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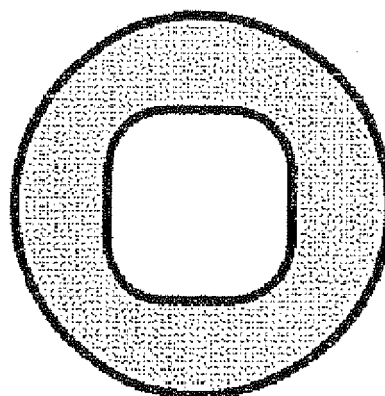
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(54) **FILAMENT NONWOVEN FABRIC**

(57) The invention has an object of providing a continuous fiber nonwoven fabric including a hollow fiber having excellent strength, in particular mono-filament strength, and having high hollowness even when formed to a fine filament.

A continuous fiber nonwoven fabric includes a hollow fiber including a propylene polymer having a ratio of the Z average molecular weight (Mz) and the weight average molecular weight (Mw), (Mz/Mw), in the range of 1.5 to 1.9, and in a preferred embodiment having a ratio of the weight average molecular weight (Mw) and the number average molecular weight (Mn), (Mw/Mn), in the range of 2.0 to 2.9.

[Fig. 2]



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to continuous fiber nonwoven fabrics that comprise propylene polymer fibers having high mono-filament strength and high hollowness even when formed to fine filaments.

BACKGROUND ART

10 **[0002]** Polypropylene nonwoven fabrics have excellent breathability, softness and lightweight properties and are widely used in various applications. The nonwoven fabrics require specific properties depending on the applications and are required to be improved in these properties.

[0003] To reduce the weight of nonwoven fabrics, various kinds of processes have been proposed in which fibers that form nonwoven fabrics are hollowed. Reducing the slit width of a die increases the hollowness of the obtainable polypropylene fibers. However, reducing the slit width of a die also increases the pressure in the die and therefore has a limitation. Accordingly, it is necessary that the diameter of a die be increased in order to produce polypropylene fibers having a high hollowness. For example, Patent Literature 1 discloses that continuous fiber nonwoven fabrics are formed of polypropylene fibers that have a hollow cross section with a hollowness of 10 to 60% achieved by increasing the fiber diameter to, for example, not less than 25 μm . Example 1 of Patent Literature 1 describes a continuous fiber nonwoven fabric having a fiber diameter of 33 μm and a hollowness of 40%, and Example 2 discloses the production of a continuous fiber nonwoven fabric having a fiber diameter of 40 μm and a hollowness of 50%. These nonwoven fabrics, however, are still insufficient in strength, with tensile strength of 7.4 kg/5 cm (36.3 N/25 mm) and 6.8 kg/5 cm (33.3 N/25 mm), respectively.

[0004] Patent Literature 2 discloses polypropylene nonwoven fabrics having a fiber diameter of not more than 20 μm and a hollowness of 5 to 70%. However, TABLE 1 and TABLE 2 in Patent Literature 2 disclose only polypropylene nonwoven fabrics with a hollowness of 12.5 to 19% and a fiber diameter of approximately 20 μm . The results in the literature show that fine fibers with a fiber diameter of less than 25 μm in fact have a low hollowness of not more than 19% and the production of polypropylene nonwoven fabrics of fine fibers and high hollowness is difficult.

Citation List

[0005]

Patent Literature 1: JP-A-H08-126440, Claims, Examples 1 and 2.

35 Patent Literature 2: U.S. Patent No. 6,368,990, Claims, TABLES 1 and 2.

SUMMARY OF THE INVENTION

Technical Problem

40 **[0006]** The present inventors studied diligently to develop continuous fiber nonwoven fabrics formed of hollow propylene polymer fibers having excellent strength, in particular mono-filament strength, and having high hollowness even when formed to fine filaments. They have then found that a propylene polymer having a specific ratio of the Z average molecular weight (M_z) and the weight average molecular weight (M_w), (M_z/M_w), can provide such nonwoven fabrics.

Solution to the Problem

[0007] The present invention provides a continuous fiber nonwoven fabric which comprises a hollow fiber comprising a propylene polymer having a ratio of the Z average molecular weight (M_z) and the weight average molecular weight (M_w), (M_z/M_w), in the range of 1.5 to 1.9, and in a preferred embodiment provides a continuous fiber nonwoven fabric which comprises such hollow fiber as above wherein the hollow fiber has a fiber diameter of 15 to 50 μm and a hollowness of 5 to 50%.

[0008] The present invention also provides a continuous fiber nonwoven fabric which comprises a propylene polymer fiber having a hollow cross section wherein the fiber diameter is 15 to 24 μm and the hollowness is 22 to 35%, and in a preferred embodiment provides a continuous fiber nonwoven fabric which comprises such hollow fiber as above wherein the propylene polymer forming the propylene polymer fiber has a ratio of the Z average molecular weight (M_z) and the weight average molecular weight (M_w), (M_z/M_w), in the range of 1.5 to 1.9.

Effects of the Invention

[0009] The continuous fiber nonwoven fabrics according to the present invention have high fiber strength, in particular mono-filament strength, compared to conventional hollow fiber nonwoven fabrics and have high hollowness even when the propylene polymer fibers forming the nonwoven fabrics are reduced in fiber diameter. In addition, the nonwoven fabrics of the invention have high breathability and particularly high lightweight properties, opacity and reflecting properties.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a schematic view of a nozzle orifice configuration according to the present invention.

