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(54) HEAT-BONDABLE COMPOSITE FIBER, PROCESS FOR PRODUCING THE SAME, AND FIBROUS MASS

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(57) ABSTRACT

A POM/POM thermoadhesive conjugate fiber is produced by providing two kinds of POM-based polymers A and B which satisfy $30<MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the POM-based polymer A (conditions: 190° C., load: 21.18N (2.16 kg)), and $T_B>T_A+10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the POM-based polymers A and B respectively, compositely spinning a first component containing the POM-based polymer A and a second component containing the POM-based polymer B such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber, subjecting the spun fiber to a drawing treatment, and subjecting the drawn fiber to an annealing treatment at a temperature of from 60° C. to 110° C.

HEAT-BONDABLE COMPOSITE FIBER, PROCESS FOR PRODUCING THE SAME, AND FIBROUS MASS

TECHNICAL FIELD

[0001] The present invention is related to a thermoadhesive conjugate fiber wherein a core component and a sheath component are formed from polyoxymethylene-based polymers and the sheath component has thermoadhesiveness and the production method of the fiber, and a fiber assembly including the fiber.

BACKGROUND ART

[0002] Polyoxymethylene is called "polyacetal" and known as an engineering plastic which is excellent in electrical insulation, heat resistance and chemical resistance. The molded article of the polyoxymethylene is widely used as, for example, a component of a car. Since the polyoxymethylene has excellent crystallizability and present a high crystallization speed and a large crystallinity, it is said that it is difficult to produce a fiber from this resin. Nevertheless, the production of the fiber from the polyoxymethylene has been tried by i) selecting a particular polyoxymethylene resin, ii) mixing a particular additive with the polyoxymethylene, or iii) compositely spinning the polyoxymethylene combined with a particular polymer, in order that the excellent properties of the polyoxymethylene is utilized (Patent Literatures 1 to 5). Further, a multi-layer oxymethylene-based copolymer fiber has been proposed, wherein a cross-section structure has at least two layers, every layer is exposed to a surface of the fiber and an amount of comonomer in a copolymer that forms each layer is defined.

[0003] [Patent Literature 1] Unexamined Japanese Patent (Kokai) Publication No. H1-272821

[0004] [Patent Literature 2] Unexamined Japanese Patent (Kokai) Publication No. H8-144128

[0005] [Patent Literature 3] Unexamined Japanese Patent (Kokai) Publication No. H11-293523

[0006] [Patent Literature 4] Unexamined Japanese Patent (Kokai) Publication No. 2003-268627

[0007] [Patent Literature 5] Unexamined Japanese Patent (Kokai) Publication No. 2006-9205

[0008] [Patent Literature 6] Unexamined Japanese Patent (Kokai) Publication No. 2008-138331

DISCLOSURE OF INVENTION

Problems to be Solved by Invention

[0009] In the case where the polyoxymethylene is made into a fiber and a product (such as civil engineering and construction material, an interfacing, a cushion, and a mat) is manufactured of a nonwoven, a woven fabric, or a knitted fabric which is formed of the fibers, and a component other than the polyoxymethylene is not included in the product, the properties of the polyoxymethylene is utilized maximally. In other words, when the fibers are made into the nonwoven or the like and another binder component is included in the nonwoven, some binders make the chemical resistance of the product poor as a whole, even though the fiber itself is formed from the polyoxymethylene. The same is applicable to a conjugate fiber which comprises of the polyoxymethylene and another polymer. The present inventors considered that, in order to avoid such inconvenience, it is only necessary to form the fiber only from the polyoxymethylene and have the fiber itself function as the binder. More specifically, when the two polyoxymethylenes which have different melting points are compositely spun with one component being a thermoadhesive component, a sheet, particularly a nonwoven, wherein the fibers are integrally bonded can be obtained without using the another binder component.

[0010] A sheath-core conjugate fiber wherein two kinds of polyoxymethylenes are used is disclosed in Patent Literature 5. The conjugate fiber described in Patent Literature is proposed for the purpose of achieving a high knot strength retention and is not intended to be used as the thermoadhesive fiber. Further, the conjugate fiber produced by a method described in Patent Literature 5 does not necessarily have sufficient properties as the thermoadhesive fiber. Furthermore, a fine fiber could not be obtained when the present inventors produced the conjugate fiber by the method described in Patent Literature 5. The multi-layer fiber described in Patent Literature 6 is intended to have good crimpability. Therefore, if a thermoadhesive nonwoven is produced using this fiber, difference in area of the nonwoven between before and after thermal treatment is large due to crimp of the fiber, whereby it is difficult to obtain the nonwoven of a predetermined dimension. The present invention was made in light of these situations, and an object of the present invention is to provide a thermoadhesive conjugate fiber formed mainly from the polyoxymethylene.

Solution to Solve Problems

[0011] When the sheath component of the sheath-core conjugate fiber produced only from the polyoxymethylenes by the method described in Patent Literature 5 was melted or softened as the thermoadhesive component to produce a sheet-shaped product, the core component significantly shrank and it was difficult to obtain the sheet-like product. Then, the present inventors have reviewed various kinds of polyoxymethylenes and the various production conditions in order to suppress the shrink of the core component. As a result, they have found that a fiber which functions well as the thermoadhesive conjugate fiber by using polyoxymethylenes which have a particular difference in melting point, one polyoxymethylene having a high melt index as the sheath component; and employing particular drawing conditions and drying conditions. Further, the inventors found that 150° C. ½ crystallization time, and/or Mz (Z-average molecular weight) of the core component effects spinnablity of the conjugate fiber and that it is important to select these parameters appropriately, particularly when a fine fiber is produced.

[0012] In a first aspect, the present invention provides a thermoadhesive conjugate fiber including a first component as a thermoadhesive component which contains a polyoxymethylene-based polymer A and a second component which contains a polyoxymethylene-based polymer B, wherein the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

[0013] which fiber satisfies:

[0014] $30<MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)), and

[0015] $Tf_B>Tf_A+10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121.

[0016] Selecting two kinds of polyoxymethylene-based polymers so that MI_A, Tf_A and Tf_B satisfy the above relationships suppresses the shrink of the second component when the first component is heated so as to function as the thermoadhesive component, which results in good adhesion between the fibers.

[0017] Further, in a second aspect, the present invention provides a thermoadhesive conjugate fiber including a first component as a thermoadhesive component which contains a polyoxymethylene-based polymer A and a second component which contains a polyoxymethylene-based polymer B, wherein:

[0018] the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

[0019] a before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is from 10 seconds to 100 seconds, and

[0020] $Tf_B > Tf_A + 10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121.

[0021] The crystallization time relates to a time until the molten resin solidifies. By limiting the 150° C. ½ crystallization time of the polyoxymethylene-based polymer for the second component, the crystallization is accelerated and therefore solidification proceeds during the discharge of the molten resin from nozzles and the draft of the discharged resin at a predetermined draft ratio. This increases the spinnablity and particularly makes it possible to obtain a spun filament having a small fineness.

[0022] The second aspect may be combined with the first aspect. Such combination provides better spinnability and makes it possible to obtain the fiber having a smaller fineness.

[0023] In any aspect (or another aspect) of the thermoadhesive conjugate fiber of the present invention, the before-spinning Z-average molecular weight (Mz) of the polyoxymethylene-based polymer B is preferably 500,000 or less. Further, it is preferable that, in any aspect, the thermoadhesive conjugate fiber of the preset invention is one wherein the after-spinning Z-average molecular weight (Mz) of the polyoxymethylene polymer B is 350,000 or less.

[0024] Mz is a parameter which relates to a high-molecular-weight component of a polymer. As the value of Mz is larger, the crystallization speed is higher. In the present invention, the crystallization speed of the core component is adjusted by defining the upper limit of before- and/or after-spinning Mz of the polyoxymethylene-based polymer B, whereby the spinnability of the entire conjugate fiber is improved.

[0025] In any aspect, the thermoadhesive conjugate fiber is preferably a sheath-core conjugate fiber consisting of a first component and a second component wherein the first component is a sheath component and the second component is a core component. Since the first component occupies all the length of the peripheral surface in the sheath-core structure, the fiber having such structure presents more favorable thermal adhesiveness.

[0026] In the case where the thermoadhesive conjugate fiber of the present invention is the sheath-core conjugate fiber, it may have an eccentric sheath-core cross section wherein a center position of the second component is shifted from the center position of the fiber. The fiber having such cross-sectional structure tends to develop three-dimensional crimps and confers stretchability, bulkiness and/or soft feeling to, for example, a nonwoven made of the fibers.

[0027] In a third aspect, the present invention provides a method for producing the thermoadhesive conjugate fiber of the first aspect of the present invention, which includes:

[0028] providing two kinds of polyoxymethylene-based polymers A and B which satisfy:

[0029] $30 < MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)), and

[0030] $Tf_B > Tf_A + 10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121,

[0031] compositely spinning a first component containing the polyoxymethylene-based polymer A and a second component containing the polyoxymethylene-based polymer B such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

[0032] subjecting the spun fiber to a drawing treatment, and

[0033] subjecting the drawn fiber to an annealing treatment at a temperature of from 60° C. to 110° C.

[0034] This production method is characterized in that the two polyoxymethylene-based polymers are selected so that MI_A, T_A and T_B satisfy the above relationships and the annealing treatment is conducted at a temperature of from 60° C. to 110° C. after spinning the fiber. These characteristics make it possible to obtain the thermoadhesive conjugate fiber which presents good cardability and small shrink of the second component upon thermal adhesion of the first component. A more preferable annealing treatment temperature is from 60° C. to 90° C.

[0035] In a fourth aspect, the present invention provides a method for producing the thermoadhesive conjugate fiber of the second aspect of the present invention, which comprises:

[0036] providing two kinds of polyoxymethylene-based polymers A and B, the polymer B having a before-spinning 150° C. ½ crystallization time of from 10 seconds to 100 seconds, and the polymers satisfying $Tf_B > Tf_A + 10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively which temperatures are determined according to JIS K 7121,

[0037] compositely spinning a first component containing the polyoxymethylene-based polymer A and a second component containing the polyoxymethylene-based polymer B such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

[0038] subjecting the spun fiber to a drawing treatment, and

[0039] subjecting the drawn fiber to an annealing treatment at a temperature of from 60° C. to 110° C.

[0040] This production method is characterized in that the two kinds of the polyoxymethylene-based polymers are selected so that the before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B satisfies the above relationship and T_A and T_B satisfy the above relationship and that the annealing treatment is conducted at a temperature of from 60° C. to 110° C. after spinning the fiber. These characteristics make it possible to obtain the thermoadhesive conjugate fiber which presents good cardability and has a small fineness. A more preferable annealing temperature is from 60° C. to 90° C.

[0041] The fourth aspect may be combined with the third aspect. Such combination makes it possible to produce the thermoadhesive conjugate fiber which passes the carding machine well, has a small fineness and presents a small thermal shrink upon the thermal adhesion.

[0042] In the production method in any aspect of the present invention, the spinning is preferably conducted with a draft ratio of from 100 times to 1000 times and the drawing treatment is preferably conducted with a draw ratio of from 4 times to 10 times. Setting the draft ratio and the draw ratio within these ranges gives the thermoadhesive conjugate fiber which has more favorable cardability and presents less shrink of the second component upon the thermal adhesion. Further, setting the draft ratio and the draw ratio within these ranges enables the fineness to be small, for example, from about 0.1 dtex to about 3 dtex.

[0043] In a fifth aspect, the present invention provides a fiber assembly which contains the thermoadhesive conjugate fiber of the first or the second aspect of the present invention in an amount of 10 mass % or more. This fiber assembly may be, for example, a nonwoven or a molded article.

