric, a vibration absorber, a finger cot, an air filter for a clean room, an electret filter subjected to electret processing, a separator, a heat insulator, a coffee bag, a food packaging material, a ceiling skin material for an automobile, an acoustic insulating material, a cushioning material, a speaker dust-proof material, an air cleaner material, an insulator skin, a backing material, an adhesive nonwoven fabric sheet, various members for automobiles, such as a door trim, various cleaning materials, such as a cleaning material for a copying machine, the facing and backing of a carpet, an agricultural beaming, a timber drain, members for shoes, such as a sport shoe skin, a member for a bag, an industrial sealing material, a wiping material, and a sheet.

Examples

[0089] Next, the present invention is specifically described by reference to Examples, but it should be construed that the present invention is by no means limited by these Examples.

[Half-crystallization Time]

[0090] The half-crystallization time was measured using FLASH DSC (manufactured by Mettler Toledo International Inc.) by the following method.

(1) A sample was heated and melted at 230°C for 2 minutes and then cooled to 25°C at a rate of 2,000°C/sec, thereby measuring a change in calorific value with time in an isothermal crystallization process at 25°C.

(2) When an integrated value of the calorific value from the start of isothermal crystallization until the completion of crystallization was defined as 100%, a time from the start of isothermal crystallization until the integrated value of

the calorific value became 50% was defined as the half-crystallization time.

[Melt Flow Rate (MFR)]

[0091] In conformity with JIS K7210, the melt flow rate (MFR) was measured for the thermoplastic resin (A) under a condition at a temperature of 190°C and a load of 2.16 kg and for the thermoplastic resin (B) and the thermoplastic resin (C) under a condition at a temperature of 230°C and a load of 2.16 kg, respectively.

[DSC Measurement]

[0092] A melting endotherm ($\Delta H-D$) was determined from a melting endothermic curve obtained by holding 10 mg of a sample at -10°C for 5 minutes under a nitrogen atmosphere and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC-7, manufactured PerkinElmer Inc.). In addition, a melting point (T_m-D) was determined from a peak top of a peak observed on the highest temperature side of the obtained melting endothermic curve.

[0093] The melting endotherm ($\Delta H-D$) is calculated in a manner in which when a line connecting a point on the low-temperature side free from a change of the amount of heat with a point on the high-temperature side free from a change of the amount of heat is defined as a baseline, an area surrounded by a line portion including the peak of the melting endothermic curve obtained by the DSC measurement using a differential scanning calorimeter (DSC-7, manufactured PerkinElmer Inc.) and the baseline is determined.

[Measurement of Weight Average Molecular Weight (M_w) and Molecular Weight Distribution (M_w/M_n)]

[0094] The weight average molecular weight (M_w) and the number average molecular weight (M_n) were measured by the gel permeation chromatography (GPC) method to obtain the molecular weight distribution (M_w/M_n). The following device and condition were used for the measurement to obtain a weight average molecular weight and a number average molecular weight as expressed in terms of polystyrene. The molecular weight distribution (M_w/M_n) is a value calculated from these weight average molecular weight (M_w) and number average molecular weight (M_n).

<GPC Measuring Device>

[0095]

Column: "TOSO GMHHR-H(S)HT", manufactured by Tosoh Corporation

Detector: RI detector for liquid chromatogram, "WATERS 150C", manufactured by Waters Corporation

<Measurement Condition>

[0096]

Solvent: 1,2,4-Trichlorobenzene

Measurement temperature: 145°C

Flow rate: 1.0 mL/min

Sample concentration: 2.2 mg/mL

Injection amount: 160 μ L

Calibration curve: Universal Calibration

Analysis program: HT-GPC (Ver. 1.0)

(Production of Propylene-based Polymer (C1) [Thermoplastic Resin (C1)])

[0097] Into a stirrer-equipped stainless steel-made reactor having an internal volume of 20 L, 20 L/h of n-heptane, 15 mmol/h of triisobutylaluminum, and further a catalyst component obtained by previously bringing dimethylanilinium tetrakis(pentafluorophenyl)borate, (1,2'-dimethylsilylene)(2,1'-dimethylsilylene)-bis(3-trimethylsilylmethylindenyl)zirconium dichloride, and triisobutylaluminum in a mass ratio of 1/2/20 into contact with propylene in an amount of 6 μ mol/L as expressed in terms of zirconium were continuously supplied.

[0098] Propylene and hydrogen were continuously supplied at a polymerization temperature of 75°C so as to keep a hydrogen concentration in the vapor phase at 24 mol% and a whole pressure within the reactor at 1.0 MPa-G, respectively. To the resulting polymerization solution, an antioxidant was added in a content proportion of 1,000 ppm by mass, and

the n-heptane as a solvent was then removed to obtain a propylene-based polymer (C1).

[0099] The resulting propylene-based polymer (C1) was subjected to the aforementioned measurements. The results are shown in Table 1.

(Production of Propylene-based Polymer (C2) [Thermoplastic Resin (C)])

[0100] Into a stirrer-equipped stainless steel-made reactor having an internal volume of 20 L, 20 L/h of n-heptane, 15 mmol/h of triisobutylaluminum, and further a catalyst component obtained by previously bringing dimethylanilinium tetrakis(pentafluorophenyl)borate, (1,2'-dimethylsilylene)(2,1'-dimethylsilylene)-bis(3-trimethylsilylmethylindenyl)zirconium dichloride, and triisobutylaluminum in a mass ratio of 1/2/20 into contact with propylene in an amount of 6 $\mu\text{mol/L}$ as expressed in terms of zirconium were continuously supplied.

[0101] Propylene and hydrogen were continuously supplied at a polymerization temperature of 65°C so as to keep a hydrogen concentration in the vapor phase at 8 mol% and a whole pressure within the reactor at 1.0 MPa·G, respectively. To the resulting polymerization solution, an antioxidant was added in a content proportion of 1,000 ppm by mass, and the n-heptane as a solvent was then removed to obtain a propylene-based polymer (C2).

[0102] The resulting propylene-based polymer (C2) was subjected to the aforementioned measurements. The results are shown in Table 1.

Table 1

	Unit	Propylene-based polymer (C1)	Propylene-based polymer (C2)
Half-crystallization time	sec	1 or more	1 or more
MFR	g/10 min	2,600	50
Melting point (Tm-D)	°C	80	80
Melting endotherm ($\Delta H-D$)	J/g	36	37
Weight average molecular weight (Mw)	-	45,000	130,000
Molecular weight distribution (Mw/Mn)	-	2	2

[0103] In the following Examples, the following raw materials were used.

<Thermoplastic Resin (A)>

Ethylene-based resin (A1):

[0104] "ASPUN XUS 61800.52 LE" (manufactured by The Dow Chemical Company, density: 0.948 g/cm³)

Ethylene-based resin (A2):

[0105] "ULTZEX 20200J" (manufactured by Prime Polymer Co., Ltd.) Ethylene-based resin (A3):

[0106] "ASPUN 6834" (manufactured by The Dow Chemical Company) Ethylene-based resin (A4):

[0107] "ASPUN 6850" (manufactured by The Dow Chemical Company) Ethylene-based resin (A5):

[0108] "Engage 8402" (manufactured by The Dow Chemical Company) Ethylene-based resin (A6):

[0109] "EVOLUE SP50500" (manufactured by Prime Polymer Co., Ltd.)