Fig. 2 is a schematic cross sectional view of a fiber forming a continuous fiber nonwoven fabric according to the present invention.

Fig. 3 is a schematic view of a spunbonding apparatus used in Examples and Comparative Examples in the present invention.

DESCRIPTION OF EMBODIMENTS

(Propylene polymers)

[0011] The propylene polymer which constitutes the propylene polymer fibers forming the continuous fiber nonwoven fabric of the present invention has a ratio of the Z average molecular weight (Mz) and the weight average molecular weight (Mw), (Mz/Mw), in the range of 1.5 to 1.9, and preferably has a ratio of the weight average molecular weight (Mw) and the number average molecular weight (Mn), (Mw/Mn), in the range of 2.0 to 2.9. If a propylene polymer having Mz/Mw in excess of 1.9 is used, it is difficult to produce continuous fibers having a fiber diameter of not more than 24 μm and a hollowness of not less than 22%.

[0012] The fact that the propylene polymers of the invention have the ratios, Mw/Mn and Mz/Mw, means that the polymers have a smaller content of high-molecular weight components than conventional propylene polymers.

The propylene polymers of the invention have a melt flow rate (MFR) (ASTM D-1238, 230°C, 2160 g load) in the range of 10 to 100 g/10 min, and preferably 20 to 70 g/10 min. Propylene polymers having MFR of less than 10 g/10 min. have a high melt viscosity and low spinnability, and therefore production of fine fibers having high hollowness may be difficult. On the other hand, propylene polymers having a melt flow rate in excess of 100 g/10 min may possibly give continuous fiber nonwoven fabrics having poor properties, for example inferior in tensile strength.

[0013] The propylene polymer in the invention is a propylene homopolymer or a random copolymer of propylene and one, two or more α -olefins having 2 or more carbon atoms, preferably 2 to 8 carbon atoms, such as ethylene, 1-butene, 1-pentene, 1-hexene, 1-octene and 4-methyl-1-pentene (propylene/ α -olefin random copolymer). The melting point (Tm) thereof is usually not less than 135°C, and preferably in the range of 135 to 165°C. The content of the α -olefin(s) copolymerized is not particularly limited as long as the melting point (Tm) of the obtainable propylene polymer is within the above-mentioned range, but is usually not more than 10 mol%, and preferably not more than 6 mol%.

[0014] In the invention, Mn, Mw, Mz, Mw/Mn and Mz/Mw of the propylene polymers can be measured by known methods with GPC (gel permeation chromatography).

[0015] The propylene polymers according to the present invention are manufactured and sold under the trade name of Achieve 3854 by Exxon Mobil Chemical. Alternatively, the propylene polymers of the invention may be obtained by polymerizing propylene and optionally an α -olefin having two or more carbon atoms in the presence of a specific metallocene catalyst disclosed in JP-A-2001-508472.

[0016] The propylene polymers in the invention may be blended with commonly used additives or other polymers as required while still achieving the objects of the invention. Exemplary additives are antioxidants, weathering stabilizers, light stabilizers, antistatic agents, antifogging agents, anti-blocking agents, lubricants, nucleating agents and pigments.

(Continuous fiber nonwoven fabrics)

[0017] The continuous fiber nonwoven fabric according to the present invention is formed of a hollow fiber of the above propylene polymer which preferably has a fiber diameter of 15 to 50 μm and a hollowness of 5 to 50%, more preferably a fiber diameter of 25 to 45 μm and a hollowness of 15 to 50%, and still more preferably a fiber diameter of 35 to 45 μm and a hollowness of 15 to 50%.

[0018] In another aspect of the present invention, the continuous fiber nonwoven fabric is formed of a propylene

polymer fiber having a hollow cross section wherein the fiber diameter is as small as 15 to 24 μm , preferably 19 to 22 μm and the hollowness is high at 22 to 35%, preferably 25 to 30%.

[0019] The continuous fiber nonwoven fabric formed of the propylene polymer fiber having a hollow cross section with such fineness and high hollowness as described above may be easily obtained by using a propylene polymer having a Z average molecular weight (M_z) to weight average molecular weight (M_w) ratio (M_z/M_w) in the range of 1.5 to 1.9 and preferably a weight average molecular weight (M_w) to number average molecular weight (M_n) ratio (M_w/M_n) in the range of 2.0 to 2.9.

[0020] The continuous fiber nonwoven fabric of the invention usually has a basis weight of 1 to 1000 g/m^2 , preferably 10 to 100 g/m^2 , and more preferably 10 to 30 g/m^2 .

The continuous fiber nonwoven fabric may be entangled by various known entangling methods depending on applications, for example by needle punching, water jetting or ultrasonication or by partial thermal fusion bonding by means of hot embossing with an embossing roll or by blowing hot air through the fibers. These entangling methods may be used singly, or a plurality of these methods may be used in combination.