EFFECT OF INVENTION

[0044] The thermoadhesive conjugate fiber of the present invention is one wherein both of the low-melting-point thermoadhesive component and the high-melting-point component are formed of the polyoxymethylene-based polymers. Therefore, when a sheet article such as a nonwoven is made using this fiber, the fibers are integrated with the polyoxymethylene-based component having the low melting point and another binder component is not required. Such a sheet article presents the heat resistance and the chemical resistance of the polyoxymethylene-based polymer, particularly when it is formed only from the thermoadhesive conjugate fibers of the present invention. Further, the fiber assembly containing the thermoadhesive conjugate fibers of the present invention has a high water retentivity, slippability, crease resistance, and bulk recoverability, and/or good wiping-ability. Therefore, the fiber assembly is suitable for applications which require such properties.

EMBODIMENT OF THE INVENTION

[0045] The thermoadhesive conjugate fiber includes at least two components each of which contains the polyoxymethylene-based polymer. In the present specification, the polyoxymethylene-based polymer is a polymer wherein an oxymethylene unit is a main repeating unit. The polyoxymethylene-based polymer may be a so-called "POM homopolymer" which is obtained by a polymerization reaction wherein a main raw material is formaldehyde or trioxane, or may be a so-called "POM copolymer" which is composed mainly of the oxymethylene unit and contains an oxyalkylene unit which has from two to eight adjacent carbon atoms, preferably CH_2CH_2O, and may have a substituent. The oxyalkylene unit is preferably contained in the POM copolymer in an amount of 10 mass % or less, and more preferably in an amount of from 0.5 mass % to 8 mass % as an ethyleneoxide equivalent. The substituent which can be bonded to the oxyalkylene group is, for example, an alkyl group, a phenyl group, or another organic group. Further, the polyoxymethylene-based polymer may be a copolymer which has another constituent unit, that is, a block copolymer, a terpolymer, or a cross-linked polymer.

[0046] The thermoadhesive conjugate fiber of the first aspect of the present invention includes the first component containing the polyoxymethylene-based polymer A and the second component containing the polyoxymethylene-based polymer B. The polyoxymethylene-based polymers A and B satisfy:

[0047] $30<MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)), and

[0048] $Tf_B>Tf_A+10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively which are determined according to JIS K 7121.

[0049] In order that, MI_A, Tf_A and Tf_B satisfy the above formulae, the polyoxymethylene-based polymers A and B are different from each other in at least one of a molecular weight, the kind or the content of the comonomer which co-polymerizes with the oxymethylene unit.

[0050] Specifically, the polyoxymethylene-based polymer A is, for example, a polymer of which MI_A is preferably from 40 to 75, and more preferably from 50 to 70, and of which before-spinning melting point T_A is preferably from 140° C. to 160° C. and more preferably from 150° C. to 158° C. Such a polyoxymethylene-based polymer is, for example, one which contains CH_2CH_2O in an amount of from 3 mass % to 10 mass % as the ethyleneoxide equivalent, preferably 5 mass % to 9 mass %. The polyoxymethylene-based polymer B is a polymer of which before-spinning melting point MI_B (g/10 min) is preferably from 20 to 80 and more preferably from 50 to 70, and of which before-spinning fusion peak temperature T_B is preferably from 160° C. to 174° C. and more preferably from 165° C. to 172° C. Such a polyoxymethylene-based polymer is, for example, one which contains CH_2CH_2O in an amount of from 0.5 mass % to 3 mass % as the ethyleneoxide equivalent, preferably from 0.5 mass % to 1.5 mass %.

[0051] "$30<MI_A$" wherein MI_A is the before-spinning melt index MI (g/10 min) of the polyoxymethylene-based polymer A means that a resin of a sheath component has high fluidity. Therefore, when the thermoadhesive conjugate fibers of the present invention are processed into a nonwoven and heated to be thermally adhered, there is a tendency that the first component spreads over a wide area, the adhesive strength becomes high and the strength of the nonwoven is increased. Further, when the fineness is made small, a take-over speed is higher during spinning (that is, a drafting ratio is larger). Therefore, when the resin of the sheath component satisfies $30<MI_A$, the resin has high fluidity, which gives advantage that the resin is easy to melt and deform during spinning.

[0052] Further, the draft ratio during spinning and the draw ratio during a drawing treatment can be made high to give a finer fiber, by setting MI_B (g/10 min) within a range of from 20 to 80 wherein MI_B is the before-spinning melt index of the polyoxymethylene-based polymer B. As a result, crystal orientation of the fiber is facilitated, and thereby the shrink of the fiber is expected to be suppressed, whereby a non-woven shrinkability can be suppressed upon processing the fibers into the non-woven.

[0053] Further, there is a 150° C. ½ crystallization time as the property for defining the polyoxymethylene-based polymer B. In the conjugate fiber of the present invention, the polyoxymethylene-based polymer B preferably has the 150° C. ½ crystallization time of from 10 seconds to 100 seconds, which time is determined as follow.

[0054] [A method for determining 150° C. ½ crystallization time]

[0055] A sample of 10 mg is put into an aluminum container and a temperature is raised from 20° C. to 200° C. at a temperature rising speed of 10° C./min and the temperature is retained for 2 minutes, using a differential scanning calorimeter under a nitrogen atmosphere. Then the temperature is lowered at a temperature falling speed of 50° C./min and is retained at 150° C. The time period between the time at which the retention of the temperature starts and the time at which a crystallization heat-release peak (a peak which appears near 150° C.) is determined as the 150° C. ½ crystallization time.

[0056] The details of the conditions for determination are as follow:

[0057] Differential scanning calorimeter: trade name "DSC 6200" manufactured by SEIKO Instruments;

[0058] Atmosphere: nitrogen flow (50 mL/min)

[0059] Temperature calibration: pure water, and melting points of high-purity indium and high-purity tin;

[0060] Sensitivity calibration: high-purity indium (ΔHm=6.86 cal/g).

[0061] Temperature range: 20° C. to 220° C.

[0062] When the before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is within the above range, the crystallization is facilitated and thereby the solidification proceeds to some extent during the discharge of the molten resin and the drafting of the discharged resin at a predetermined drafting ratio. This improves the spinnability of the conjugate fiber and particularly enables the spun filament of a small fineness. Particularly when the conjugate fiber is a sheath-core conjugate fiber which is described below, the sheath component tends to be solidified by being cooled by a chimney, while the core component may not be cooled sufficiently, which makes the solidification of the component difficult. This tendency is a reason why it is preferable that the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is within the above ramge.

[0063] In the case where the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is shorter than 10 seconds, the second component is solidified quickly, whereby the drafting is not made during spinning; fiber breakage occurs just under the nozzle; and many blocks tend to generate. In the case where the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is longer than 100 seconds, the cooling during spinning is not sufficient, which causes the breakage during drafting due to the shortage of a melt tension.

[0064] In the case where the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is within the above range, it is preferable that difference between the before-spinning melt indexes MI (g/10 min) of the polyoxymethylene-based polymers B and A is small. Specifically, the ratio (before-spinning MI_B/before-spinning MI_A) is preferably from 0.8 to 1.2. This is because the drafting smoothly proceeds when the fluidity of the two components are more similar to each other during the spinning drafting.

[0065] In the case where the conjugate fiber having the fineness of about 1.7 dtex or less is produced, the before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is preferably from 15 seconds to 50 seconds, more preferably from 20 seconds to 50 seconds, and still more preferably from not less than 20 seconds to less than 30 seconds.

[0066] Alternatively, the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B may be determined after spinning. In this case, the preferable range of the 150° C. ½ crystallization time is from 10 seconds to 100 seconds. The after-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is determined, by raising and retaining the temperature according to the determination method described above using the conjugate fiber as the sample. In the conjugate fiber having the fineness of about 1.7 dtex or less, the after-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is preferably from 15 seconds to 50 seconds, and more preferably from 20 seconds to 50 seconds. The polyoxymethylene-based polymer A is in a melted or softened state during the determination of the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B in the conjugate fiber, and does not affect the determination as to the polyoxymethylene-based polymer B.

[0067] The polyoxymethylene-based polymer B which has the before-spinning or the after-spinning 150° C. ½ crystallization time is not necessarily required to be used in combination with the polyoxymethylene-based polymer A having the before-spinning MI_A within the above range. In other words, even if the before-spinning melt properties of the polyoxymethylene-based polymer A is not limited to particular ones, the thermoadhesive conjugate fiber which is spun well and presents good thermal adhesiveness can be obtained, as long as the before-spinning or the after-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is within the above range.

[0068] Further, the physical properties which define the polyoxymethylene-based polymer B include a Z-average molecular weight (Mz). In the conjugate fiber of the present invention, a before-spinning Mz of the polyoxymethylene-based polymer B is preferably 500,000 or less which is determined under the following conditions.

[0069] <Conditions for Determination of Mz>

- **[0070]** Method: GPC (Gel Permeation Chromatography) Conditions:
  - **[0071]** Device: Gel permeation chromatograph GPC (produced by Waters)
  - **[0072]** Detector: differential refractive index detector RI (Type 2414, sensitivity 256, produced by Waters)
  - **[0073]** Column: Shodex-HFIP-806M two columns (S/N A406246, A406247) (produced by Showa Denko K.K., ϕ8.0 mm×30 cm, number of theoretical plates of about 14,000 plates/two columns)
  - **[0074]** Solvent: Hexafluoroisopropanol (HFIP, produced by Central Glass Co., Ltd., NaTFA 5 mM added)
  - **[0075]** Flow speed: 0.5 mL/min
  - **[0076]** Sample:
  - **[0077]** (Dissolution) Agitating gently at a room temperature,
  - **[0078]** (Solubility) Visual good
  - **[0079]** (Concentration) 0.05 w/v %
  - **[0080]** (Filtration) Membrane filter with a pore diamter of 0.45 μm (H-13-5, produced by Tosoh Corporation)
  - **[0081]** (Charged amount) 0.200 mL
  - **[0082]** (Standard specimen) polymethylmethacrylate produced by Showa Denko K.K.) and
  - **[0083]** Dimethylterephthalate (produced by Tokyo chemical industry Co., Ltd.).

[0084] Determination of Mz: Mz is determined from the following formula:

$$Mz=\Sigma(Ni\cdot Mi^3)/\Sigma(Ni\cdot Mi^2)$$

[0085] wherein Mi is a molecular weight at an elution position of a GPC curve which is obtained through a molecular weight calibration curve, and Ni is a number of molecule.

[0086] The spinning was conducted, by the present inventors, in which various polyoxymethylene-based polymers are used as the second component. As a result, they found that difference in distribution of the molecular weight affects the spinnability, even though the before-spinning MI_B, is the same. Further, they found that as Mz which is a parameter relating to the high-molecular-weight component of the polymer is larger, the crystallization speed is higher. Specifically, when the Mz of the polyoxymethylene-based polymer B is 500,000 or lower, good spinnability is achieved. When the composite fiver having a fineness of less than 2 dtex, particularly 1.8 dtex or less, more particularly 1.6 dtex or less, and still more particularly 1.4 dtex, the Mz of the polyoxymethylene-based polymer B is preferably 390,000 or less, more preferably 380,000 or less and still more preferably 360,000 or less. When the Mz of the polyoxymethylene-based polymer B is over 500,000 or less, the crystallization speed is high, resulting in deterioration of the spinnability. Further, the polymer of such a high Mz generates unmelted substance upon melting the polymer in an extruder, which causes breakage of fiber during spinning.

[0087] Otherwise, the Mz of the polyoxymethylene-based polymer B may be determined after spinning. In that case, the Mz is preferably 500,000 or less. When the Mz is determined by the above determination method wherein the sample is the conjugate fiber, the Mz of the polyoxymethylene-based polymer A and the Mz of the polyoxymethylene-based polymer B are combined and one Mz is determined. However, it is considered that the most of the determined Mz is occupied by the polyoxymethylene-based polymer B. In the conjugate fiber having a fineness of about 1.7 dtex or less, Mz is preferably 350,000 or less, and more preferably 300,000 or less.