[0110] The half-crystallization time, the MFR, and the melting point (Tm-D) of each of the ethylene-based resins (A1), (A2), (A3), (A4), (A5), and (A6) as measured by the aforementioned methods are shown in Table 2.

<Thermoplastic Resin (B)>

Propylene homopolymer (B1):

[0111] "NOVATEC SA03" (manufactured by Japan Polypropylene Corporation)

Propylene homopolymer (B2):

[0112] "PP3155" (manufactured by ExxonMobil Chemical Corporation)

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[0113] The half-crystallization time, the MFR, and the melting point (T_m-D) of each of the propylene homopolymers (B1) and (B2) as measured by the aforementioned methods are shown in Table 2.

<Other Component>

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[0114] Slip inhibitor: Erucamide, a trade name: EA-10

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Table 2

	Unit	Ethylene-based resin (A1)	Ethylene-based resin (A2)	Ethylene-based resin (A3)	Ethylene-based resin (A4)	Ethylene-based resin (A5)	Ethylene-based resin (A6)	Propylene homopolymer (B1)	Propylene homopolymer (B2)
Half-crystallization time	sec	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.05	0.05
MFR	g/10 min	17	18.5	17	30	30	50	30	35
Melting point (T _m -D)	°C	129	120	130	130	98	125	167	166

Example 1

(Preparation of First Component)

5 **[0115]** Only the ethylene-based resin (A1) was used as the thermoplastic resin (A) to provide the first component.

(Preparation of Second Component)

10 **[0116]** 80% by mass of the propylene homopolymer (B1) as the thermoplastic resin (B) and 20% by mass of the propylene-based polymer (C1) obtained in Production Example 1 as the thermoplastic resin (C) were compounded to provide the second component.

(Production of Side-by-Side Type Crimped Fiber and Spunbonded Nonwoven Fabric Constituted of Said Crimped Fiber)

15 **[0117]** The formation of a side-by-side type crimped fiber was performed using a conjugate melt fiber spinning machine, bi-component spinning apparatus having two extruders. The first component and the second component were each separately melt extruded with a single-screw extruder at a resin temperature of 240°C, and the molten resin was discharged and spun from a side-by-side composite nozzle having a nozzle diameter of 0.60 mm (number of holes: 1,795 holes) at a rate of 54 kg/h per single hole in a mass ratio of the first component to the second component of 50/50, to
20 obtain a side-by-side type crimped fiber. The resulting side-by-side type crimped fiber was sucked at an ejector pressure of 5.0 kg/cm² while cooling with air at a cooling temperature of 12.5°C and at a wind velocity of 0.6 m/sec and collected on a moving net surface. The fiber bundle thus collected on the net surface was embossed by a heat roll heated at a calendar temperature of 110°C/110°C at a line pressure of 40 N/mm and wound up by a take-up roll.

25 Example 2

[0118] A side-by-side type crimped fiber and a nonwoven fabric were obtained in the same manner as in Example 1, except that in Example 1, the first component was changed to a composition composed of 98% by mass of the ethylene-based resin (A1) and 2% by mass of erucamide, and the second component was changed to a composition composed
30 of 78% by mass of the propylene homopolymer (B1), 20% by mass of the propylene-based polymer (C1), and 2% by mass of erucamide.

Example 3

35 **[0119]** A side-by-side type crimped fiber and a nonwoven fabric were obtained in the same manner as in Example 1, except that in Example 1, the first component was changed from the ethylene-based resin (A1) to the ethylene-based resin (A2), and the ejector pressure and the calendar temperature were changed to 4.5 kg/cm² and 100°C/100°C, respectively.

40 Comparative Example 1

[0120] A side-by-side type crimped fiber and a nonwoven fabric were obtained in the same manner as in Example 1, except that in Example 1, the second component was changed to a composition composed of 100% by mass of the propylene homopolymer (B1), and the ejector pressure and the calendar temperature were changed to 2.0 kg/cm² and
45 100°C/100°C, respectively.

[0121] With respect to the side-by-side type crimped fiber and the nonwoven fabric obtained in each of the Examples, the following measurements and evaluations were performed. The results are shown in Table 3.

[Measurement of Basis Weight]

50 **[0122]** A mass of 20 cm × 20 cm of the resulting nonwoven fabric was measured to measure a basis weight (gsm).

[Measurement of Fineness]

55 **[0123]** Fibers in the nonwoven fabric were observed with a polarizing microscope, an average value (d) of diameter of randomly selected 100 fibers was measured, and the fineness of the nonwoven fabric sample was calculated from a density of the resin ($\rho = 900,000 \text{ g/m}^3$) according to the following expression.

$$\text{Fineness (denier)} = \rho \times \pi \times (d/2)^2 \times 9,000$$

[Tensile Test]

[0124] A specimen having a size of 150 mm in length and 50 mm in width was sampled from the resulting nonwoven fabric in each of the machine direction (MD) and the transverse direction (TD) against the machine direction. Using a tensile tester (Autograph AG-I, manufactured by Shimadzu Corporation) and setting an initial length L_0 to 100 mm, the specimen was stretched at a tensile speed of 300 mm/min and measured for a strain and a load in a stretching process, and a maximum strength in a process until the nonwoven fabric was broken was defined as a nonwoven fabric strength.

[Hydrometer Test]

[0125] A specimen having a size of 200 mm in length and 200 mm in width was sampled from the resulting nonwoven fabric. The specimen was set on a slit having a width of 1/4 inch such that it was at an angle of 90° to the slit, and the position of 67 mm (1/3 of the specimen width) from the side of the specimen was indented in a proportion of 8 mm by a blade of a penetrator. A resistance value at this time was measured to evaluate flexibility of the specimen. The characteristic feature of this measurement method resides in the matter that the specimen slightly slips on a test bench, and a force in which a frictional force generated and a resistance force (flexibility) at the indentation time are combined together is measured. It is meant that as the value of resistance value obtained by the measurement is small, the flexibility of the nonwoven fabric is favorable.

[Measurement of Static Friction Coefficient]

[0126] A specimen having a size of 220 mm in length and 100 mm in width and a specimen having a size of 220 mm in length and 70 mm in width were sampled from the resulting nonwoven fabric in each of the machine direction (MD) and the transverse direction (TD) against the machine direction. Two sheets of the nonwoven fabrics were overlaid on a seating of a static friction coefficient measuring device ("friction measuring device AN type", manufactured by Toyo Seiki Kogyo Co., Ltd.); a weight of 1,000 g was placed thereon; the seating was inclined at a rate of 2.7 degrees/min; and an angle when the nonwoven fabrics slipped 10 mm was measured. From the mass (1,000 g) of the placed weight and the angle when the nonwoven fabrics slipped 10 mm, the static friction coefficient was calculated.