[0021] When the fibers are thermally fusion bonded by hot embossing, the emboss area percentage is usually in the range of 5 to 20%, preferably 5 to 10%, and the non-emboss unit area is not less than 0.5 mm^2 , preferably in the range of 4 to 40 mm^2 . The non-emboss unit area is the maximum area of a quadrangular minimum non-emboss unit that is inscribed around embosses. By forming the embosses in the above ranges, the obtainable nonwoven fabrics achieve excellent strength and softness.

[0022] When the fibers are entangled by needle punching, a known needle punching machine may be used and conditions such as needle density, needle type, needle depth and number of punches may be controlled depending on properties of the fibers, thereby producing nonwoven fabrics having excellent strength and softness. Where necessary, the entanglement treatment may be optimized by passing the nonwoven fabrics through a plurality of needle punching machines.

(Processes for producing continuous fiber nonwoven fabrics)

[0023] The continuous fiber nonwoven fabrics according to the present invention may be produced by spunbonding the aforementioned propylene polymer according to a known production method of a spunbonded nonwoven fabric.

[0024] In detail, the propylene polymer is molten in an extruder, and the molten polymer is fed to and blown from a spinneret (a die) having a number of spinning orifices (nozzles) that will form fibers with a hollow cross section, for example as illustrated in Fig. 1, and the melt-spun hollow propylene polymer continuous fibers are introduced into a cooling chamber and are cooled with cooling air, and the continuous fibers are thereafter drawn (attenuated) with drawing air and are deposited on a moving collection surface. The temperature for melting the propylene polymer may be generally set at 180 to 240°C, preferably 190 to 230°C, and more preferably 200 to 225°C.

[0025] The temperature of the cooling air is not particularly limited as long as the propylene polymer may be solidified. The temperature is, however, usually in the range of 5 to 50°C, preferably 10 to 40°C, and more preferably 15 to 30°C. The velocity of the drawing air is usually in the range of 100 to 10,000 m/min , and preferably 500 to 10,000 m/min .

[0026] In order to obtain propylene polymer fibers having a hollow cross section with a fiber diameter of 15 to 50 μm and a hollowness of 5 to 50%, in particular a fiber diameter of 15 to 24 μm and a hollowness of 22 to 35%, it is necessary that a spinneret should be used which has spinning orifices (nozzles) having an outer diameter of 0.5 to 5.0 mm and a slit width of 0.05 to 0.5 mm. If the spinning orifices have an outer diameter exceeding 5.0 mm, it may be difficult to obtain continuous fibers having a fiber diameter of 24 μm or less. If the spinning orifices have a slit width exceeding 0.5 mm, it may be difficult to obtain continuous fibers having a hollowness of 22% or more.

[0027] It has been found that spinning orifices with a slit width of less than 0.05 mm have structural restrictions such that the pressure immediately before the spinning orifices is so high that spinning is difficult even with the aforementioned propylene polymer. The production of hollow fibers with a fiber diameter of not more than 24 μm and a hollowness of not less than 22% similarly involves narrowing the slit width, and therefore fibers may be broken during the spinning and stable fiber production will be difficult.

(Continuous fiber nonwoven fabric laminates)

[0028] The continuous fiber nonwoven fabrics according to the invention may be laminated with other layers depending on applications. The additional layers that are laminated to the continuous fiber nonwoven fabrics are not particularly limited, and a variety of layers may be laminated depending on use applications.

[0029] Examples of the additional layers include knitted fabrics, woven fabrics, nonwoven fabrics and films. These layers may be laminated (bonded) to the continuous fiber nonwoven fabric of the invention by known methods including thermal fusion bonding methods such as hot embossing and ultrasonic fusion bonding; mechanical entangling methods such as needle punching and water jetting; use of adhesives such as hot melt adhesives and urethane adhesives; and

extrusion lamination.

[0030] Examples of the additional nonwoven fabrics laminated with the continuous fiber nonwoven fabrics of the invention include usual known nonwoven fabrics such as conventional spunbonded nonwoven fabrics, melt blown nonwoven fabrics, wet-process nonwoven fabrics, dry-process nonwoven fabrics, dry-process nonwoven pulp fabrics, flash spinning nonwoven fabrics and spread fiber nonwoven fabrics.

[0031] The films laminated with the continuous fiber nonwoven fabrics of the invention are preferably breathable (moisture permeable) films that do not hinder the characteristic breathability, softness and lightweight properties of the continuous fiber nonwoven fabrics of the invention. Conventionally known breathable films are usable, with examples including moisture permeable films of thermoplastic elastomers such as polyurethane elastomers, polyester elastomers and polyamide elastomers; and porous films produced by drawing films of thermoplastic resins which contain inorganic or organic fine particles to create a plurality of pores. Preferred examples of the thermoplastic resins for the porous films include polyolefins such as high-pressure low-density polyethylene, linear low-density polyethylene (LLDPE), high-density polyethylene, polypropylene, polypropylene random copolymers and compositions thereof.

[0032] The nonwoven fabric laminates with the breathable films can be cloth-like composite materials that have softness inherent to the continuous fiber nonwoven fabrics of the invention and very high water resistance.

EXAMPLES

[0033] The present invention will be described based on Examples without limiting the scope of the invention. In Examples and Comparative Examples, properties were determined as follows.

(1) Molecular weight distributions and average molecular weights of propylene polymer

[0034] A propylene polymer weighing 30 mg was completely dissolved in 20 mL of o-dichlorobenzene at 145°C. The solution was filtered through a 1.0 μm pore sintered filter to give a sample solution.