[0088] When the first component contains a component(s) other than the polyoxymethylene-based polymer A, it preferably contains the polyoxymethylene-based polymer A in an amount of at least 50 mass %. When the content of the polyoxymethylene-based polymer is less than 50 mass %, the fiber which presents the properties (for example, chemical resistance) provided by the polyoxymethylene-based polymer cannot be obtained. It is preferable that the first component essentially consists of the polyoxymethylene-based polymer A. The term "essentially" is used considering that the content of the polyoxymethylene-based polymer A is not completely 100 mass % in the case where the first component contains an additive such as a stabilizer or the like. The component other than the polyoxymethylene-based polymer A contained in the first component is preferably, for example, a high-density polyethylene, a low-density polyethylene, ethylene-propylene copolymer, or polypropylene.

[0089] The above applies to the second component.

[0090] After-spinning Tf_A is preferably in a range of from 138° C. to 160° C., and more preferably from 148° C. to 156° C.

[0091] After-spinning Tf_B is higher than Tf_A by 10° C. or more, preferably 13° C. or more, and more preferably 15° C. or more. When the difference between Tf_A and Tf_B is small, the second component shrinks during the heat adhesion and the fiber loses its form, whereby a nonwoven having a shape cannot be formed upon producing the nonwoven, for example.

[0092] The thermoadhesive conjugate fiber of the present invention has a cross-sectional structure wherein the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber. Such structure is preferably a sheath-core conjugate fiber structure wherein the first component is the sheath component and the second component is the core component. The sheath-core structure gives favorable thermal adhesiveness since the first component which is the thermoadhesive component exists over the entire fiber surface in this structure. The sheath-core conjugate fiber may have an eccentric sheath-core cross section wherein the center position of the second component (the core component) is shifted from the center position of the fiber. A fiber having such cross section tends to develop three-dimensional crimps and provides stretchability, bulkiness and/or soft feeling to, for example, a nonwoven made of the fibers when the nonwoven is made from this fiber. Further, the thermoadhesive conjugate fiber having the eccentric sheath-core cross section can be obtained as a fiber which develops the three-dimensional crimps by subjecting it to a thermal treatment.

[0093] In the sheath-core conjugate fiber, a composite ratio of the first component to the second component is preferably in a range of 3:7 to 7:3 by volume. The more preferable range of the volume ratio is from 4:6 to 6:4. When the ratio of the first component is less than three, the thermoadhesiveness may be insufficient. When the ratio of the first component is over seven, the cardability may be deteriorated. Further, the large ratio of the first component makes the bulk of the nonwoven prone to difficult to obtain (that is, the nonwoven lacks for bulkiness), resulting in deterioration of feeling, when the fibers are processed to form the nonwoven.

[0094] The thermoadhesive conjugate fiber of the present invention may include the first component, the second component and possibly a third component containing another polyoxymethylene-based polymer to give a construction wherein all the components are disposed concentrically, or a construction wherein the components are disposed to be parallel to each other. In the case where the thermoadhesive conjugate fiber includes another component other than the first component and the second component, it is preferable that the another component also contains another polyoxymethylene-based polymer and the another polyoxymethylene-based polymer and the polyoxymethylene-based polymer A satisfy the same relationship as that between the polyoxymethylene-based polymer B and the polyoxymethylene-based polymer A, with respect to the after-spinning fusion peak temperature.

[0095] The thermoadhesive conjugate fiber of the present invention can be obtained as a fine fiber having a fineness of from about 0.1 dtex to about 3 dtex. Fibers of such a fineness is equivalent to those of a polypropylene fiber and a polyester fiber which are widely used as a fiber for producing a nonwoven (including a paper (a wetlaid nonwoven)), and therefore makes it possible to produce a fiber assembly (particularly the nonwoven) by a method which is employed when using these widely-used fibers.

[0096] The thermoadhesive conjugate fiber presents the reduced shrink of the second component upon the thermal adhesion due to the use of the particular polyoxymethylene-based polymers. This is shown by a single fiber dry heat shrinkage percentage determined according to JIS L 1015 (dry heat shrinkage percentage) at a temperature of 140° C., for a time of 15 minutes under an initial tension (load) of 0.018 mN/dtex (2 mg/d). The thermoadhesive conjugate fiber of the present invention preferably shows the single fiber dry heat shrinkage percentage of 15% or less, and more preferably 12% or less, when the center position of the second component almost coincide with the center position of the fiber, that is, when the fiber is the concentric sheath-core conjugate fiber.

[0097] Further, the thermoadhesive conjugate fiber of the present invention tends to have a high knot strength retention. Specifically, the thermoadhesive conjugate fiber of the present invention has a knot strength retention of 90% or more, and more specifically from 96% to 98%, when the center position of the second component coincides with the center position of the fiber, that is, when the fiber is the concentric sheath-core conjugate fiber. The reason why the thermoadhesive conjugate fiber of the present invention has the high knot strength retention is not clear, but one reason may be that a smoothness of the fiber of the present invention is high, and the fiber is orientationally crystallized by drawing, resulting in hardening of the fiber. It is considered that the knot strength retention tends to be lowered when the fibers are damaged because they are rubbed on each other upon knotting the fiber. It is presumed that since the thermoadhesive conjugate fiber has a high surface smoothness and is hard, the damage due to friction is small, leading to the high knot strength retention.

[0098] Another reason is that the thermoadhesive conjugate fiber of the present invention can be produced being drawn sufficiently at a high draw ratio, and thereby can be obtained as a fine fiber. Since the fine fiber of from about 0.1 dtex to about 3 dtex is particularly flexible in general, it is presumed that the knot strength retention of such a fine fiber becomes high.

[0099] It is presumed that the crystallization of each component of the thermoadhesive conjugate fiber of the present invention proceeds to harden the entire fiber, since the fiber is preferably produced by a production method which involves drawing the fiber sufficiently at a relatively high draw ratio during spinning and drawing. In the hard fiber, mechanical crimps tend to be kept for a long time after the crimps are given, whereby the fibers are entangled well. This gives a tendency that, for example, uniformity of a web which is obtained by carding the fibers is excellent.

[0100] Next, a method for producing the thermoadhesive conjugate fiber of the present invention is described. Firstly, two kinds of polyoxymethylene-based polymers A and B are prepared, which satisfy:

[0101] $30<MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)), and

[0102] $T_B>T_A+10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively after being spun, which are determined according to JIS K 7121. Such polyoxymethylene-based polymers A and B are as described above.

[0103] In addition to or as a substitute for MI_A of the above range, the 150° C. ½ crystallization time of the polyoxymethylene-based polymer B may be within a range of from 1 second to 100 seconds. Alternatively, in addition to MI_A of the above range and/or the 150° C. ½ crystallization time of the above range, the polyoxymethylene-based polymer B may have Mz of 500,000 or less. Such a polyoxymethylene-based polymer B is as described above.

[0104] Then, the first component containing the polyoxymethylene-based polymer A and the second component containing the polyoxymethylene-based polymer B are compositely spun such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber. A spinning temperature is preferably from 180° C. to 200° C. The spun filament having an after-drafting fineness in a range of from 2 dtex to 15 dtex is made. In the case where the fiber having a fineness of less than 2.0 dtex is intended to be obtained, an after-drafting fineness is made 8 dtex or less. When the after-drafting fineness of the spun filament is less than 2.0 dtex, the productivity of the fiber is lowered due to break of filament. When the after-drafting fineness of the spun filament is over 15 dtex, the filament is not drawn sufficiently and a fiber with uniform fineness cannot be obtained due to necking. When an orifice diameter of a spinning nozzle is from 0.3 mm to 1 mm, the draft ratio (drawing ratio) during spinning is, for example, preferably from about 100 times to about 1000 times, more preferably from about 300 times to about 900 times, and still more preferably about 400 times to about 800 times in order to obtain the spun filament having the fineness in the above range. The relatively high draft ratio during spinning can give, synergized with a later drawing treatment, the thermoadhesive conjugate fiber of which second component presents suppressed shrink upon the thermal adhesion. The orifice diameter of the spinning nozzle may be selected arbitrarily in order to achieve the above draft ratio.

[0105] Next, the spun filament is subjected to a drawing treatment to give a drawn filament. The drawing treatment is preferably conducted at a temperature lower than the fusion peak temperature of the polyoxymethylene-based polymer A. Specifically, the drawing temperature is preferably set at a temperature of from 130° C. to 150° C. The draw ratio is preferably from 4 times to 10 times, and more preferably from 4.2 times to 7 times. The drawing method is preferably a dry drawing method. Alternatively, the drawing may be conducted by a wet drawing method.

[0106] A predetermined amount of a fiber treatment agent is applied to the resultant drawn filament and then mechanical crimps are given to the filament with a crimper (a crimp-giving machine) in the case where the fiber is one for being opened and forming a web with a carding machine or for forming an airlaid web. The number of crimps is preferably in a range of from 12 peaks/25 mm to 19 peaks/25 mm. When the number of crimps is less than 12 peaks/25 mm, the cardability of the fiber is deteriorated since winding on a cylinder and fly tend to occur in the card. Further, a small number of crimps makes a web strength low, which indicates a degree of entanglement of fibers, and tends to cause trouble in the carding process. When the number of crimps is more than 19 peaks/25 mm, unevenness such as nep and cloudy tends to generate due to bad openability of the fibers in the carding process. The number of crimps is more preferably in a range of from 14 peaks/25 mm to 16 peaks/25 mm. In the case where the conjugate fiber is intended to be obtained as a short-length fiber (particularly, a short fiber for making paper) having a fiber length of less than 10 mm, the mechanical crimps may not be given to the fiber.

[0107] After forming the crimps (or applying the fiber treatment agent without forming the crimps), the filament is subjected to an annealing treatment at a temperature in a range of from 60° C. to 110° C. for a several seconds to about 30 minutes. When the annealing treatment is conducted after the fiber treatment agent is applied, the annealing treatment is preferably conducted at an annealing temperature in a range of from 60° C. to 110° C. for a treatment time of at least 5 minutes in order that the fiber treatment agent is dried at the same time. When the annealing treatment is conducted at a temperature in the above-described range, the crimp shape is stabilized which results in, for example, reduced thinning of the nonwoven, whereby a bulky and bouncy nonwoven is obtained when the nonwoven is produced. Further, the annealing treatment at such a relatively low temperature can suppress the single fiber dry heat shrinkage percentage of the resultant fiber. The annealing treatment may be omitted when the short fiber for making paper.

[0108] After completing the annealing treatment (after applying the fiber treatment agent in the case of the short fiber for making paper), the filament is cut so that the fiber length is from 3 mm to 100 mm depending on use. The thermoadhesive conjugate fiber of the present invention may be used as a long fiber, if necessary. The thermoadhesive conjugate fiber of the present invention can be produced by a meltblown method and a spunbond method as long as the particular polyoxymethylene-based polymers as described above are used for the first and the second components.

[0109] The present invention also provides a fiber assembly which contains the thermoadhesive conjugate fiber of the present invention as described above in an amount of 10 mass % or more. The fiber assembly is preferably one wherein the fibers are bonded by the first component. The fiber assemblies include a woven fabric, a knitted fabric and nonwoven. The fiber assembly contains the thermoadhesive conjugate fiber more preferably in an amount of 50 mass % or more and most preferably 100 mass %.

[0110] Then, the nonwoven is described as an example of the fiber assembly of the present invention, together with the production method of the nonwoven. The nonwoven is produced by making a web containing the thermoadhesive conjugate fiber of the present invention in an amount of 10 mass % or more and subjecting the web to a thermal treatment to melt or soften the first component of the fiber so that the fibers are bonded. The nonwoven may be produced using a web which is obtained by mixing the thermoadhesive conjugate fiber of the present invention and another fiber(s), or a laminate wherein a web of another fiber(s) is stacked on the web of the fiber of the present invention. As the another fiber, one or more fibers may be selected from a natural fiber such as cotton, silk, wool, hemp and pulp; a regenerated fiber such as rayon and cupraammonium rayon (Cupra); and a synthetic fiber such as an acrylic fiber, a polyester fiber, a polyamide fiber, a polyolefin fiber and a polyurethane fiber, depending on use and so on of the nonwoven.