[0127] It is meant that as the value of the friction coefficient is small, the texture of the nonwoven fabric, such as hand touch feeling, is favorable.

[Measurement of Bulkiness]

[0128] A specimen having a size of 50 mm in length and 50 mm in width was sampled from the resulting nonwoven fabric. Ten sheets of the specimens were superimposed, 1.9 g of a metal plate was placed on the superimposed specimens, and a thickness of the superimposed specimens was measured. It is meant that as the numerical value of the thickness is high, the nonwoven fabric is high in bulkiness.

[Measurement of Number of Crimps]

[0129] The number of crimps was measured using an automated crimp elastic modulus measuring device according to the measurement method of a number of crimps as prescribed in JIS L1015:2000. One fiber was extracted from a cotton-like sample before embossing in such a manner that a tension was not applied to the fiber; a length when an initial load of 0.18 mN/tex was applied to 25 mm of the sample was measured; and the number of crimps at that time was counted, thereby determining the number of crimps in a length of 25 mm. It is meant that as the number of crimps is large, the fiber-nonwoven fabric is high in the crimping properties.

[Measurement of Crimping Degree]

[0130] About 10 cm of the resulting side-by-side type crimped fiber was collected from the take-up roll, and one fiber was separated from the bundled yarn and measured for a number of crimps per 1 mm using a microscope. Ten samples were used for the measurement, and an average value thereof was defined as the crimping degree. It is meant that as the value of the crimping degree is high, the fiber is crimped, and a bulky fiber-nonwoven fabric product is obtained.

Table 3

			Unit	Example 1	Example 2	Example 3	Comparative Example 1
First component	Thermoplastic resin (A)	Ethylene-based resin (A1)	mass%	100	98	0	100
		Ethylene-based resin (A2)	mass%	0	0	100	0
	Slip inhibitor	Erucamide	mass%	0	2	0	0
	Half-crystallization time of first component		sec	0.01 or less	0.01 or less	0.01 or less	0.01 or less
	MFR of first component		g/10 min	17	17	18.5	17
	Melting point (Tm-D) of first component		°C	129	129	120	129
Second component	Thermoplastic resin (B)	Propylene homopolymer (B1)	mass%	80	78	80	100
	Thermoplastic resin (C)	Propylene-based polymer (C1)	mass%	20	20	20	0
	Slip inhibitor	Erucamide	mass%	0	2	0	0
	Half-crystallization time of second component		sec	0.09	0.09	0.09	0.05
	MFR of second component		g/10 min	73	73	73	30
	Melting point (Tm-D) of second component		°C	163	163	163	167
(First component)/(Second component) mass ratio			-	50/50	50/50	50/50	50/50
Proportion of resin (C) to a sum total of resin (A), resin (B), and resin (C)			%	10	10	10	0
Resin temperature			°C	240	240	240	240
Discharge amount of single hole			g/min/hole	0.5	0.5	0.5	0.5
Speed per single hole			kg/h	54	54	54	54
Ejector pressure			kg/cm ²	5.0	5.0	4.5	2.0
Calendar temperature			°C	110	110	100	100
			°C	110	110	100	100
Nip pressure (line pressure)			N/mm	40	40	40	40
Line speed			m/min	75	75	75	75
Basis weight			gsm	21	21	20	21
Fineness (fiber diameter)			μm	13.4	13.1	14.0	16.3
			denier	1.1	1.1	1.3	1.7

(continued)

		Unit	Example 1	Example 2	Example 3	Comparative Example 1
Tensile test	MD	%	21	21	66	13
		N/5 cm	25	23	25	17
	CD	%	44	37	91	25
		N/5 cm	6	5	12	4
Handle-O-Meter	MD	mN	133	104	110	155
	CD	mN	52	41	99	66
Static friction coefficient	MD	-	0.50	0.36	1.07	0.38
	CD	-	0.58	0.44	1.05	0.41
Bulkiness		μm	486	478	496	449
Number of crimps		per 25 mm	17.3	19.4	18.6	4.3
Crimping degree		%	10.3	12.1	10.4	2.1

[0131] In the side-by-side type crimped fiber of the present embodiment, the fiber diameter could be reduced, and the nonwoven fabric composed of the foregoing crimped fiber was bulky, high in crimping properties, and excellent in flexibility and smoothness.

Example 4

(Preparation of First Component)

[0132] Only the ethylene-based resin (A3) was used as the thermoplastic resin (A) to provide the first component.

(Preparation of Second Component)

[0133] 80% by mass of the propylene homopolymer (B2) as the thermoplastic resin (B) and 20% by mass of the propylene-based polymer (C1) obtained in Production Example 1 as the thermoplastic resin (C) were compounded to provide the second component.

(Production of Side-by-Side Type Crimped Fiber)

[0134] A side-by-side type crimped fiber was obtained by spinning in the same manner as in Example 1, except that the number of holes of the side-by-side composite nozzle was set to 6,800 holes, and the molten resin was discharged at a rate of 265 kg/h per single hole.

(Production of Spunbonded Nonwoven Fabric Constituted of Side-by-Side Type Crimped Fiber)

[0135] The resulting side-by-side type crimped fiber was sucked at a cabin pressure of 6,300 Pa while cooling at a cooling temperature of 20°C and collected on a moving net surface. The fiber bundle thus collected on the net surface was embossed by a heat roll heated at a calendar temperature of 140°C/130°C at a line pressure of 60 N/mm and wound up by a take-up roll.

Comparative Example 2

[0136] A side-by-side type crimped fiber was obtained in the same manner as in Example 4, except that the second component was changed to 100% by mass of the propylene homopolymer (B2). In addition, a nonwoven fabric was obtained in the same manner as in Example 4, except that the cabin pressure was changed to 3,400 Pa.

[0137] With respect to the side-by-side type crimped fiber and the nonwoven fabric obtained in each of Example 4

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and Comparative Example 2, the aforementioned measurements and evaluations were performed. The results are shown in Table 4.