[0035] The sample solution was analyzed with a gel permeation chromatograph (Alliance GPC 2000 manufactured by Waters) under the conditions in which the column temperature was 140°C, the mobile phase was o-dichlorobenzene and the flow rate was 1 mL, thereby determining the molecular weight distributions and the average molecular weights.

(2) Measurement of melting point (T_m) of propylene polymer

[0036] The melting point (T_m) of a propylene polymer was measured with a differential scanning calorimeter (DSC) by the following conventional method. In the DSC method, the polymer was heated to a temperature approximately 50°C higher than the temperature that would give a peak value in a melting endothermic curve by heating at a rate of 10°C/min, and was held at the temperature for 10 minutes, cooled to 30°C at a rate of 10°C/min, and heated again to a predetermined temperature at a rate of 10°C/min and a melting curve was recorded. From the melting curve, the temperature that gave a peak value in the melting endothermic curve was determined in accordance with ASTM D3419, and the endothermic peak at the peak temperature was obtained as the melting point (T_m).

(3) Fiber diameter (μm)

[0037] A continuous fiber nonwoven fabric was observed with an optical microscope (ECLIPSE E-400 manufactured by Nikon Corporation). Of the filaments on the screen, arbitrary 30 filaments were selected and the fiber diameters thereof were measured. The average of the fiber diameters was obtained as the fiber diameter of the nonwoven fabric.

(4) Fineness [d]

[0038] The fineness of the continuous fiber nonwoven fabric was calculated from the following equation:

$$\text{Fineness [d]} = 0.00225 \times \pi \times \rho \text{ [g/cm}^3\text{]} \times D^2 \text{ [}\mu\text{m]} \times (1 - \text{hollowness [\%]})$$

wherein ρ [g/cm³] is the melt density of the resin at service temperature and D is the fiber diameter.

(5) mono-filament strength [gf/d]

[0039] In accordance with JIS L1905 (7.5.1 methods) 60 filaments were collected in a constant temperature chamber at a temperature of $20\pm 2^{\circ}\text{C}$ and a humidity of $65\pm 2\%$ as specified in JIS Z8703 (standard atmospheric conditions for testing) and were each tensile tested with a tensile tester (Instron 5564 manufactured by Instron Japan Co., Ltd.) at a span of 20 mm and a stress rate of 20 mm/min to determine the tensile load of the 60 filament test pieces. The average of the maximum loads was obtained as the mono-filament strength.

(6) Hollowness [%]

[0040] A continuous fiber nonwoven fabric was embedded in an epoxy resin and was cut with a microtome to give a sample piece. The sample piece was observed with an electron microscope (scanning electron microscope S-3500N manufactured by Hitachi, Ltd.). In the cross sectional image obtained, the cross sectional area of the entire fiber and that of the hollow portion were obtained. The hollowness was determined from the following equation:

$$\text{Hollowness [\%]} = (\text{cross sectional area of hollow portion} / \text{cross sectional area of entire fiber}) \times 100$$

The hollowness herein is an average of 20 fibers.

(7) Bulkiness [mm/(g/m²)]

[0042] In accordance with JIS L1906 (6.5), a continuous fiber nonwoven fabric was cut to give a test piece 10 cm in machine direction (MD) and 10 cm in cross direction (CD) in a constant temperature chamber at a temperature of $20\pm 2^{\circ}\text{C}$ and a humidity of $65\pm 2\%$ as specified in JIS Z8703 (standard atmospheric conditions for testing), and the weight of the test piece was measured to determine the basis weight (g/m²). The thickness (mm) of the test piece was measured with a thickness gauge (TESTER SANGYO CO., LTD.) at five points in a manner such that a 1.6 cm diameter head was pressed against the test piece for a predetermined time (10 seconds) at a constant pressure (20 g). The thickness (mm) of the test piece was divided by the basis weight (g/m²) to determine the bulkiness of the continuous fiber nonwoven fabric. The larger the thickness per the basis weight, the higher the bulkiness of the continuous fiber nonwoven fabric.

(8) Shape stability

[0043] In a constant temperature chamber at a temperature of $20\pm 2^{\circ}\text{C}$ and a humidity of $65\pm 2\%$ as specified in JIS Z8703 (standard atmospheric conditions for testing), a continuous fiber nonwoven fabric was cut to give three test pieces each 26 cm in machine direction (MD) and 13 cm in cross direction (CD). The test pieces were tensile tested with a tensile tester (Instron 5564 manufactured by Instron Japan Co., Ltd.) at a span of 210 mm and a stress rate of 50 mm/min to the 4 kgf load. The length, A mm, in the cross direction CD at the middle of the machine direction MD was measured, and the value $(A/130) \times 100$ (%) was obtained. The average of the values of the three test pieces was obtained as the shape stability. The higher the shape stability value, the more excellent the necking resistance properties during the processing of the continuous fiber nonwoven fabric.