[0111] The fiber mixed with the fiber of the present invention may be a splittable conjugate fiber consisting of two or more resin components. The splittable conjugate fiber has a fiber cross-sectional structure wherein at least one component is divided into two or more segments and at least a portion of each component is exposed on a surface of the fiber and the exposed portion extends continuously in the longitudinal direction of the fiber. The preferable polymer combination for constituting the splittable conjugate fiber is, polyethylene terephthalate/polyethylene, polyethylene terephthalate/polypropylene, polyethylene terephthalate/ethylene-propylene copolymer, polypropylene/polyethylene, and polyethylene terephthalate/nylon.

[0112] The webs used for producing the nonwoven include a carded web such as a parallel web, a semi-random web, a random web, a cross-laid web, and crisscross-laid web; a wetlaid web; and an airlaid web. Two or more fiber webs of different types may be stacked. Further, the fiber web may be optionally subjected to a second process such as a hydroentangling treatment or a needle-punching treatment before and/or after the thermal treatment in order to entangle the fibers.

[0113] The fiber web is subjected to a thermal treatment with a known thermal treating means. It is preferable to employ at least one thermal treating technique selected from a hot air-through technique and a thermocompression bonding technique as the thermal treating means. The conditions for the thermal treatment such as a thermal treatment temperature and soon are optimally selected depending on the thermal treating technique employed. When the hot air-through technique is employed, the thermal treatment temperature may be set at a temperature at which the first component of the thermoadhesive conjugate fiber is melted or softened, preferably in a range of from 145° C. to 170° C., a more preferably in a range of from 150° C. to 165° C., and still more preferably in a range of 155° C. to 165° C. This thermal treatment temperature is preferably employed when the fiber assembly of another embodiment (for example, the woven fabric or the knitted fabric) is produced.

[0114] A mass per unit area is not limited to a particular one, and may be selected from a range of from 10 g/m^2 to 5000 g/m^2 depending on the use. Further, a density of the nonwoven may be selected from a range of from 0.01 g/cm^3 to 1.0 g/cm^3 depending on the use.

[0115] The resultant nonwoven has excellent slippability because the smoothness of the surface of the thermoadhesive conjugate fiber is high. Further, the nonwoven is bulky and has cushioning properties. Furthermore, this nonwoven presents high water retentivity, high bulk recoverability, and high crease resistance. Therefore, this nonwoven is favorably suitable for applications such as hygiene products (menstrual sanitary products and paper diaper), paper, a wiper, a wet tissue, a mask, an interfacing, a brassiere pad, a civil engineering and construction material, a buffer (including a cushion), a wrapping material, clothes, a mat and a sponge-like nonwoven material. Further, the fiber assembly of another embodiment (for example, the woven fabric and the knitted fabric) may be used for the same applications.

[0116] Particularly when the nonwoven for the wiper is produced, it is preferable to combine the thermoadhesive conjugate fiber of the present invention with the splittable conjugate fiber. The splittable fiber gives ultrafine fibers by dividing the fiber, for example, by means of the hydroentangling treatment, resulting in a nonwoven wherein the fibers of the present invention and the ultrafine fibers exist on the surface. Such a nonwoven has high slippability which is conferred by the fiber of the present invention, and is excellent in wiping-ability. Alternatively, a fiber which is widely used for forming the wiper may be used instead of the splittable conjugate fiber. The conjugate fiber of the present invention is preferably contained in an amount of from 20 mass % to 70 mass %, and more preferably in an amount of from 30 mass % to 50 mass % regardless of the type of the fiber which is mixed with the conjugate fiber of the present invention.

[0117] The thermoadhesive conjugate fiber of the present invention is not necessarily required to be used for bonding the fibers in the fiber assembly. Particularly when the fiber assembly is used as the nonwoven for the wiper, the fiber assembly is integrated by the fiber entanglement (for example, the hydroentanglement) without being subjected to the thermal treatment, so that a softer and a better feeling are obtained.

[0118] The fiber assembly of the present invention may be a molded article which is produced by conducting the thermal treatment with the fibers or the fiber web within a mold. For example, the molded article can be simply formed by making the fiber web containing the thermoadhesive conjugate fiber of the present invention with a carding machine, and putting the web into the mold followed by the thermal treatment. The kinds of the carded webs are described as above. The thermal treatment may be conducted employing the hot air-through technique. The fiber web may be put into the mold after being subjected to the hydroentangling treatment. The molded article having a large thickness may be produced by laminating the fiber webs using a cross-layer machine and putting the laminated web into the mold. The laminated web may be optionally subjected to the needle-punching treatment and/or the hydroentangling treatment.

[0119] The density of the molded article is selected depending on the use of the article, regardless of the method for producing the molded article. Specifically, the density of the molded article is preferably from 0.01 g/cm^3 to 1.0 g/cm^3, more preferably from 0.02 g/cm^3 to 0.8 g/cm^3, and still more preferably from 0.04 g/cm^3 to 0.6 g/cm^3. The mass per unit area is also selected depending on the use. Specifically, it is preferably from 10 g/m^2 to 5000 g/m^2.

[0120] The molding process is conducted at a thermal treatment temperature in a range of from 140° C. to 180° C. for the thermal treatment time in a range of from 5 seconds from 120 minutes depending on the mass per unit area of the fiber web and the intended density of the resultant molded article. Specifically, the thermal treatment temperature is preferably at least the melting point of the first component of the thermoadhesive conjugate fiber of the present invention and at most (the melting temperature of the second component −5° C.). More specifically, in the case where the mass per unit area is 100 g/m^2 or less, the thermal treatment is preferably conducted using a conveyer type hot air-through thermal treating machine and setting the thermal treatment time within a range of from 5 seconds to 20 minutes. In the case where the mass per unit area is over 100 g/m^2, the thermal treatment is preferably conducted using a batch type hot air-through thermal treating machine and setting the thermal treatment time within a range of from 1 minute to 120 minutes.

[0121] The molding process is preferably conducted using a mold formed from a air-permeable material such as a metal mesh or a resin mesh sheet so that the thermal treatment is conducted evenly in a thickness direction of the fiber web when using a hot air-through thermal treating machine. For example, the molding process may be conducted by a method wherein the mold is made by shaping the air-permeable sheet into a predetermined shape, and then the fiber web is put into this mold. Alternatively, the fiber web may be mold-processed by a method wherein the fiber web is sandwiched with two air-permeable sheets (for example, the metal mesh) and then the sandwiched web is shaped into a desired shape and subjected to the thermal treatment. The shape of the molded article is not limited to a particular one, and it may be any of a flat plate shape, a shape with a curbed surface, a box shape, a convex shape, a hat shape, a glass shape, a cup shape, a columnar shape and a spherical shape.

EXAMPLES

[0122] Hereinafter, the present invention is specifically described by examples. In the following examples, the melting points T_A and T_B of the polyoxymethylene-based polymers A and B which were used as a first and a second components respectively in the production of fiber. The after-spinning melting point Tf_A of the first component, the after-spinning melting point Tf_B of the second component, the single fiber strength and rupture elongation, the number of crimps, the percentage of crimp, the knot strength, the knot strength retention, the single fiber dry heat shrinkage percentage, the cardability, the area shrinkage percentage of nonwoven, the thickness and the strength of nonwoven were determined as described below.

[0123] [Determination of T_A and T_B]

[0124] A differential scanning calorimeter (manufactured by Seiko Instruments Inc.) was employed. A sample amount was 5.0 mg. The sample was maintained at 200° C. for 5 minutes, and cooled to 40° C. at a temperature falling speed of 10° C./min and then melted at a temperature rising speed of 10° C./min so that a curve for heat of fusion was obtained for each of the first component and the second component. From the curve for heat of fusion, the fusion peak temperatures T_A and T_B were determined as the melting points, respectively.

[0125] [Determination of Tf_A and Tf_B]

[0126] A differential scanning calorimeter (manufactured by Seiko Instruments Inc.) was employed. A sample amount was 6.0 mg. The temperature of fiber was risen from a room temperature to 200° C. at a temperature rising speed of 10° C./min to be melted, and Tf_A and Tf_B were determined from a resultant curve for heat of fusion.

[0127] [Mz and 150° C. ½ crystallization time]

[0128] These were determined according to the methods which are described in "Embodiment for Carrying Out Invention."

[0129] [Spinnability]

[0130] The spinnablity was estimated according to the following standards:

[0131] ○ No fiber breakage occurred during 1-hour spinning;

[0132] Δ The filament could be take off even though the fiber breakage occurred;

[0133] x The filament could not be taken off because fiber breakage occurred frequently.

[0134] [Tensile Strength and Rupture Elongation of a Single Fiber]

[0135] A load and an elongation when the fiber broke were measured according to JIS L 1015 using an extension tensile tester with a sample gage length of 20 mm and they were determined as the single fiber strength and the single fiber rupture elongation respectively.

[0136] [Knot Strength and Knot Strength Retention]

[0137] The knot strength of a single filament was determined according to JIS L 1013 and the knot strength retention which was a ratio of the knot strength to the filament strength (the fiber tensile strength) was calculated.

[0138] [Number of Crimps, and Percentage of Crimp]

[0139] They were determined according to JIS L 1015.

[0140] [Single Fiber Dry Heat Shrinkage Percentage]

[0141] Dry heat shrinkage percentages were determined according to JIS L 1015 with a gage length of 100 mm at a treatment temperature of 140° C. for a treatment time of 15 minutes under an initial tension of 0.018 mN/dtex (2 mg/d).

[0142] [Cardability]

[0143] A parallel carding machine was used. A carded web having a mass per unit area of about 30 g/m^2 was discharged at a line speed of 10 m/min and uniformity of the carded web, presence or absence of fly, and transferability of web (continuousness of web transferring from a roller to a roller) were observed and cardability was evaluated according to the following criteria:

[0144] ○: Favorable as to all of the uniformity of the carded web, the fly, winding and the transferability of the web;

[0145] Δ: Bad as to one of the uniformity of the web, the fly, winding and the transferability of the web; and

[0146] x: Bad as to two or more of the uniformity of the carded web, the fly, winding and the transferability of the web.

[0147] [Nonwoven-Area Shrinkage Percentage: Samples 1 to 9 and 11 to 16]

[0148] The Nonwoven-area shrinkage percentage was determined by the following method.

[0149] (1) A carded web having a mass per unit area shown in Tables 1 to 4 using a parallel carding machine and it was cut into a square with a size of 20 cm in the lengthwise direction× 20 cm in a crosswise direction. The size (cm) of the web before a shrinking treatment was determined.

[0150] (2) The carded web was subjected to a thermal treatment without being restricted in order to be shrunk, at a thermal treatment temperature shown in Tables 1 to 4 and an air flow rate of 1.5 m/sec (upper flow) using a hot air-through thermal treating machine. The thermal treatment time was set at 12 seconds.

[0151] (3) The size (cm) of the nonwoven after the treatment was determined.

[0152] (4) The area shrinkage percentage was calculated based on a following formula:

$$\text{Nonwoven-}\mathit{areashrinkagepercentage}(\%) = \frac{\left(\begin{array}{c}\text{Before-shrinking lengthwise}-\text{direction size}\times\\ \text{crosswise}-\text{direction size}\end{array}\right) - \left(\begin{array}{c}\text{After-shrinking lengthwise}-\mathit{directionsize}\times\\ \text{crosswise}-\text{direction size}\end{array}\right)}{\begin{array}{c}\text{Before-shrinking lengthwise}-\text{direction size}\times\\ \text{crosswise}-\text{direction size}\end{array}}$$

[0153] [Nonwoven-Area Shrinkage Percentage: Sample 10]

[0154] The Nonwoven-area shrinkage percentage was determined by the following method.

[0155] (1) 2 L water was put into a household mixer, and 4.4 g fibers were put into the mixer followed by the mixing for 1 minute. Then, a wet-laid web of 70 g/m^2 was obtained using a 25 cm×25 cm hand-made paper device. The size of the web was determined.

[0156] (2) The thermal treatment was conducted at a thermal treatment shown in Table 3 (150° C.) using a Yankee drier. The thermal treatment time was set at 45 seconds.

[0157] (3) The size of the nonwoven after the thermal treatment was determined.