Table 4

			Unit	Example 4	Comparative Example 2
First component	Thermoplastic resin (A)	Ethylene-based resin (A1)	mass%	0	0
		Ethylene-based resin (A3)	mass%	100	100
	Slip inhibitor	Erucamide	mass%	0	0
	Half-crystallization time of first component		sec	0.01 or less	0.01 or less
	MFR of first component		g/10 min	17	17
	Melting point (Tm-D) of first component		°C	130	130
Second component	Thermoplastic resin (B)	Propylene homopolymer (B1)	mass%	0	0
		Propylene homopolymer (B2)	mass%	80	100
	Thermoplastic resin (C)	Propylene-based polymer (C1)	mass%	20	0
	Slip inhibitor	Erucamide	mass%	0	0
	Half-crystallization time of second component		sec	0.09	0.05
	MFR of second component		g/10 min	73	35
	Melting point (Tm-D) of second component		°C	163	166
(First component)/(Second component) mass ratio			-	50/50	50/50
Proportion of resin (C) to a sum total of resin (A), resin (B), and resin (C)			%	10	0
Resin temperature			°C	240	240
Discharge amount of single hole			g/min/hole	0.6	0.6
Total discharge amount			kg/h	265	265
Cabin pressure			Pa	6300	3400
Calendar temperature			°C	140	140
			°C	130	130
Nip pressure (line pressure)			N/mm	60	60
Line speed			m/min	192	192
Basis weight			gsm	20.0	20.0
Fineness (fiber diameter)			μm	15.4	16.9
			denier	1.50	1.80
Tensile test		MD	%	25	42
			N/5 cm	11	14
		CD	%	41	73
			N/5 cm	5	5
Handle-O-Meter		MD	mN	70	95
		CD	mN	39	60

(continued)

		Unit	Example 4	Comparative Example 2
5	Static friction coefficient	MD	-	0.41
		CD	-	0.46

10 **[0138]** The nonwoven fabric composed of the side-by-side type crimped fiber of Example 4 was favorable in flexibility and texture, such as hand touch feeling, as compared with the nonwoven fabric composed of the thermoplastic resin (C)-free side-by-side type crimped fiber of Comparative Example 2.

Example 5

15 (Preparation of First Component)

[0139] Only the ethylene-based resin (A3) was used as the thermoplastic resin (A) to provide the first component.

(Preparation of Second Component)

20 **[0140]** 80% by mass of the propylene homopolymer (B2) as the thermoplastic resin (B) and 20% by mass of the propylene-based polymer (C1) obtained in Production Example 1 as the thermoplastic resin (C) were compounded to provide the second component.

25 (Production of Side-by-Side Type Crimped Fiber)

[0141] A side-by-side type crimped fiber was obtained by spinning in the same manner as in Example 1, except that the number of holes of the side-by-side composite nozzle was set to 6,800 holes, and the molten resin was discharged at a rate of 220 kg/h per single hole.

(Production of Spunbonded Nonwoven Fabric Constituted of Side-by-Side Type Crimped Fiber)

35 **[0142]** The resulting side-by-side type crimped fiber was sucked at a cabin pressure of 6,000 Pa while cooling at a cooling temperature of 20°C and collected on a moving net surface. Subsequently, using three continuing ovens, the ovens were heated under a condition at a temperature of 125°C, 133°C, and 133°C, respectively, and the fiber bundle thus collected on the net surface was partially thermally fusion bonded.

Comparative Example 3

40 **[0143]** A side-by-side type crimped fiber was obtained in the same manner as in Example 5, except that the second component was changed to 100% by mass of the propylene homopolymer (B2). In addition, a nonwoven fabric was obtained in the same manner as in Example 5, except that the cabin pressure was changed to 3,400 Pa.

45 **[0144]** In the side-by-side type crimped fiber and the nonwoven fabric obtained in each of Example 5 and Comparative Example 3, with respect to the measurements of fineness, tensile test, hydrometer test, and bulkiness, the evaluation was performed by the aforementioned measurements. The results are shown in Table 5.

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Table 5

			Unit	Example 5	Comparative Example 3
First component	Thermoplastic resin (A)	Ethylene-based resin (A1)	mass%	0	0
		Ethylene-based resin (A3)	mass%	100	100
	Slip inhibitor	Erucamide	mass%	0	0
	Half-crystallization time of first component		sec	0.01 or less	0.01 or less
	MFR of first component		g/10 min	17	17
	Melting point (Tm-D) of first component		°C	130	130
Second component	Thermoplastic resin (B)	Propylene homopolymer (B1)	mass%	0	0
		Propylene homopolymer (B2)	mass%	80	100
	Thermoplastic resin (C)	Propylene-based polymer (C1)	mass%	20	0
	Slip inhibitor	Erucamide	mass%	0	0
	Half-crystallization time of second component		sec	0.09	0.05
	MFR of second component		g/10 min	73	35
	Melting point (Tm-D) of second component		°C	163	166
(First component)/(Second component) mass ratio			-	50/50	50/50
Proportion of resin (C) to a sum total of resin (A), resin (B), and resin (C)			%	10	0
Resin temperature			°C	240	240
Discharge amount of single hole			g/min/hole	0.6	0.6
Speed per single hole			kg/h	220	220
Cabin pressure			Pa	6000	3400
Hot air oven temperature			°C	125	125
			°C	133	133
			°C	133	133
Nip pressure (line pressure)			N/mm	-	-
Line speed			m/min	167	167
Basis weight			gsm	20.0	20.0
Fineness (fiber diameter)			μm	15.8	17.7
			denier	1.60	1.99
Tensile test		MD	%	35	42
			N/5 cm	12	30
		CD	%	98	71
			N/5 cm	10	18
Handle-O-Meter		MD	mN	213	431
		CD	mN	135	262
Bulkiness			μm	580	420

[0145] The nonwoven fabric composed of the side-by-side type crimped fiber of Example 5 was excellent in flexibility and was able to make the thickness of the nonwoven fabric thick, as compared with the nonwoven fabric composed of the thermoplastic resin (C)-free side-by-side type crimped fiber of Comparative Example 3.

5 Example 6

(Preparation of First Component)

10 **[0146]** Only the ethylene-based resin (A4) was used as the thermoplastic resin (A) to provide the first component.

(Preparation of Second Component)

15 **[0147]** 80% by mass of the propylene homopolymer (B1) as the thermoplastic resin (B) and 20% by mass of the propylene-based polymer (C1) obtained in Production Example 1 as the thermoplastic resin (C) were compounded to provide the second component.

(Production of Side-by-Side Type Crimped Fiber)

20 **[0148]** The formation of a side-by-side type crimped fiber was performed using a conjugate melt fiber spinning machine, bi-component spinning apparatus having two extruders. The first component and the second component were each separately melt extruded with a single-screw extruder at a resin temperature of 230°C, and the molten resin was discharged and spun from a side-by-side composite nozzle having a nozzle diameter of 0.60 mm (number of holes: 1,795 holes) at a rate of 43 kg/h per single hole in a mass ratio of the first component to the second component of 50/50, followed by sucking at an ejector pressure of 3.0 kg/cm² while cooling with air at a wind velocity of 0.6 m/sec, to obtain
25 a side-by-side type crimped fiber.

Example 7

30 **[0149]** A side-by-side type crimped fiber was obtained in the same manner as in Example 6, except that in Example 6, the first component was changed from the ethylene-based resin (A4) to the ethylene-based resin (A5), and the ejector pressure was changed to 4.0 kg/cm².

Example 8

35 **[0150]** A side-by-side type crimped fiber was obtained in the same manner as in Example 6, except that in Example 6, the first component was changed from the ethylene-based resin (A4) to the ethylene-based resin (A6), and the ejector pressure was changed to 2.5 kg/cm².

Example 9

40 **[0151]** A side-by-side type crimped fiber was obtained in the same manner as in Example 6, except that in Example 6, the first component was changed to a composition composed of 50% by mass of the ethylene-based resin (A1) and the 50% by mass of the ethylene-based resin (A6).