(9) Flexural rigidity (45° cantilever method)

[0044] In accordance with JIS L1096 (6.19.1 A method), a continuous fiber nonwoven fabric was cut in a constant temperature chamber at a temperature of $20\pm 2^{\circ}\text{C}$ and a humidity of $65\pm 2\%$ as specified in JIS Z8703 (standard atmospheric conditions for testing) to give five 20 mm x 150 mm test pieces in each of the machine direction (MD) and the cross direction (CD). Each test piece was placed on a horizontal, smooth-surface table having a 45° slope surface, with the shorter side of the test piece aligned at the scale baseline. The test piece was slowly slid toward the slope surface by hand. When the central point on one edge of the test piece touched the slope surface, the length in which the other edge had moved was measured by reading the scales. The flexural rigidity was indicated in length (mm) in which the test piece had moved. Each of the five test pieces was tested on both the front and back surface. The average in machine direction (MD) and that in cross direction (CD) were obtained.

(10) Tensile strength

[0045] In accordance with JIS L1906 (6.12.1 A method), a continuous fiber nonwoven fabric was cut in a constant temperature chamber at a temperature of $20 \pm 2^\circ\text{C}$ and a humidity of $65 \pm 2\%$ as specified in JIS Z8703 (standard atmospheric conditions for testing) to give three test pieces 25 cm in machine direction (MD) and 2.5 cm in cross direction (CD). The test pieces were each tensile tested with a tensile tester (Instron 5564 manufactured by Instron Japan Co., Ltd.) at a span of 30 mm and a stress rate of 30 mm/min to determine the tensile load of the three test pieces. The average of the maximum loads was obtained as the tensile strength.

[Example 1]

[0046] A propylene polymer used was a propylene homopolymer (PP-1) having a MFR at 230°C under 2160 g load of 24 g/10 min [Achieve 3854 manufactured by Exxon Mobil Chemical, Mw/Mn: 2.3, Mz/Mw: 1.8, melting point (T_m): 148°C , produced with metallocene catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C . The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a spinning rate of 2550 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m^2 .

[0047] In Fig. 3, the reference signs 1 and 1' indicate a first extruder and a second extruder wherein an identical propylene polymer is fed to the first and the second extruder, 2 a spinneret, 3 a continuous filament, 4 a cooling air, 5 an ejector, 6 a collection apparatus, 7 a suction device, 8 a web, 9 an embossing apparatus, and 10 a take-up roll.

[0048] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Example 2]

[0049] A propylene polymer used was a propylene homopolymer (PP-2) having a MFR at 230°C under 2160 g load of 65 g/10 min [Mw/Mn: 2.6, Mz/Mw: 1.7, melting point (T_m): 155°C , produced with metallocene catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 190°C .

The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 3158 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m^2 .

[0050] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Example 3]

[0051] A propylene polymer used was a propylene homopolymer (PP-3) having a MFR at 230°C under 2160 g load of 65 g/10 min [Mw/Mn: 2.8, Mz/Mw: 1.8, melting point (T_m): 155°C , produced with metallocene catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 190°C . The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2769 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a standard weight of 30 g/m^2 .

[0052] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth

in Table 1.

[Comparative Example 1]

[0053] A propylene polymer used was a propylene homopolymer (PP-4) having a MFR at 230°C under 2160 g load of 60 g/10 min [Mw/Mn: 2.9, Mz/Mw: 2.5, melting point (T_m): 163°C, produced with titanium-catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2506 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m².

[0054] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Comparative Example 2]

[0055] A propylene polymer used was a propylene/ethylene random copolymer (PP-5) having a MFR at 230°C under 2160 g load of 60 g/10 min [Mw/Mn: 2.8, Mz/Mw: 2.2, melting point (T_m): 145°C, ethylene content: 4 mol%, produced with titanium-catalyst]. The copolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2496 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 130°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m².

[0056] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Comparative Example 3]

[0057] A propylene polymer used was a propylene polymer (PP-6) having a MFR at 230°C under 2160 g load of 65 g/10 min [MM302 manufactured by FINA, Mw/Mn: 2.5, Mz/Mw: 2.0, melting point (T_m): 156°C, produced with metallocene catalyst]. The propylene polymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2545 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m².

[0058] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Comparative Example 4]

[0059] A propylene polymer used was a propylene homopolymer (PP-7) having a MFR at 230°C under 2160 g load of 15 g/10 min [Mw/Mn: 6.0, Mz/Mw: 4.0, melting point (T_m): 163°C, produced with titanium-catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 260°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable

of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2282 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m².

[0060] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength. The results are set forth in Table 1.

[Comparative Example 5]

[0061] The propylene polymer PP-4 used in Comparative Example 1 was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C. Spinning of the molten polymer was attempted with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 that had a slit width half (1/2) that of the nozzles used in Comparative Example 1 and were capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 2501 m/min using 25°C cooling air. However, the resin pressure in the nozzles exceeded the overburden pressure and the spinning was infeasible.

[Comparative Example 6]

[0062] The propylene polymer PP-4 used in Comparative Example 1 was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 210°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.3 g/min per orifice and a filament velocity of 1255 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was thermally pressure treated with an embossing roll (emboss area percentage: 20.6%, emboss temperature: 140°C) to give a continuous fiber nonwoven fabric having a basis weight of 30 g/m².

The continuous fiber nonwoven fabric had a fineness that was substantially the same as that of the continuous fiber nonwoven fabric obtained in Comparative Example 1. The other properties (mono-filament strength, hollowness, bulkiness, shape stability, flexural rigidity and tensile strength) were similar to those obtained in Comparative Example 1.