[0158] (4) The area shrinkage percentage was calculated from the above formula.

[0159] [Thickness of Nonwoven]

[0160] The thickness of the nonwoven after the thermal treatment was determined using a thickness meter (manufactured by Daiei Kagaku Seiki Seisakusho Co., Ltd., trade name: THICKNESS GAUGE model CR-60A) under a load of 2.94 cN/cm^2.

[0161] [Tensile strength of Nonwoven]

[0162] A sample piece of 5 cm in width is held at a grasp interval of 10 cm and extended at a pulling rate of 30±2 cm/min with a constant speed extension tensile tester in accordance with JIS L 1096 6.12.1 A method (strip method). The value of load at break is taken as the tensile strength. The tensile test was made for each of a lengthwise direction (a machine direction) of the nonwoven and a crosswise direction (a cross direction). The extension tensile test of the nonwoven produced from the fibers of Sample 10 was made only for one direction.

Experimental Example 1

Evaluation of Fiber Properties and the Nonwoven-Processability

(Sample 1)

[0163] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 156.0° C., MI_A was 51, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V40EX-1 produced by Mitsubishi Engineering-Plastics Corporation). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 169.0° C., MI_B was 28, and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A30EX-1 produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle (an office diameter 0.6 mm: this was the same in the production of the following samples) at a sheath-component spinning temperature of 190° C. and a core-component spinning temperature of 200° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 440 times. As a result, a spun filament having a fineness of 9.9 dtex was obtained.

[0164] The spun filament was drawn in hot air of 140° C. with a draw ratio of 4.7 times to give a drawn filament having a fineness of about 2 dtex. Next, a fiber treatment agent was applied to the drawn filament and mechanical crimps were formed in the filament with a stuffing box type crimper. Then, the filament in a relaxed state was subjected to an annealing treatment and a drying treatment at the same time for about 15 minutes, in a hot air-through thermal treatment machine wherein a temperature was set at 110° C. The filament was then cut into a fiber length of 51 mm and a thermoadhesive conjugate fiber in form of a staple fiber was obtained.

[0165] [Sample 2]

[0166] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 1, except that the setting temperature of the hot air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 90° C.

[0167] [Sample 3]

[0168] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 1, except that the setting temperature of the hot air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 60° C.

[0169] [Sample 4]

[0170] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 1, except that the spun filament was dry-drawn in the hot air of 140° C. at 5.7 times to obtain a drawn filament having a fineness of about 1.7 dtex and the setting temperature of the hot air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 60° C.

[0171] [Sample 5]

[0172] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 1, except that a eccentric sheath-core composite nozzle was used and the cross-sectional structure was made an eccentric sheath-care structure having an eccentricity of 40%.

[0173] [Sample 6]

[0174] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 156.0° C., MI_A was 51, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V40EX-1 produced by Mitsubishi Engineering-Plastics Corporation). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 169.4° C., MI_B was 53, and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40EX-1 produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 190° C. and a core-component spinning temperature of 200° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 495 times. As a result, a spun filament having a fineness of 8 dtex was obtained.

[0175] The spun filament was drawn on a hot plate of 140° C. with a draw ratio of 4.7 times to give a drawn filament having a fineness of about 1.7 dtex. Next, a fiber treatment agent was applied to the drawn filament and mechanical crimps were formed in the filament with a stuffing box type crimper. Then, the filament in a relaxed state was subjected to an annealing treatment and a drying treatment at the same time for about 15 minutes, in a hot air-through thermal treatment machine wherein a temperature was set at 60° C. The filament was then cut into a fiber length of 51 mm and a thermoadhesive conjugate fiber in form of a staple fiber was obtained.

[0176] [Sample 7]

[0177] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 6, except that the setting temperature of the hot air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 80° C.

[0178] [Sample 8]

[0179] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 6, except that the setting temperature of the air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 100° C.

[0180] [Sample 9: Comparative]

[0181] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 1, except that a polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 164° C., MI_B was 51, and content of CH_2CH_2O as the comonomer was 2.6 mass % as the ethylene oxide equivalent (trade name: F40-73R-1 produced by Mitsubishi Engineering-Plastics Corporation) and the setting temperature of the hot air-through thermal treatment (that is, the temperature for the annealing treatment and the drying treatment) was 60° C.

[0182] The properties of the staple fibers obtained as Samples 1 to 9 are shown in Tables 1 and 2. In the tables, "–" means that the item was not measured, and a box wherein "/" is indicated entirely means that the item could not be measured since the spinning could not be conducted or the nonwoven could not be produced.

TABLE 1

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Sheath Component	MI_A	(g/10 min)	51	51	51	51	51
	Melting Point (T_A)	(° C.)	156.0	156.0	156.0	156.0	156.0
	Melting Point (Tf_A)	(° C.)	153.6	153.6	153.8	154.0	154.7
Core Component	MI_B	(g/10 min)	28	28	28	28	28
	Melting Point (T_B)	(° C.)	169.0	169.0	169.0	169.0	169.0
	Melting Point (Tf_B)	(° C.)	167.7	168.2	169.5	170.0	170.1
Eccentric Form	Eccentricity	(%)	0	0	0	0	40
Production Conditions	Spinning Temperature (Sheath/Core)	(° C./° C.)	190/200	190/200	190/200	190/200	190/200
	Fineness of Spun Filament	(dtex)	9.0	9.0	9.0	9.0	9.0
	Drawing Temperature	(° C.)	140	140	140	140	140
	Draw Ratio	(times)	4.7	4.7	4.7	5.7	4.7
	Annealing/Drying Temp.	(° C.)	110	90	60	60	110
	Fiber Length	(mm)	51	51	51	51	51

TABLE 1-continued

			Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Single Fiber Properties	Fineness	(dtex)	2.0	2.0	2.0	1.7	2.0
	Strength	(cN/dtex)	4.76	4.78	4.81	4.93	2.85
	Elongation	(%)	94.1	96.3	103.6	87.6	132.7
	Number of Crimps	(peaks/25 mm)	116	12.2	16.7	16.5	21.3
	Percentage Crimps	(%)	7.3	8.8	11.0	13.8	16.4
	Knot Strength	(cN)	8.83	8.96	8.94	8.08	4.82
	Knot Strength Retention	(%)	92.75	93.72	92.93	96.41	84.56
Single Fiber Dry Heat Shrinkage Percentage	Initial Tension 0.018 mN/dtex	(%)	8.11	9.15	10.73	10.01	18.33
Cardability			Δ	○~Δ	○	○	Δ
Nonwoven Process Temperature		(° C.)	153	153	153	153	153
Nonwoven Area Shrinkage Percentage		(%)	7.4	9.9	8.1	2.7	36.4
Nonwoven Properties	Mass Per Unit Area	(g/m^2)	29.5	30.1	31.6	30.3	—
	Thickness	(mm)	0.61	0.68	0.81	1.01	—
	Specific Volume	(cm^3/g)	20.5	22.7	25.6	33.3	—
	Strength	MD	65.1	53.0	45.6	56.7	—
	(N/5 cm)	CD	15.5	15.4	13.5	15.1	—

TABLE 2

			Sample 6	Sample 7	Sample 8	Sample 9
Sheath Component	MI_A	(g/10 min)	51	51	51	51
	Melting Point (T_A)	(° C.)	156.0	156.0	156.0	156.0
	Melting Point (Tf_A)	(° C.)	154.5	154.6	154.6	156.5
Core Component	MI_B	(g/10 min)	53	53	53	51
	Melting Point (T_B)	(° C.)	168.3	168.3	168.3	164.0
	Melting Point (Tf_B)	(° C.)	171.4	171.5	171.8	162.7
Eccentric Form	Eccentricity	(%)	0	0	0	0
Production Conditions	Spinning Temperature (Sheath/Core)	(° C./° C.)	190/200	190/200	190/200	190/200
	Fineness of Spun Filament	(dtex)	8.0	8.0	8.0	9.0
	Drawing Temperature	(° C.)	140	140	140	140
	Draw Ratio	(times)	5.0	5.0	5.0	4.7
	Annealing/Drying Temp.	(° C.)	60	80	100	60
	Fiber Length	(mm)	51	51	51	51
Single Fiber Properties	Fineness	(dtex)	1.68	1.72	1.73	2.0
	Strength	(cN/dtex)	3.87	3.69	3.67	2.31
	Elongation	(%)	36.50	35.90	43.90	134.0
	Number of Crimps	(peaks/25 mm)	15.20	12.40	18.90	16.5
	Percentage Crimps	(%)	8.50	6.80	10.00	11.3
	Knot Strength	(cN)	6.31	6.11	6.20	3.32
	Knot Strength Retention	(%)	97.05	96.27	97.65	71.86
Single Fiber Dry Heat Shrinkage Percentage	Initial Tension 0.018 mN/dtex	(%)	10.20	9.80	8.60	43.41
Cardability			○	○	Δ	○
Nonwoven Process Temperature		(° C.)	155	155	155	155
Nonwoven Area Shrinkage Percentage		(%)	2.0	1.8	1.8	
Nonwoven Properties	Mass Per Unit Area	(g/m^2)	31.4	29.0	30.4	
	Thickness	(mm)	0.72	0.63	0.55	
	Specific Volume	(cm^3/g)	23.5	21.7	18.1	
	Strength	MD	90.3	75.6	89.9	
	(N/5 cm)	CD	20.0	14.8	15.3	

[0183] The conjugate fibers of Samples 2 to 4, 6 and 7 presented good cardability and small shrinkage upon the thermal adhesion treatment, which means favorable processability. In contrast, the conjugate fibers of Samples 1, 5 and 8 presented a slightly deteriorated cardability. It is considered that this is because the annealing temperatures for the conjugate fibers of Samples 1, 5 and 8 were slightly high. The measurement of knot strengths and knot strength retentions of Samples 6 to 8 showed that knot strength retentions of Samples 6 to 8 were high.

[0184] The fiber of Sample 9 could not give a nonwoven because of the shrink of the fiber upon the thermal adhesion treatment, although the fiber could be produced.

[0185] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 155.4° C., MI_A was 55, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V40-EX1 produced by Mitsubishi Engineering-Plastics Corporation). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 170.4° C., MI_B was 55, Mz was 320000, 150° C. ½ crystallization time was 25 seconds and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40-EX1 produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 185° C. and a core-component spinning temperature of 190° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 705 times. As a result, a spun filament having a fineness of 4.7 dtex was obtained.

[0186] The spun filament was drawn in hot air of 140° C. with a draw ratio of 6.5 times to give a drawn filament having a fineness of about 0.8 dtex. Next, a fiber treatment agent was applied to the drawn filament then cut into a fiber length of 5 mm and a thermoadhesive conjugate fiber in form of a short fiber was obtained.

[0187] [Sample 11]

[0188] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 155.0° C., MI_A was 58, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V40-EF produced by Mitsubishi Engineering-Plastics Corporation). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 170.5° C., MI_B was 58, Mz was 349000, 150° C. ½ crystallization time was 19 seconds and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40-EF produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 185° C. and a core-component spinning temperature of 190° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 417 times. As a result, a spun filament having a fineness of 8.0 dtex was obtained.

[0189] The spun filament was drawn in hot air of 140° C. with a draw ratio of 5.0 times to give a drawn filament having a fineness of about 1.8 dtex. Next, a fiber treatment agent was applied to the drawn filament and mechanical crimps were formed in the filament with a stuffing box type crimper. Then, the filament in a relaxed state was subjected to an annealing treatment and a drying treatment at the same time for about 15 minutes, in a hot air-through thermal treatment machine wherein a temperature was set at 60° C. The filament was then cut into a fiber length of 51 mm and a thermoadhesive conjugate fiber in form of a staple fiber was obtained.

[0190] [Sample 12]

[0191] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 11, except that the spinning temperature of the second component was 200° C. and the draw ratio of the spun filament was 4.3 times so as to obtain the drawn filament having a fineness of about 1.9 dtex.