45 Example 10

[0152] A side-by-side type crimped fiber was obtained in the same manner as in Example 6, except that in Example 6, the first component was changed from the ethylene-based resin (A4) to the ethylene-based resin (A1), the second component was changed to a composition composed of 95% by mass of the propylene homopolymer (B1) and 5% by
50 mass of the propylene-based polymer (C2) obtained in Production Example 2 as the thermoplastic resin (C), and the ejector pressure was changed to 2.0 kg/cm².

Example 11

55 **[0153]** A side-by-side type crimped fiber was obtained in the same manner as in Example 10, except that in Example 10, the second component was changed to a composition composed of 90% by mass of the propylene homopolymer (B1) and 10% by mass of the propylene-based polymer (C2).

Example 12

[0154] A side-by-side type crimped fiber was obtained in the same manner as in Example 10, except that in Example 10, the second component was changed to a composition composed of 80% by mass of the propylene homopolymer (B1) and 20% by mass of the propylene-based polymer (C2).

Example 13

[0155] A side-by-side type crimped fiber was obtained in the same manner as in Example 12, except that in Example 12, the mass ratio of the first component to the second component was changed to 30/70, and the ejector pressure was changed to 2.5 kg/cm².

Example 14

[0156] A side-by-side type crimped fiber was obtained in the same manner as in Example 10, except that in Example 10, the second component was changed to a composition composed of 95% by mass of the propylene homopolymer (B1) and 5% by mass of the propylene-based polymer (C1), and the ejector pressure was changed to 2.5 kg/cm².

Example 15

[0157] A side-by-side type crimped fiber was obtained in the same manner as in Example 14, except that in Example 14, the second component was changed to a composition composed of 90% by mass of the propylene homopolymer (B1) and 10% by mass of the propylene-based polymer (C1).

Comparative Example 4

(Preparation of First Component)

[0158] Only the ethylene-based resin (A6) was used as the thermoplastic resin (A) to provide the first component.

(Preparation of Second Component)

[0159] Only the propylene homopolymer (B1) was used as the thermoplastic resin (B) to provide the second component.

(Production of Side-by-Side Type Crimped Fiber)

[0160] The formation of a side-by-side type crimped fiber was performed using a conjugate melt fiber spinning machine, bi-component spinning apparatus having two extruders. The first component and the second component were each separately melt extruded with a single-screw extruder at a resin temperature of 230°C, and the molten resin was discharged from a side-by-side composite nozzle having a nozzle diameter of 0.60 mm (number of holes: 1,795 holes) at a rate of 43 kg/h per single hole in a mass ratio of the first component to the second component of 50/50. However, spinning could not be performed.

Comparative Example 5

[0161] A side-by-side type crimped fiber was obtained in the same manner as in Example 9, except that in Example 9, the second component was changed to a composition composed of 100% by mass of the propylene homopolymer (B1), and the ejector pressure was changed to 1.5 kg/cm².

[0162] With respect to the side-by-side type crimped fiber obtained in each of Examples 6 to 15 and Comparative Example 5, the aforementioned measurements and evaluations were performed. The results are shown in Table 6.

Table 6

	Unit	Example 6	Example 7	Example 8	Comparative Example 4	Example 9	Comparative Example 5	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15
First component	Ethylene-based resin (A1)	0	0	0	0	50	50	100	100	100	100	100	100
	Ethylene-based resin (A4)	100	0	0	0	0	0	0	0	0	0	0	0
	Ethylene-based resin (A5)	0	100	0	0	0	0	0	0	0	0	0	0
	Ethylene-based resin (A6)	0	0	100	100	50	50	0	0	0	0	0	0
	Slip inhibitor	0	0	0	0	0	0	0	0	0	0	0	0
	Half-crystallization time of first component	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less	0.01 or less
	MFR of first component	30	30	50	50	30	30	17	17	17	17	17	17
	Melting point (T _m -D) of first component	130	98	125	125	127	127	129	129	129	129	129	129

(continued)

		Unit	Example 6	Example 7	Example 8	Comparative Example 4	Example 9	Comparative Example 5	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15
Second component	Thermoplastic resin (B)	mass%	80	80	80	100	80	100	95	90	80	80	95	90
	Propylene homopolymer (B1)													
	Thermoplastic resin (C)	mass%	20	20	20	0	20	0	0	0	0	0	5	10
	Propylene-based polymer (C1)													
	Propylene-based polymer (C2)													
	Slip inhibitor	mass%	0	0	0	0	0	0	0	0	0	0	0	0
	Half-crystallization time of second component	sec	0.09	0.09	0.09	0.05	0.09	0.05	0.07	0.08	0.1	0.1	0.07	0.08
	MFR of second component	g/10 min	73	73	73	30	73	30	31	32	33	33	38	47
	Melting point (Tm-D) of second component	°C	163	163	163	167	163	167	163	163	163	163	163	163
	(First component)/(Second component) mass ratio	-	50/50	50/50	50/50	50/50	50/50	50/50	50/50	50/50	50/50	30/70	50/50	50/50
Proportion of resin (C) to a sum total of resin (A), resin (B), and resin (C)			10	10	10	0	10	0	2.5	5	10	14	2.5	5
Resin temperature			230	230	230	230	230	230	230	230	230	230	230	230
Discharge amount of single hole			0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Speed per single hole			43	43	43	43	43	43	43	43	43	43	43	43
Ejector pressure			3.0	4.0	2.5	Spinning impossible	3.0	1.5	2.0	2.0	2.0	2.5	2.5	2.5
			14.0	13.0	14.6	-	13.9	17.4	15.3	15.3	15.4	14.6	14.6	14.6
Fineness (fiber diameter)			1.2	1.1	1.4	-	1.2	1.9	1.5	1.5	1.5	1.4	1.4	1.4

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(continued)

	Unit	Example 6	Example 7	Example 8	Comparative Example 4	Example 9	Comparative Example 5	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15
Number of crimps	per 25 mm	4.2	15.5	4.5	-	5.5	3.7	2.2	3.1	2.4	5.2	2.4	2.2
Crimping degree	%	2.4	9.5	2.2	-	2.5	2.1	1.4	1.9	1.3	2.4	1.5	1.4

[Observation Method of Side-by-Side Type Crimped Fiber]

[0163] The side-by-side type crimped fiber placed on a glass slide was immobilized with a rapid non-aqueous mounting medium (Entellan, manufactured by Merck) and then covered by a cover glass, followed by observation. For the observation, using an optical microscope (BX51, manufactured by Olympus Corporation), the fiber was observed in a darkfield inspection mode at an observation magnification of 200 times.