[Table 1]

[0063]

Table 1

Measurement items		Example 1	Example 2	Example 3	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Mw/Mn		2.3	2.6	2.8	2.9	2.8	2.5	6.0
Mz/Mw		1.8	1.7	1.8	2.5	2.2	2.0	4.0
Tm [°C]		148	155	155	163	145	156	163
Nozzle orifice configuration		Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1
Filament velocity [m/min]		2550	3158	2769	2506	2496	2545	2282
Fiber diameter [μm]		21.5	18.5	20.9	20.1	19.8	20.1	21.5
Fineness [d]		2.12	1.71	1.95	2.15	2.16	2.12	2.37
mono-filament strength		4.02	3.62	4.22	2.36	2.40	3.34	1.92
Hollowness [%]		28.5	22.1	30.3	16.8	13.8	18.4	20.3
Bulkiness		0.0108	0.0124	0.0111	0.0099	0.0087	0.0105	0.0101
Shape stability [%]		97.7	98.7	97.7	92.3	97.7	97.7	97.7
Flexural rigidity [mm]		111.8	75.4	105.3	98.2	77.4	107.4	107.4
		60.2	43.0	62.2	61.6	45.0	57.2	53.2
Tensile strength [N/25 mm]		58.00	55.45	60.00	43.21	27.43	53.65	49.77
		19.10	18.22	20.10	16.28	15.28	16.57	18.80

[Example 4]

[0064] A propylene polymer used was a propylene homopolymer (PP-1) having a MFR at 230 °C under 2160 g load of 24 g/10 min [Achieve 3854 manufactured by Exxon Mobil Chemical, Mw/Mn: 2.3, Mz/Mw: 1.8, melting point (T_m): 148°C, produced with metallocene catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 225°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig. 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4.0 mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 646 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was mechanically entangled with a needle punch (needle depth: 10 mm, number of punches: 150 times/min) to give a continuous fiber nonwoven fabric having a basis weight of 341 g/m².

[0065] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, hollowness, mono-filament strength and tensile strength. The results are set forth in Table 2.

[Comparative Example 7]

[0066] A propylene polymer used was a propylene homopolymer (PP-4) having a MFR at 230°C under 2160 g load of 60 g/10 min [Mw/Mn: 2.9, Mz/Mw: 2.5, melting point (T_m): 163°C, produced with titanium-catalyst]. The propylene homopolymer was molten in an extruder (screw diameter: 75 mm) at a shaping temperature of 220°C. The molten polymer was spun with use of a nonwoven fabric manufacturing apparatus (a spunbonding apparatus, 320 mm, in length perpendicular to the machine direction on a collecting surface) as illustrated in Fig 3 which had a spinneret having nozzle pitches 4.5 mm in vertical direction and 4. mm in horizontal direction and orifices as illustrated in Fig. 1 capable of giving a fiber cross section as shown in Fig. 2, at a throughput of 0.6 g/min per orifice and a filament velocity of 576 m/min. The fibers were cooled with 25°C cooling air and deposited on a collecting belt. The web was mechanically entangled with a needle punch (needle depth: 10 mm, number of punches: 150 times/min) to give a continuous fiber nonwoven fabric having a basis weight of 352 g/m².

[0067] The filaments and the continuous fiber nonwoven fabric obtained were tested to evaluate fineness, hollowness, mono-filament strength and tensile strength. The results are set forth in Table 2.

[0068]

[Table 2]

Table 2

Measurement items		Example 4	Comparative Example 7
Mw/Mn		2.3	2.9
Mz/Mw		1.8	2.5
T _m [°C]		148	163
Nozzle orifice configuration		Fig. 1	Fig. 1
Filament velocity [m/min]		646	576
Fiber diameter [μm]		40.4	40.3
Fineness [d]		8.36	9.37
Hollowness [%]		20.4	10.2
mono-filament strength		4.00	2.06
Tensile strength [N/25 mm]	MD	45.6	42.3
	CD	40.3	36.7

[0069] As shown in Table 1, the propylene homopolymer (PP-1) having Mz/Mw of 1.8 (Example 1) gave a hollow continuous fiber which was thin with a fiber diameter of 21.5 μm but still had a high hollowness of 28.5%. Further, the mono-filament strength was high at 4.02 gf/d, and the continuous fiber nonwoven fabric was rigid and had a high strength with a tensile strength of 58.00 N/25 mm in MD and 19.10 N/25 mm in CD.

[0070] The propylene homopolymer (PP-2) having Mz/Mw of 1.7 (Example 2) gave a hollow continuous fiber which

was thin with a fiber diameter of 18.5 μm but still had a high hollowness of 22.1%. Further, the mono-filament strength was high at 3.62 gf/d, and the continuous fiber nonwoven fabric was rigid and had a high strength with a tensile strength of 58.45 N/25 mm in MD and 18.22 N/25 mm in CD.

[0071] The propylene homopolymer (PP-3) having Mz/Mw of 1.8 (Example 3) gave a hollow continuous fiber which was thin with a fiber diameter of 20.9 μm but still had a high hollowness of 30.3%. Further, the mono-filament strength was high at 4.22 gf/d, and the continuous fiber nonwoven fabric was rigid and had a high strength with a tensile strength of 60.00 N/25 mm in MD and 20.10 N/25 mm in CD.