[0192] [Sample 13]

[0193] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 11, except that the draw ratio (the spinning draft) during the melt extrusion was 572 times to obtain the spun filament having a fineness of 5.8 dtex and the fineness of the spun filament after the dry drawing was about 1.3 dtex.

[0194] [Sample 14]

[0195] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 11, except that the draw ratio (the spinning draft) during the melt extrusion was 572 times to obtain the spun filament having a fineness of 5.8 dtex and the draw ratio of the spun filament was 6.5 times to obtain the drawn filament having a fineness of about 1.0 dtex.

[0196] [Sample 15]

[0197] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 11, except that a polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 170.8° C., MI_B was 59, Mz was 357000, 150° C. ½ crystallization time was 10 seconds and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40-EF produced by Mitsubishi Engineering-Plastics Corporation), the draw ratio (the spinning draft) during the melt extrusion was 572 times to obtain the spun filament having a fineness of 5.8 dtex and the draw ratio of the spun filament was 4.3 times to obtain the drawn filament having a fineness of about 1.3 dtex.

[0198] [Sample 16]

[0199] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 11, except that a polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 170.8° C., MI_B was 59, Mz was 357000, 150° C. ½ crystallization time was 10 seconds and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40-EF produced by Mitsubishi Engineering-Plastics Corporation), the draw ratio (the spinning draft) during the melt extrusion was 370 times to obtain the spun filament having a fineness of 9.0 dtex and the draw ratio of the spun filament was 4.7 times to obtain the drawn filament having a fineness of about 2.0 dtex.

[0200] [Sample 17]

[0201] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 155.0° C., MI_A was 61, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V40-EF produced by Mitsubishi Engineering-Plastics Corporation). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 171.0° C., MI_B was 40, Mz was 400000, 150° C. ½ crystallization time was 18 seconds and content of CH_2CH_2O as the comonomer was 0.9 mass % as the ethylene oxide equivalent (trade name: A40-EF-L, produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 185° C. and a core-component spinning temperature of 190° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 396 times. As a result, a spun filament having a fineness of 8.4 dtex was obtained.

[0202] The spun filament was drawn in hot air of 140° C. with a draw ratio of 4.7 times to give a drawn filament having a fineness of about 1.8 dtex. Next, a fiber treatment agent was applied to the drawn filament and mechanical crimps were formed in the filament with a stuffing box type crimper. Then, the filament in a relaxed state was subjected to an annealing treatment and a drying treatment at the same time for about 15 minutes, in a hot air-through thermal treatment machine wherein a temperature was set at 60° C. The filament was then cut into a fiber length of 51 mm and a thermoadhesive conjugate fiber in form of a staple fiber was obtained.

[0203] [Sample 18]

[0204] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 17, except that the draw ratio (the spinning draft) was 370 times to obtain the spun filament having a fineness of 9.0 dtex and the resultant fiber having a fineness of about 2.0 dtex was obtained.

[0205] [Sample 19]

[0206] A polyoxymethylene-based polymer was prepared as the first component (the sheath component), of which T_A was 155.8° C., MI_A was 29, and content of CH_2CH_2O as the comonomer was 7.1 mass % as the ethylene oxide equivalent (trade name: V30-EF produced by Mitsubishi Engineering-Plastics Corporation). The polyoxymethylene-based polymer which was used as the second component in the production of Sample 15 was prepared as the second component (the core component). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 185° C. and a core-component spinning temperature of 190° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 370 times. As a result, a spun filament having a fineness of 9.0 dtex was obtained.

[0207] The spun filament was drawn in hot air of 140° C. with a draw ratio of 4.7 times to give a drawn filament having a fineness of about 2.0 dtex. Next, a fiber treatment agent was applied to the drawn filament and mechanical crimps were formed in the filament with a stuffing box type crimper. Then, the filament in a relaxed state was subjected to an annealing treatment and a drying treatment at the same time for about 15 minutes, in a hot air-through thermal treatment machine wherein a temperature was set at 60° C. The filament was then cut into a fiber length of 51 mm and a thermoadhesive conjugate fiber in form of a staple fiber was obtained.

[0208] [Sample 20]

[0209] A thermoadhesive conjugate fiber was produced according to the same procedures as those employed in the production of Sample 19, except that the draw ratio (the spinning draft) was 417 times to obtain the spun filament having a fineness of 8.0 dtex and the resultant fiber having a fineness of about 1.7 dtex was obtained.

[0210] [Sample 21]

[0211] A thermoadhesive conjugate fiber having a fineness of 5.8 dtex was intended to be produced with the draw ratio (the spinning draft) of 572 times, but the spinning could not be conducted.

[Sample 22]

[0212] The polyoxymethylene-based polymer which was used as the first component in Sample 19 (trade name: V30-EF produced by Mitsubishi Engineering-Plastics Corporation) was prepared as the first component (the sheath component). A polyoxymethylene-based polymer was prepared as the second component (the core component), of which T_B was 161.9° C., MI_B was 31, 150° C. ½ crystallization time was 353 seconds and content of CH_2CH_2O as the comonomer was 2.6 mass % as the ethylene oxide equivalent (trade name: F30-EF produced by Mitsubishi Engineering-Plastics Corporation). These two components were melted and extruded using a sheath-core composite nozzle at a sheath-component spinning temperature of 185° C. and a core-component spinning temperature of 190° C. The composite ratio (volume ratio) of first component/second component was 50/50. The draw ratio (spinning draft) was 370 times. Under the spinning conditions, a spun filament having a fineness of 9.0 dtex was intended to be produced, but the spinning could not be conducted.

[0213] [Sample 23]

[0214] The spun filament having a fineness of 33.0 dtex was intended to be obtained by setting the draw ratio (the spinning ratio) at 100 times, but the spinning could not be conducted.

[0215] The properties of the staple fibers obtained as Samples 10 to 23 are shown in Tables 3 to 5. In the tables, "–" means that the item was not measured, and a box wherein "/" is indicated entirely means that the item could not be measured since the spinning could not be conducted or the nonwoven could not be produced.

TABLE 3

			Sample 10	Sample 11	Sample 12	Sample 13
Sheath Component	MI_A	(g/10 min)	55	58	58	58
	Melting Point (T_A)	(° C.)	154.4	155.0	155.0	155.0
	Melting Point (Tf_A)	(° C.)	155.1	155.5	156.2	156.3
Core Component Before-Spinning	MI_B	(g/10 min)	55	58	58	58
	Melting Point (T_B)	(° C.)	170.4	170.5	170.5	170.5
	Z-Average Molecular Weight	Mz	320,000	349,000	349,000	349,000
	150° C. ½ Crystallization Time	(seconds)	25	19	19	19
Core Component After-Spinning	Wetting Poing (Tf_B)	(° C.)	171.4	171.7	172.8	171.1
	Z-Average Molecular Weight	Mz	—	—	—	289,000
	150° C. ½ Crystallization Time	(seconds)	33.0	20.4	27.0	24.0
Eccentric Form	Eccentricity	(%)	0	0	0	0
Production Conditions	Spinning Temperature (Sheath/Core)	(° C./° C.)	185/190	185/190	185/200	185/190
	Fineness of Spun Filament	(dtex)	4.7	8.0	8.0	5.8
	Drawing Temp.	(° C.)	140	140	140	140
	Draw Ratio	(times)	6.5	5.0	4.3	5.0
	Annealing/Drying Temp.	(° C.)	60	60	60	60

TABLE 3-continued

			Sample 10	Sample 11	Sample 12	Sample 13
	Fiber Length	(mm)	5	51	51	51
	Spinnablity		○	○	○	○
Single Fiber Properties	Fineness	(dtex)	0.8	1.8	1.9	1.3
	Strength	(cN/dtex)	4.4	4.2	4.0	4.3
	Elongation	(%)	18	26	22	21
	Number of Crimps	(peaks/25 mm)	17.1	16.4	16.7	16.9
	Percentage Crimps	(%)	12.6	12.4	12.7	12.5
	Knot Strength	(cN)	—	—	—	—
	Knot Strength Retention	(%)	—	—	—	—
Single Fiber Dry Heat Shrinkage Percentage	Initial Tension 0.018 mN/dtex	(%)	6.7	2.4	0	1.8
Cardability			—	○	○	○
Nonwoven Process Temperature		(° C.)	150	140	140	140
Nonwoven-Area Shrinkage Percentage		(%)	12.3	5.2	0	3.5
Nonwoven Properties	Mass Per Unit Area	(g/m^2)	70	28	28	28
	Thickness	(mm)	0.20	0.71	0.82	060
	Specific Volume	(cm^3/g)	2.85	25.1	29.2	21.6
	Strength (N/5 cm)	MD	23	99	98	98
		CD	—	20	18	18

TABLE 4

			Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
Sheath Component	MI$_A$	(g/10 min)	58	58	58	61	61
	Melting Point (T$_A$)	(° C.)	155.0	155.0	155.0	155.0	155.0
	Melting Point (Tf$_A$)	(° C.)	156.7	155.6	155.2	155.4	155.3
Core Component Resin	MI$_B$	(g/10 min)	58	59	59	40	40
	Melting Point (T$_B$)	(° C.)	170.5	170.8	170.8	171.0	171.0
	Z-Average Molecular Weight	Mz	349,000	357,000	357,000	400,000	400,000
	150° C. ½ Crystallization Time	(seconds)	19	24	24	18	18
Core Component Fiber	Melting Poing (Tf$_B$)	(° C.)	172.5	172.2	171.8	171.9	171.7
	Z-Average Molecular Weight	Mz	—	—	—	—	—
	150° C. ½ Crystallization Time	(seconds)	31.8	13.8	24.0	18.0	18.0
Eccentric Form	Eccentricity	(%)	0	0	0	0	0
Production Conditions	Spinning Temperature (Sheath/Core)	(° C./° C.)	185/200	185/190	165/190	185/195	185/195
	Fineness of Spun Filament	(dtex)	5.8	5.8	9.0	8.4	9.0
	Drawing Temp.	(° C.)	140	140	140	140	140
	Draw Ratio	(times)	6.5	4.3	4.7	4.7	4.7
	Annealing/Drying Temp.	(° C.)	60	60	60	60	60
	Fiber Length	(mm)	51	51	51	51	51
	Spinnability		○	○	○	Δ	○
Single Fiber Properties	Fineness	(dtex)	1.0	1.3	2.0	1.8	2.0
	Strength	(cN/dtex)	4.2	4.1	3.8	3.6	3.9
	Elongation	(%)	19	19	23	20	21
	Number of Crimps	(peaks/25 mm)	17.3	16.6	17.2	16.7	17.1
	Percentage Crimps	(%)	12.3	11.9	12.2	11.8	12.1
	Knot Strength	(cN)	—	—	—	—	—
	Knot Strength Retention	(%)	—	—	—	—	—
Single Fiber Dry Heat Shrinkage Percentage	Initial Tension 0.018 mN/dtex	(%)	0	0	0	0	0
Cardability			○	○	○	○	○
Nonwoven Process Temperature		(° C.)	156	156	156	156	156
Nonwoven-Area Shrinkage Percentage		(%)	0	0	0	0	0
Nonwoven Properties	Mass Per Unit Area	(g/m^3)	30	29	30	28	29
	Thickness	(mm)	0.55	0.61	0.80	0.78	0.79
	Specific Volume	(cm^3/g)	18.3	21.2	26.7	27.9	27.2
	Strength (N/5 cm)	MD	96	97	96	99	95
		CD	20	18	19	20	19