Example 16

[0164] A side-by-side type crimped fiber was obtained in the same manner as in Example 1, except that in Example 1, the second component was changed to a composition composed of 79.5% by mass of the propylene homopolymer (B1), 20% by mass of the propylene-based polymer (C1) obtained in Production Example 1 as the thermoplastic resin (C), and 0.5% by mass of a Phthalocyanine Blue masterbatch (propylene-based compound, MFR: 48 g/10 min), and the ejector pressure was changed to 3.0 kg/cm². In order to confirm the crimping direction, the resulting crimped fiber was observed with an optical microscope. As a result, it was noted that the outside of the crimped fiber was the first component containing the ethylene-based resin (A1), and the inside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1) (see Fig. 1).

Example 17

[0165] A side-by-side type crimped fiber was obtained in the same manner as in Example 16, except that in Example 16, the ejector pressure was changed to 2.5 kg/cm². The crimping direction of the resulting crimped fiber was confirmed. As a result, it was noted that the outside of the crimped fiber was the first component containing the ethylene-based resin (A1), and the inside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1) (see Fig. 2).

Example 18

[0166] A side-by-side type crimped fiber was obtained in the same manner as in Example 16, except that in Example 16, the ejector pressure was changed to 2.0 kg/cm². The crimping direction of the resulting crimped fiber was confirmed. As a result, it was noted that the outside of the crimped fiber was the first component containing the ethylene-based resin (A1), and the inside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1) (see Fig. 3).

Example 19

[0167] A side-by-side type crimped fiber was obtained in the same manner as in Example 16, except that in Example 16, the ejector pressure was changed to 1.5 kg/cm². The crimping direction of the resulting crimped fiber was confirmed. As a result, it was noted that the outside of the crimped fiber was the first component containing the ethylene-based resin (A1), and the inside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1) (see Fig. 4).

Example 20

[0168] A side-by-side type crimped fiber was obtained in the same manner as in Example 16, except that in Example 16, the ejector pressure was changed to 1.0 kg/cm². The crimping direction of the resulting crimped fiber was confirmed. As a result, it was noted that the outside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1), and the inside of the crimped fiber was the first component containing the ethylene-based resin (A1) (see Fig. 5).

Example 21

[0169] A side-by-side type crimped fiber was obtained in the same manner as in Example 16, except that in Example 16, the ejector pressure was changed to 0.5 kg/cm². The crimping direction of the resulting crimped fiber was confirmed. As a result, it was noted that the outside of the crimped fiber was the second component containing the propylene homopolymer (B1) and the propylene-based polymer (C1), and the inside of the crimped fiber was the first component containing the ethylene-based resin (A1) (see Fig. 6).

[0170] With respect to the side-by-side crimped fibers obtained Examples 16 to 21, images when observed with the

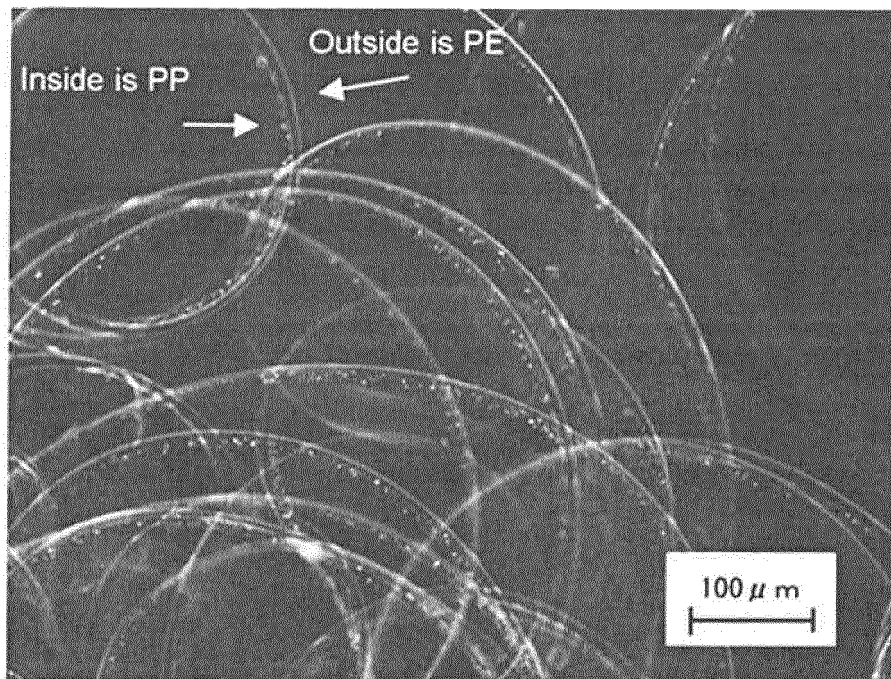
optical microscope (magnification: 200 times) are shown in Figs. 1 to 6, respectively. In Figs. 1 to 6, it was confirmed that the side containing the particle component was the side of the second component having the Phthalocyanine Blue masterbatch added thereto, and as for the curve of the crimped fiber, the inside and the outside were reversed depending upon the difference in the ejector pressure. From this fact, when the crimping components of the inside and the outside of the fiber are altered, a nonwoven fabric which is excellent in terms of a texture and a balance between flexibility and strength can be expected.