[0072] In general, hollow fibers having a lower hollowness tend to have higher strength at an identical fiber diameter. In Comparative Examples in the present invention, the propylene polymer (PP-6) (Comparative Example 3) was a metallocene catalyzed polymer having Mz/Mw of 2.0. In this case, the hollow fibers therefrom had a fiber diameter of 20.1 μm which was as small as that in Example 1, but the hollowness of the continuous fibers was low at 18.4%. In spite of the fact that the hollowness was lower than that in Example 1, the mono-filaments strength was low at 3.34 gf/d. As a result, the continuous fiber nonwoven fabric had low rigidity and low strength with a tensile strength of 53.65 N/25 mm in MD and 16.57 N/25 mm in CD.

[0073] The propylene homopolymer (PP-4) (Comparative Example 1) was a titanium-catalyst catalyzed polymer having Mz/Mw of 2.5. The hollow fibers therefrom had a fiber diameter of 20.1 μm which was as small as that in Example 1, but the hollowness of the continuous fibers was lower at 16.8%. In spite of the fact that the hollowness was lower than that in Example 1, the mono-filament strength was low at 2.36 gf/d. As a result, the continuous fiber nonwoven fabric had rather low rigidity and low strength with a tensile strength of 43.21 N/25 mm in MD and 16.28 N/25 mm in CD.

[0074] The titanium-catalyst catalyzed propylene/ethylene random copolymer (PP-5) (Comparative Example 2) having Mz/Mw of 2.5 gave hollow fibers having a fiber diameter of 19.8 μm which was as small as that in Example 1, but the hollowness of the continuous fibers was lower at 13.8%. In spite of the fact that the hollowness was lower than that in Example 1, the mono-filament strength was low at 2.40 gf/d. As a result, the continuous fiber nonwoven fabric had low rigidity and low strength with a tensile strength of 27.43 N/25 mm in MD and 15.23 N/25 mm in CD.

[0075] The titanium-catalyst catalyzed homopolymer (PP-7) (Comparative Example 4) having Mz/Mw of 4.0 gave hollow fibers having a fiber diameter of 21.5 μm which was as small as that in Example 1, but the hollowness of the continuous fibers was low at 20.3%. In spite of the fact that the hollowness was lower than that in Example 1, the mono-filament strength was lower at 1.92 gf/d. As a result, the continuous fiber nonwoven fabric had rather low rigidity and low strength with a tensile strength of 49.77 N/25 mm in MD and 18.80 N/25 mm in CD.

[0076] As shown in Table 2, the propylene homopolymer (PP-1) having Mz/Mw of 1.8 gave a continuous fiber nonwoven fabric with a fiber diameter of 40.4 μm and a hollowness of 20.4% (Example 7) which had a high mono-filament strength of 4.00 gf/d and a high strength with a tensile strength of 45.6 N/25 mm in MD and 40.3 N/25 mm in CD. In contrast, the propylene homopolymer (PP-4) having Mz/Mw of 2.5 (Comparative Example 7) gave a continuous fiber nonwoven fabric which had a similar fiber diameter of 40.3 μm but a low hollowness of 10.2% and a low mono-filament strength of 2.06 gf/d.

Industrial Applicability

[0077] The continuous fiber nonwoven fabrics according to the present invention have high fiber strength, in particular mono-filament strength, compared to conventional hollow fiber nonwoven fabrics. Further, the nonwoven fabrics of the invention achieve high hollowness even when the propylene polymer fibers forming the nonwoven fabric have a reduced fiber diameter. In addition to these characteristics, the continuous fiber nonwoven fabrics have high breathability and particularly excellent lightweight properties, opacity and reflecting properties. With these advantageous properties, the nonwoven fabrics may be used in a variety of applications including hygiene materials and possibly in industrial materials such as oil adsorbent mats.

Reference Signs List

[0078] 1: first extruder, 1': second extruder, 2: spinneret, 3: continuous filament, 4: cooling air, 5: ejector, 6: collection apparatus, 7: suction device, 8: web, 9: embossing apparatus, 10: take-up roll

Claims

1. A continuous fiber nonwoven fabric which comprises a hollow fiber comprising a propylene polymer having a ratio of the Z average molecular weight (Mz) and the weight average molecular weight (Mw), (Mz/Mw), in the range of 1.5 to 1.9.

2. The continuous fiber nonwoven fabric according to claim 1, wherein the propylene polymer has a ratio of the weight

average molecular weight (M_w) and the number average molecular weight (M_n), (M_w/M_n), in the range of 2.0 to 2.9.

3. The continuous fiber nonwoven fabric according to claim 1 or 2, wherein the hollow fiber has a hollow cross section wherein the fiber diameter is 15 to 50 μm and the hollowness is 5 to 50%.

- 5 4. A continuous fiber nonwoven fabric which comprises a propylene polymer fiber having a hollow cross section wherein the fiber diameter is 15 to 24 μm and the hollowness is 22 to 35%.