TABLE 5

			Sample 19	Sample 20	Sample 21	Sample 22	Sample 23
Sheath Component	MI_A	(g/10 min)	29	29	29	29	29
	Melting Point (T_A)	(° C.)	155.8	155.8	155.8	155.8	155.8
	Melting Point (Tf_A)	(° C.)	156.1	156.1	156.1	156.1	156.1
Core Component Resin	MI_B	(g/10 min)	59	59	59	31	31
	Melting Point (T_B)	(° C.)	170.8	170.8	170.8	161.9	161.9
	Z-Average Molecular Weight	Mz	357,000	357,000	357,000	—	—
	150° C. ½ Crystallization Time	(seconds)	24	24	24	353	353
Core Component Fiber	Melting Poing (Tf_B)	(° C.)	171.4	171.4	171.4	163.1	163.1
	Z-Average Molecular Weight	Mz	—	—	—	—	—
	150° C. ½ Crystallization Time	(seconds)	26.3	26.3	26.3	366.0	366.0
Eccentric Form	Eccentricity	(%)	0	0	0	0	0
Production Conditions	Spinning Temperature (Sheath/Core)	(° C./° C.)	185/190	185/190	185/190	185/190	185/190
	Fineness of Spun Filament	(dtex)	9.0	8.0	5.8	9.0	33.0
	Drawing Temp.	(° C.)	140	140			
	Draw Ratio	(times)	4.7	4.7			
	Annealing/Drying Temp.	(° C.)	60	60			
	Fiber Length	(mm)	51	51			
	Spinnablity		○	○	x	x	x
Single Fiber Properties	Fineness	(dtex)	2.0	1.7			
	Strength	(cN/dtex)	3.6	3.7			
	Elongation	(%)	20	19			
	Number of Crimps	(peaks/25 mm)	16.3	15.5			
	Percentage Crimps	(%)	11.0	9.9			
	Knot Strength	(cN)	—	—			
	Knot Strength Retention	(%)	—	—			
Single Fiber Dry Heat Shrinkage Percentage	Initial Tension 0.018 mN/dtex	(%)	0	0			
Cardability			○	○			
Nonwoven Process Temperature		(° C.)	156	156			
Nonwoven-Area Shrinkage Percentage		(%)	0	0			
Nonwoven Properties	Mass Per Unit Area	(g/m^2)	29.3	28.8			
	Thickness	(mm)	066	0.59			
	Specific Volume	(cm^3/g)	22.5	20.5			
	Strength (N/5 cm)	MD	94	98			
		CD	20	18			

[0216] All of Samples 10 to 16 presented good spinnability and relatively small single fiber dry heat shrinkage percentages. Further, all of Samples 11 to 16 presented good cardability and small shrinkage upon the thermal adhesion. As to Sample 10, the wet-laid nonwoven was produced and the shrinkage of this nonwoven was determined. For this reason, the area shrinkage percentage was slightly high, but the percentage was a sufficiently practical level. Sample 17 was an example wherein the Z-average molecular weight of 400000 was used as the second component, and the spinnability was slightly deteriorated. Sample 18 wherein the same second component was used and the spun filament was 9.0 dtex to give the resultant fiber having a fineness of 2.0 dtex, was spun well.

[0217] Samples 19 and 20 were spun well, although the before-spinning melt index was 30 or less. This was because the before-spinning 150° C. ½ crystallization time of the second component was 24 seconds. However, when the fineness of the spun filament was made small so that a finer fiber is obtained, the spinning could not be conducted (Sample 21). In Sample 22, the spinning could not be conducted when the spun filament was set at 9.0 dtex, since the before-spinning melt index of the first component was 30 or less and the before-spinning 150° C. ½ crystallization time of the second component was long. In Sample 23, the spun filament was set at a relatively large fineness to improve the spinnability, using the same resins as those used in Sample 22, but the spinning could not be conducted.

Experimental Example 2

Evaluation of Water Retentivity of Nonwoven

[0218] (Sample NW-1)

[0219] The water retentivity of a nonwoven of the fibers of the present invention was evaluated. Sample 12 produced in Experimental Example 1 was used to make a parallel web having a mass per unit area of about 70 g/m^2 and then the web was subjected to a hydroentangling treatment. The hydroentangling treatment was conducted using a nozzle wherein orifices each having a 0.1 mm diameter were provided in a line at intervals of 0.6 mm. Water streams were applied once to one surface of the web at a water pressure of 3 MPa and the water streams were applied once to the other surface of the web at a water pressure of 3.5 MPa. Then, the web after the hydroentangling treatment was dried with a hot air-through thermal treating machine at 160° C. to give a thermally bonded nonwoven. The resultant nonwoven was cut into a size of 10 cm×10 cm and put into a water bath. The nonwoven was impregnated with water sufficiently not to float and left in the water bath for 10 minutes. Then, the nonwoven was taken out and three corners of the four corners are pinched with clothespins and suspended. After suspending the nonwoven for 10 minutes, a mass of the nonwoven was determined and the water retentivity was calculated from a difference in mass between the nonwoven before and after being immersed in water. The results are shown in Table 6.

[0220] (Sample NW-2; Comparative)

[0221] A thermoadhesive conjugate fiber (trade name: NBF(H) produced by Daiwabo Polytec Co., ltd.) wherein the sheath component/the core component was a high-density polyethylene/polypropylene, having a fiber length of 51 mm and the fineness of 1.7 dtex, was prepared. The thermally bonded nonwoven was produced according to the same procedures as those employed in the production of Sample NW-1, except that the drying temperature was set at 140° C. Further, the water retentivity of this nonwoven was determined by the same method as that employed in Sample NW-1. The results are shown in Table 6.

TABLE 6

Sample	Mass per Unit Area (g/m^2)	Thickness (mm)	Density (g/cm^3)	Mass in Dry State (g)	Mass after Leaving Sample in Water for 10 min. (g)	Water Retention (%)
NW-1	65	0.65	0.100	0.65	4.70	623
NW-2	67	0.86	0.078	0.67	3.98	494

[0222] In general, as the thickness of the nonwoven is larger, the water retentivity is higher. Although Sample NW-1 is thinner than Sample NW-2, it showed higher water retentivity. This means that the conjugate fiber of the present invention can confer excellent water retentivity to the fiber assembly. The nonwoven showing such water retentivity is suitable for a wet tissue, a wiper, a mask and so on.

Experimental Example 3

Evaluation of Slippability of Nonwoven

[0223] (Sample NW-3)

[0224] The slippability of the nonwoven formed from the fibers of the present invention was evaluated. Sample 1 produced in Experimental Example 150 mass % and rayon fiber (trade name: Corona produced by DAIWABO RAYON Co., Ltd., fineness 1.7 dtex, fiber length 40 mm) 50 mass % were mixed and a parallel web having about a mass per unit area of about 60 g/m^2 was made using the mixed fibers. The web was subjected to the hydroentangling treatment. The hydroentangling treatment was conducted using a nozzle wherein orifices each having a 0.1 mm diameter were provided in a line at intervals of 0.6 mm. Water streams were applied to one surface of the web once at a water pressure of 3 MPa and the water streams were applied to the other surface of the web once at a water pressure of 3.5 MPa. Then, the web after the hydroentangling treatment was dried with a hot air-through thermal treating machine at 160° C. to give a thermally bonded nonwoven.

[0225] (Sample NW-4; Comparative)

[0226] The thermoadhesive conjugate fiber (trade name: NBF(H) produced by Daiwabo Polytec Co., ltd.) wherein the sheath component/the core component was a high-density polyethylene/polypropylene, having the fiber length of 51 mm and the fineness of 1.7 dtex was prepared. The thermally bonded nonwoven was produced according to the same procedures as those employed in the production of Sample NW-3, except that the drying temperature was set at 140° C.

[0227] The slippability of Samples NW-3 and NW-4 were evaluated according to the following procedures:

[0228] (1) The nonwoven was cut into a size of 10 cm×10 cm;

[0229] (2) The nonwoven was placed on a glass plate so that the surface to which the water streams of 3.5 MPa were applied contacted with the glass plate, and an acrylic plate having a thickness of 1 mm was placed on the nonwoven and a weight of 200 g was further placed on the acrylic plate;

[0230] (3) The nonwoven and the acrylic plate were pinched with a clip and a spring scale (produced by Sankou Seikohjyo Co. Ltd.) which could measure a load of up to 196 cN was attached to the clip; and

[0231] (4) The average load when a laminate of the nonwoven and the acrylic plate was slid 10 cm on the glass plate was read off.

[0232] Sample NW-3 showed 44.1 cN as the load described in (4). Sample NW-4 showed 53.9 cN as the load described in (4). From these results, it was found that the nonwoven produced using the thermoadhesive conjugate fiber of the present invention presented excellent slippablity and the nonwoven was suitable for a wiper or the like used in a dry state.

Experimental Example 4

Production and Evaluation of Personal Wiper

[0233] [Sample WP-1]

[0234] 8-segment splittable conjugate fiber consisting of a combination of PET/HDPE (trade name: DFS(SH) produced by Daiwabo Polytec Co., ltd.) which has a fineness of 2.2 dtex and a fiber length of 51 mm was prepared. This splittable conjugate fiber 70 mass % and the conjugate fiber of Sample 1 30 mass % were mixed and then a parallel web having a mass per unit area of 50 g/m^2 was made. The web was subjected to the hydroentangling treatment to entangle the fibers and divide the splittable conjugate fiber to form ultrafine fibers, using a nozzle wherein orifices each having a 0.1 mm diameter were provided in a line at intervals of 0.6 mm. Water streams were applied to one surface of the web once at a water pressure of 3 MPa, and the water streams were applied to the other surface of the web once at a water pressure of 3 MPa. Next, the web after the hydroentangling treatment was dried with a hot air-through thermal treating machine at 100° C. to give a hydroentangled nonwoven. In this nonwoven, the fibers were not thermally bonded.

[0235] [Sample WP-2: Comparative]

[0236] A parallel web having a mass per unit area of 50 g/m^2 was made only from the splittable conjugate fibers used in the production of Sample WP-1. This web was subjected to the hydroentangling treatment to divide the splittable conjugate fiber. The hydroentangling treatment was conducted using a nozzle wherein orifices each having a 0.1 mm diameter were provided in a line at intervals of 0.6 mm. Water streams were applied to the one surface of the web once at a water pressure of 3 MPa and the water streams were applied to the other surface of the web once at a water pressure of 3 MPa. Then the web after the hydroentangling treatment was dried with a hot air-through thermal treating machine at 100° C. to give a hydroentangled nonwoven.

[0237] [Sample WP-3: Comparative]

[0238] A parallel web having a mass per unit area of 50 g/m^2 was made only from cotton (trade name: MS-D produced by MARUSAN INDUSTRY CO., LTD.) and this web was subjected to the hydroentangling treatment. The hydroentangling treatment was conducted using a nozzle wherein orifices each having a 0.1 mm diameter were provided in a line at intervals of 0.6 mm. Water streams were applied to one surface of the web once at a water pressure of 2.5 MPa and the water streams were applied to the other surface of the web once at a water pressure of 2.5 MPa. Next, the web after the hydroentangling treatment was dried using a hot air-through thermal treating machine at 100° C. to give a hydroentangled nonwoven.

[0239] The properties of the three samples were evaluated when the samples were used as the wiper for removing blot from skin of a person. Specifically, the evaluation was conducted according to the following procedures:

[0240] (1) Lip rouge was over painted three times on a left palm and left for three minutes;

[0241] (2) The sample was cut into a size of 5 cm×10 cm

[0242] (the lengthwise direction (MD)×crosswise direction (CD));

[0243] (3) The lip rouge was wiped off by rubbing the left palm three times by means of the sample applying a little pressure. The sample and the left palm were observed and the wiping-ability was evaluated according to the following standards;

[0244] 1: Much blot remained;

[0245] 2: Blot left on the left palm was noticeable;

[0246] 3: Much blot was transferred to the surface of the sample, but a little blot remained (slightly noticeable);

[0247] 4: Much blot was transferred to the surface of the sample and a tiny amount of blot remained (not noticeable);

[0248] 5: Much blot was transferred into the sample and a tiny amount of blot remained (not noticeable).

[0249] Further, the similar wiping-ability was evaluated by over-painting eyebrow on the left palm.

[0250] Furthermore, the feel of each sample was evaluated according to the following standards:

[0251] 1: Hard and rough;

[0252] 2: Hard and slightly rough;

[0253] 3: Slightly hard and slightly rough;

[0254] 4: Soft and slightly rough;

[0255] 5: Soft and not rough.