Claims

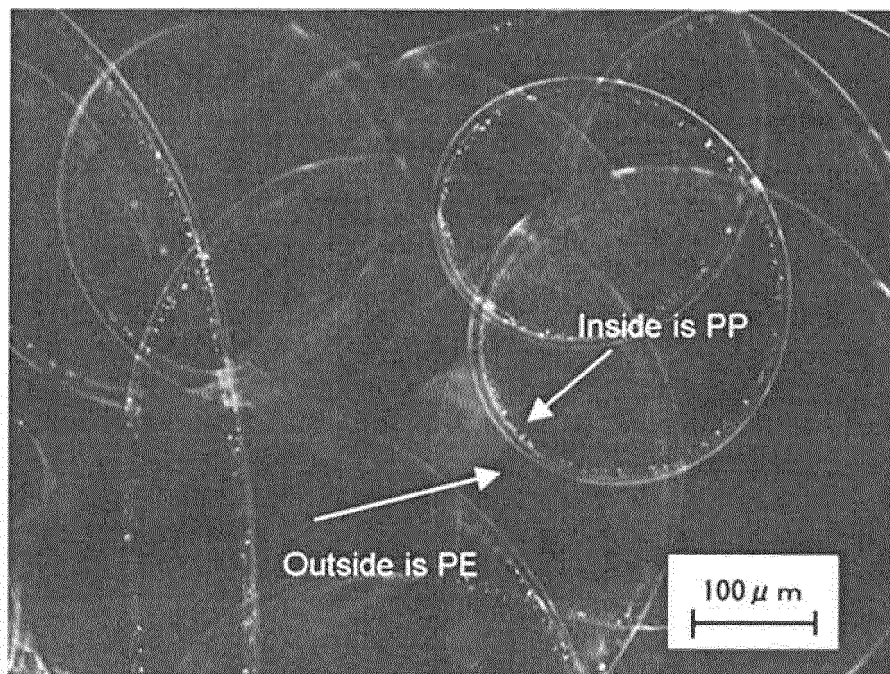
1. A crimped fiber comprising one component thereof containing a thermoplastic resin (A) and another component thereof containing a thermoplastic resin (B) and a thermoplastic resin (C), wherein a half-crystallization time at 25°C of the thermoplastic resin (A) is shorter than a half-crystallization time at 25°C of the thermoplastic resin (B), and a half-crystallization time at 25°C of the thermoplastic resin (C) is longer than the half-crystallization time at 25°C of the thermoplastic resin (B).
2. The crimped fiber according to claim 1, wherein the half-crystallization time at 25°C of the thermoplastic resin (A) is 0.01 seconds or less.
3. The crimped fiber according to claim 1 or 2, wherein the half-crystallization time at 25°C of the thermoplastic resin (B) is more than 0.01 seconds and 0.06 seconds or less.
4. The crimped fiber according to any one of claims 1 to 3, wherein the half-crystallization time at 25°C of the thermoplastic resin (C) is more than 0.06 seconds.
5. The crimped fiber according to any one of claims 1 to 4, wherein a melt flow rate (MFR) of the thermoplastic resin (A) measured under a condition at a temperature of 190°C and a load of 2.16 kg in conformity with JIS K7210 is 1 g/10 min or more and 70 g/10 min or less.
6. The crimped fiber according to any one of claims 1 to 5, wherein a melt flow rate (MFR) of the thermoplastic resin (B) measured under a condition at a temperature of 230°C and a load of 2.16 kg in conformity with JIS K7210 is 10 g/10 min or more and 500 g/10 min or less.
7. The crimped fiber according to any one of claims 1 to 6, wherein a melt flow rate (MFR) of the thermoplastic resin (C) measured under a condition at a temperature of 230°C and a load of 2.16 kg in conformity with JIS K7210 is 10 g/10 min or more and 5,000 g/10 min or less.
8. The crimped fiber according to any one of claims 1 to 7, wherein a melting point (T_m-D) of the thermoplastic resin (A) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 90°C or higher and 135°C or lower.
9. The crimped fiber according to any one of claims 1 to 8, wherein a melting point (T_m-D) of the thermoplastic resin (B) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 120°C or higher and 200°C or lower.
10. The crimped fiber according to any one of claims 1 to 9, wherein a melting point (T_m-D) of the thermoplastic resin (C) defined as a peak top of a peak observed on the highest temperature side of a melting endothermic curve obtained by holding under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 50°C or higher and 100°C or lower.
11. The crimped fiber according to any one of claims 1 to 10, wherein the thermoplastic resin (A) is a polyethylene-based resin.
12. The crimped fiber according to any one of claims 1 to 11, wherein the thermoplastic resin (B) is a polypropylene-based resin.

13. The crimped fiber according to claim 12, wherein the thermoplastic resin (B) is a propylene homopolymer.
14. The crimped fiber according to any one of claims 1 to 13, wherein in the thermoplastic resin (C), a melting endotherm ($\Delta H-D$) obtained from a melting endothermic curve obtained by holding a sample under a nitrogen atmosphere at -10°C for 5 minutes and then increasing the temperature at a rate of 10°C/min by using a differential scanning calorimeter (DSC) is 0 J/g or more and 80 J/g or less.
15. The crimped fiber according to any one of claims 1 to 14, wherein a molecular weight distribution (M_w/M_n) of the thermoplastic resin (C) is less than 3.0.
16. The crimped fiber according to any one of claims 1 to 15, wherein the content of the thermoplastic resin (C) occupying in the sum total of the thermoplastic resin (A), the thermoplastic resin (B), and the thermoplastic resin (C) is 1% or more and 50% or less.
17. The crimped fiber according to any one of claims 1 to 16, wherein the crimped fiber is a side-by-side type fiber.
18. The crimped fiber according to claim 17, wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber contains the thermoplastic resin (A).
19. The crimped fiber according to claim 17, wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber is composed of the thermoplastic resin (A).
20. The crimped fiber according to claim 17, wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber contains the thermoplastic resin (B).
21. The crimped fiber according to claim 17, wherein the resin constituting the inside of a crimp in the crimped fiber being a side-by-side type fiber is composed of the thermoplastic resin (B).
22. A nonwoven fabric comprising the crimped fiber according to any one of claims 1 to 21.
23. A multilayered nonwoven fabric comprising a laminate of two or more layers, wherein at least one layer thereof is the nonwoven fabric according to claim 22.

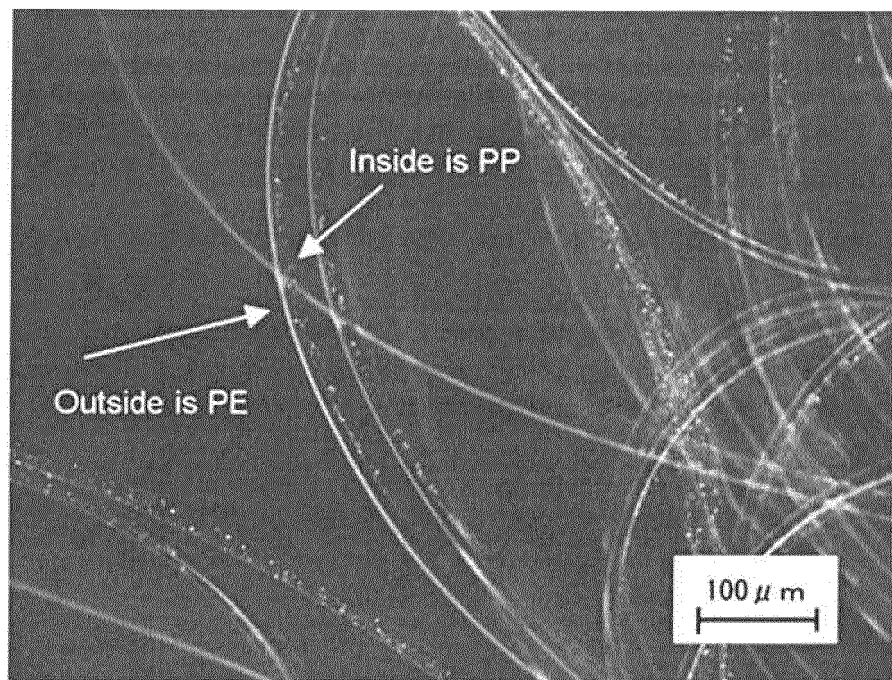
[Fig. 1]