- 10 5. The continuous fiber nonwoven fabric according to claim 4, wherein the propylene polymer forming the propylene polymer fiber has a ratio of the Z average molecular weight (M_z) and the weight average molecular weight (M_w), (M_z/M_w), in the range of 1.5 to 1.9.

- 15 6. The continuous fiber nonwoven fabric according to claim 5, wherein the propylene polymer has a ratio of the weight average molecular weight (M_w) and the number average molecular weight (M_n), (M_w/M_n), in the range of 2.0 to 2.9.

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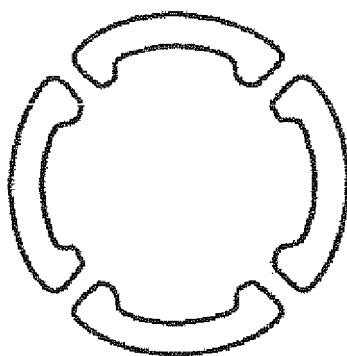
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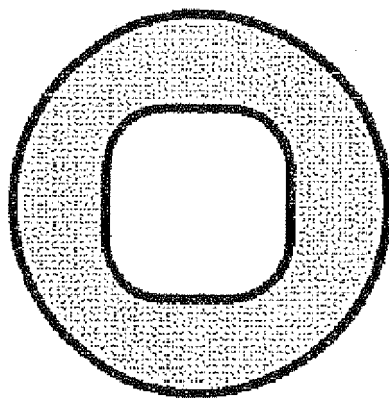
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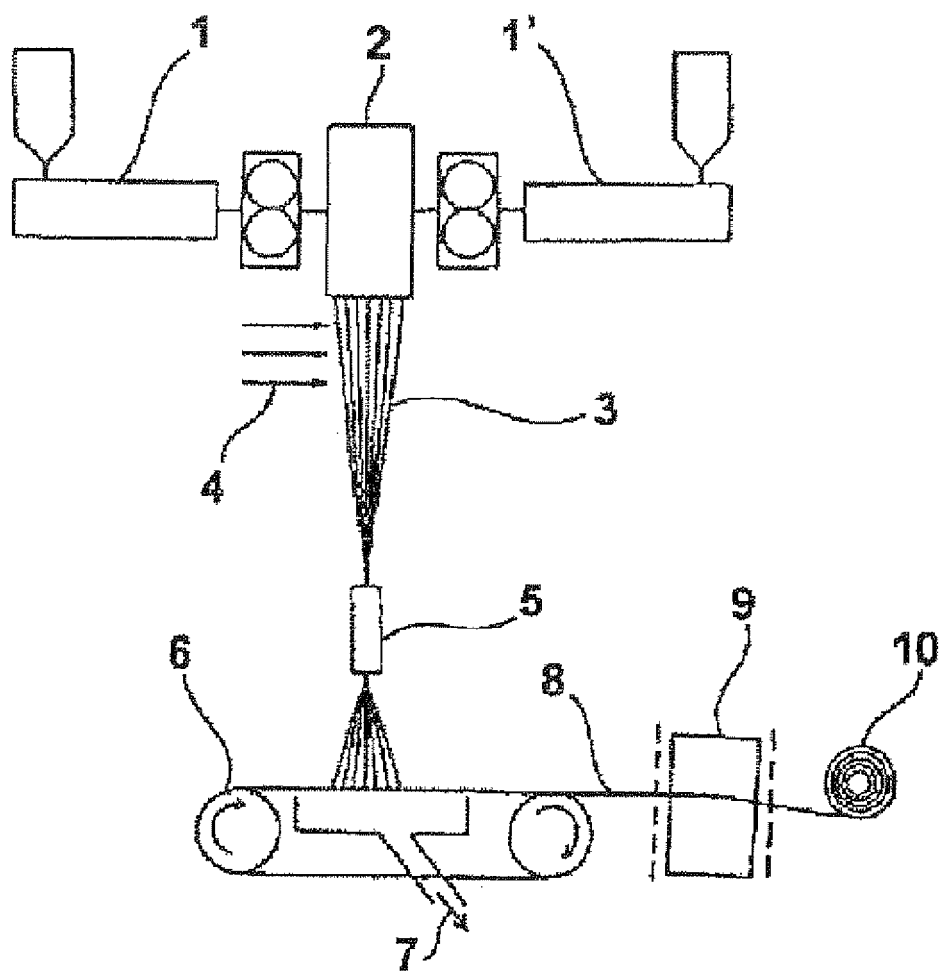
[Fig. 1]



[Fig. 2]



[Fig. 3]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/064822

A. CLASSIFICATION OF SUBJECT MATTER D04H3/00(2006.01)i, D01F6/06(2006.01)i, D04H3/14(2006.01)i, D04H3/16(2006.01)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) D04H1/00-18/00, D01F1/00-6/96 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 3-249257 A (Unitika Ltd.), 07 November 1991 (07.11.1991), claims; page 2, lower left column; page 3, lower left column; page 4, upper left column (Family: none)	4 1-3, 5, 6
Y	JP 2001-355172 A (Mitsui Chemicals, Inc.), 26 December 2001 (26.12.2001), claims; paragraphs [0002], [0006], [0134] (Family: none)	1-3, 5, 6
☐ 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 19 October, 2009 (19.10.09)		Date of mailing of the international search report 27 October, 2009 (27.10.09)
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