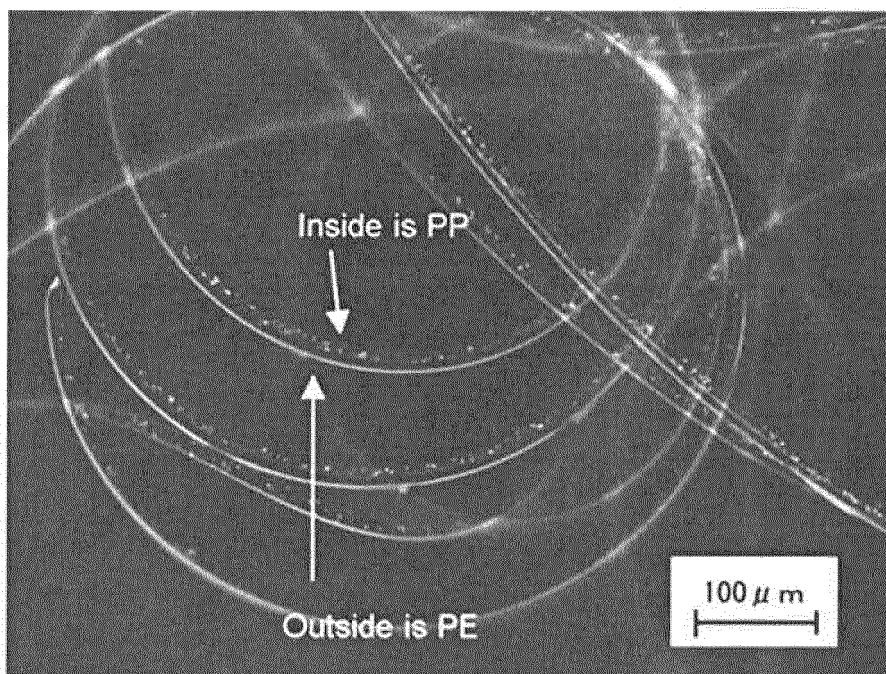
[Fig. 2]



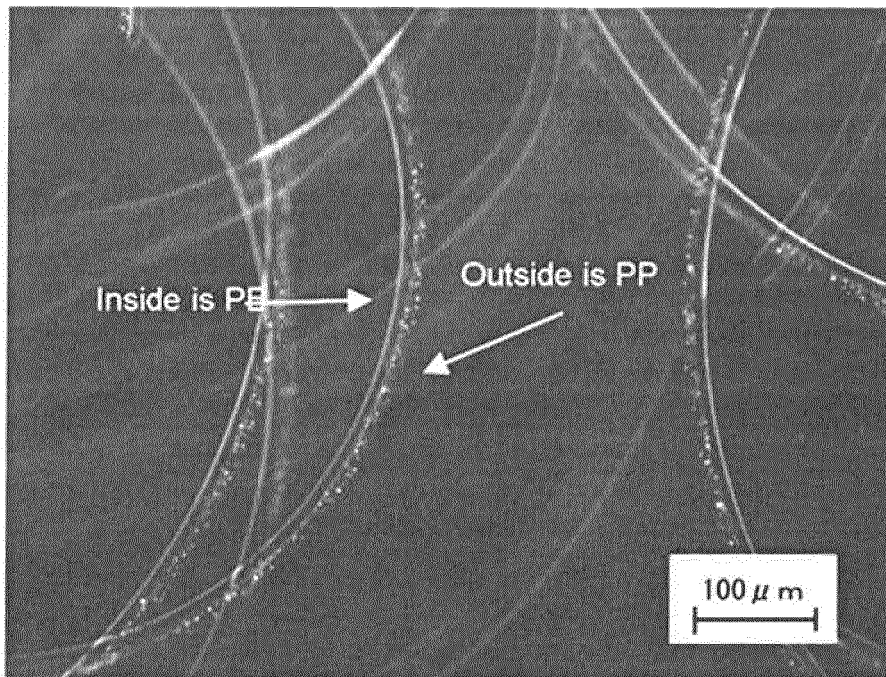
[Fig. 3]



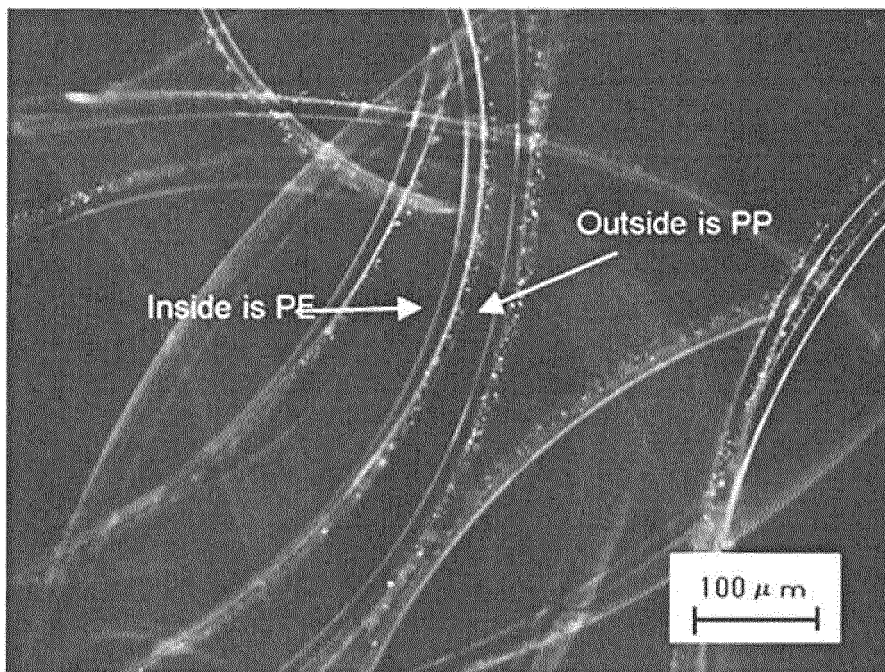
[Fig. 4]



[Fig. 5]



[Fig. 6]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/018855

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. D01F8/06(2006.01)i, D04H3/007(2012.01)i, D04H3/147(2012.01)i

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)

Int.Cl. D01F8/00-8/18, D04H1/00-18/04

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/141750 A1 (IDEMITSU KOSAN CO., LTD.) 24	1-10, 12-23
Y	September 2015, claims 1, 4, 8-10, paragraphs [0012], [0017], [0035], [0037]-[0040], [0082], table 2 & EP 3121314 A1, claims 1, 4, 8-10, paragraphs [0022], [0027], [0052], [0056]-[0074], [0136], [0137], table 2 & CN 106062261 A & JP 2016-40428 A	1-23



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

20.06.2018

Date of mailing of the international search report

03.07.2018

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Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/018855

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-291457 A (OJI PAPER CO.) 11 November 1997, claim 1 (Family: none)	1-23
A	WO 2014/142323 A1 (IDEMITSU KOSAN CO., LTD.) 18 September 2014, claims 1-11, examples & US 2016/0032504 A1, claims 1-15, examples & EP 2975167 A1 & CN 105121729 A & JP 2014-177729 A	1-23
A	WO 2016/076421 A1 (IDEMITSU KOSAN CO., LTD.) 19 May 2016, paragraphs [0027]-[0042] & US 2017/0335072 A1, paragraphs [0064]-[0088] & DE 112015005162 T & CN 107001646 A	1-23

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2012158861 A [0003]
- WO 2003087172 A [0055]
- US 3671379 A [0078]

Non-patent literature cited in the description

- Sen-i Kogaku. *Journal of the Textile Machinery Society of Japan*, 2002, vol. 55 (5), 236-242 [0071]