[0256] Furthermore, the rigidity of each sample was determined using a handleometer (model type HOM-200, manufactured by Daiei Kagaku Seiki Seisakusho Co., Ltd.). More specifically, a test piece of 20 cm×17.5 cm (the lengthwise direction (MD)×the crosswise direction (CD)) was set on a slit of a 10 mm width perpendicular to the slit and the test piece was pushed by 8 mm at a position shifted by 6.7 cm from the side of the test piece (at a position of one third of the testing width) using a blade of a penetrator and a resistance value was measured as the stiffness. The resistance values during the push were measured at two different points for each of the lengthwise direction and the crosswise direction (CD) respectively of one sample, and the sum of the measured four values was evaluated as the rigidity.

[0257] The evaluation results are shown in Table 7.

TABLE 7

Sample	Mass per Unit Area (g/m^2)	Thickness (mm)	Feeling	Rigidity (g)	Wiping-Ability	
					Rouge	Eyebrow
WP-1	54	0.72	5	18.9	5	5
WP-2	54	0.76	5	22.1	5	5
WP-3	48	0.65	3	26.1	3	3

[0258] Sample WP-3 made of cotton that is widely used in a sheet for removing cosmetics were inferior in feeling and wiping-ability compared to the other samples and had a large rigidity and hard and rough feeling. In contrast, Sample WP-2 which contains ultrafine fibers formed by division of the splittable conjugate fiber had good feeling and wiping-ability, as already known to those skilled in the art. Sample WP-1 containing the conjugate fiber of the present invention presented the feeling and the wiping-ability equivalent to those of Sample WP-2 although the content of the splittable fibers (that is, the ultrafine fibers) in Sample WP-1 was smaller than that in Sample WP-2. Further, the rigidity of Sample WP-1 is the smallest among the three samples. Therefore, Sample WP-1 was very soft. Furthermore, as shown in Experimental Example 3, since the conjugate fiber of the present invention improved the slippability of the nonwoven, Sample WP-1 was an excellent wiper which enabled the blot to be removed by lightly wiping the skin therewith. These mean that the conjugate fiber of the present invention is suitable for constituting the wiper.

Experimental Example 5

Evaluation of Impersonal Wiper

[0259] [Sample WP-4]

[0260] 8-segment splittable conjugate fiber consisting of a combination of PET/HDPE (trade name: DFS(SH) produced by Daiwabo Polytec Co., ltd.) having a fineness of 2.2 dtex and a fiber length of 51 mm was prepared. This splittable conjugate fiber 70 mass % and the conjugate fiber of Sample 1 30 mass % were mixed and then two parallel webs each of which had a mass per unit area of 27 g/m^2 were made. A tissue (produced by Havix Corporation) having a mass per unit area of 17 g/m^2 which was made from wood pulp was sandwiched with these two webs to give a a laminated web of three-layer structure.

[0261] This laminated web was subjected to the hydroentangling treatment to entangle the fibers and divide the splittable conjugate fiber to form ultrafine fibers. The hydroentangling treatment was conducted using a nozzle wherein orifices each having a 0.1 mm diameter are provided in a line at intervals of 0.6 mm. Water streams were applied to one surface of the web once at a water pressure of 3 MPa and the water streams were applied to the other surface of the web once at a water pressure of 3.5 MPa. Then the web after the hydroentangling treatment was dried with a hot air-through thermal treating machine at 100° C. to give a hydroentangled nonwoven. In this nonwoven, the fibers were not thermally bonded.

[0262] [Sample WP-5]

[0263] 16-segment splittable conjugate fiber consisting of a combination of PET/PP (trade name: DF-1 produced by Daiwabo Polytec Co., ltd.) having a fineness of 3.3 dtex and a fiber length of 51 mm was prepared. A hydroentangled nonwoven of laminated structure was produced according to the same procedures as those employed in the production of Sample WP-4, except that only this splittable conjugate fiber was used.

[0264] [Sample WP-6]

[0265] A hydroentangled nonwoven of laminate structure was produced according to the same procedures as those employed in the production of Sample WP-4, except that only the splittable fiber used in the production of Sample WP-4 was used.

[0266] The performance of each of these samples was evaluated when using each sample as a wiper to remove dirt adhered to a surface of a impersonal object. Specifically, the evaluation was conducted according to the following procedures:

[0267] The nonwoven was cut into a size of 20 cm×60 cm (the crosswise direction (CD)×the lengthwise direction (MD)) and folded in eightmo. Then, the sample was impregnated with a 50% aqueous solution wherein "Fukupika Spray Wax" (trade name) (produced by SOFT 99 Corporation) was diluted with water. The sample was impregnated with the aqueous solution of 250 mass % relative to the mass of the sample. The wetted sample was moved back and forth ten times on a portion of painted surface of a car body to remove the dirt. The operation for removing the dirt was repeated twice. Further, the sample was moved back and forth ten times on another portion of the painted surface of the car body, while lightness of wiping, how liquid is released, kink, fuzz, liquid remain, and wiping-ability were evaluated according to the following standards:

[0268] [Lightness]

[0269] 1 Heavy and difficult to use for wiping operation;

[0270] 2 Little heavy, but no problem to use for wiping operation;

[0271] 3 Light, but little resistance feeling;

[0272] 4 Light and easy to use for wiping operation.

[0273] [How Liquid is Discharged]

[0274] 1 Liquid is discharged at one time, and can be used for wiping only a small area;

[0275] 2 Liquid is discharged slightly more, and can be used for wiping a not-large area;

[0276] 3 Liquid is discharged adequately, but can be used for wiping a slightly-reduced area;

[0277] 4 Liquid is discharged adequately, and can be used for wiping a large area broad.

[0278] [Kink]

[0279] 1 Kink starts to be made just after starting wiping;

[0280] 2 Kink does not occur when starting wiping, but kink occurs slightly after a short time;

[0281] 3 kink does not occur when starting wiping, but very slight kink occurs after a short time;

[0282] 4 Very slight kink occurs when liquid in the sample starts to evaporate.

[0283] [Fuzz]

[0284] 1 Fuzz generates;

[0285] 2 A little fuzz generates during the use of the sample;

[0286] 3 Fluff generates on the sample surface, but fuzz does not generate during the use of the sample;

[0287] 4 A little fluff generates.

[0288] [Liquid Remain]

[0289] 1 Water droplets on the object being wiped after wiping are large and difficult to dry;

[0290] 2 Water droplets on the object being wiped after wiping are slightly large and require a slightly long time for drying;

[0291] 3 Water droplets on the object being wiped after wiping are small and dry in a little while;

[0292] 4 Water droplets on the object being wiped after wiping are minute and dry in a little while.

[0293] [Wiping-Ability]

[0294] 1 Dirt cannot be wiped off cleanly;

[0295] 2 Dirt can be wiped off cleanly after moving the sample back and forth five or six times;

[0296] 3 Dirt can be wiped off cleanly after moving the sample back and forth two or three times;

[0297] 4 Dirt can be wiped off cleanly after moving one or two times.

[0298] The results of evaluation are shown in Table 8.

TABLE 8

Sample	Lightness (Wiping Comfortableness)	How Liquid Is Discharged	Kink	Lint	Liquid Remain	Wiping-Ability	Total
WP-4	3	4	3	3	4	3	20
WP-5	4	2	2	2	2	2	14
WP-6	4	4	2	3	4	3	20

[0299] Although Sample WP-4 had a construction wherein the upper and the lower layers contained the conjugate fibers of the present invention which were not the splittable fibers, it presented more excellent wiping-ability than Sample WP-5 wherein the upper and the lower layers consist only of the splittable fibers. Further, Sample WP-4 showed better results for all items except for "lightness" than Sample WP-5. Sample WP-6 was formed only from the splittable conjugate fiber which constituted Sample 4 and had more ultrafine fibers than Sample WP-4. Nevertheless, Sample WP-4 presented the same properties as those of Sample WP-6. These mean that the conjugate fiber of the present invention is suitable for constituting the wiper.

Experimental Example 6

Evaluation of Compression Recoverability of Nonwoven

[0300] [Sample MA-1: Comparative]

[0301] A high-elastic PET fiber (trade name: elk produced by TEIJIN FIBERS LIMITED, fineness 6.6 dtex, fiber length 64 mm) 30 mass % and a hollow PET fiber (trade name: H18F produced by Unitika Ltd., fineness 6.7 dtex, fiber length 51 mm) 50 mass % and a latently crimpable PET fiber (trade name: C81, produced by Unitika Ltd., fineness 2.8 dtex, fiber length 51 mm) 20 mass % were mixed, and a parallel web was made using this mixed fibers and then the webs were laminated using a cross layer to give a laminated web having a mass per unit area of 800 g/m^2. The laminated web was subjected to a thermal treatment for seven minutes with an oven at 200° C. to give a bulky sponge-like nonwoven having a thickness of 28 mm.

[0302] [Sample MA-2]

[0303] A parallel web was made from the sheath-core conjugate fiber of Sample 3 produced in Experimental Example 1. Then, the webs were laminated with a cross layer to give a laminated web having a mass per unit area of 800 g/m^2. The laminated web was subjected to a thermal treatment for seven minutes at 156° C. to give a bulky sponge-like nonwoven having a thickness of 25 mm.

[0304] Each of the samples was cut into a size of 10 cm×10 cm and a weight of 5.6 kg was placed thereon and left for 24 hours. Then, the weight was removed and the thickness of the nonwoven was determined over time to evaluate the bulk recoverability. The results of the evaluation are shown in Table 9.

TABLE 9

				After Removing Weight							
Sample		Initial	Weighted	0 min.	5 min	10 min.	20 min.	60 min	150 min	360 min.	24 hours
MA-1	Thickness (mm)	28.0	8.0	24.0	25.0	25.5	26.0	26.5	26.5	27.0	27.0
	Recovery Rate (%)	—	—	85.7	89.3	91.1	92.9	94.6	94.6	24.0	96.4
MA-2	Thickness (mm)	25.0	15.0	19.0	20.0	21.0	22.0	23.0	23.5	24.0	25.0
	Recovery Rate (%)	—	—	76.0	80.0	84.0	88.0	92.0	94.0	96.0	100.0

[0305] Sample MA-1 made for comparison containing the high elastic fiber and the latently crimpable fiber was bulky enough to be used as, for example, a bed mat, and had high compression recoverability, particularly high initial bulk recoverability. On the other hand, the thermoadhesive conjugate fiber of the present invention showed a bulk recovery percentage of 100% 24 hours after removing weight and presented high bulk recoverability although it does not have latently crimpability and elasticity. The nonwoven presenting such bulk recoverability is suitable for using as a cushion material, a brassier pad and so on.

Experimental Example 7

Evaluation of Crease Resistance and Rigidity of Nonwoven

[0306] [Sample WR-1: Comparative]

[0307] A parallel carded web having a mass per unit area of 28.7 g/m^2 was made from a concentric sheath-core conjugate fiber wherein sheath/core was HDPE/PET and sheath:core (mass ratio) was 1:1 (trade name: NBF(SH) produced by Daiwabo Polytec Co., ltd., fineness 2.2 dtex, fiber length 51 mm). This web was subjected to a thermal treatment using a hot air-through thermal treating machine at 140° C. for 12 seconds to give a thermally bonded nonwoven with a thickness of 1.45 mm.

[0308] [Sample WR-2]

[0309] A parallel carded web having a mass per unit area of 27.4 g/m^2 was made from the sheath-core conjugate fiber of Sample 3 produced in Experimental Example 1. This web was subjected to a thermal treatment at 156° C. for 12 seconds to give a thermally bonded nonwoven having a thickness of 0.85 mm.

[0310] As to each of the two samples, the crease resistance percentage (wire method) was determined according to JIS L 1085, and the rigidity was determined according to JIS L 1096 (45° cantilever method). The results are shown in Table 10.

TABLE 10

Sample	Mass per Unit Area (g/m^2)	Thickness (mm)	Angle α (°)	Crease Resistance Percentage (%)	Rigidity (mm)
WR-1	28.7	1.45	145	80.6	120
WR-2	27.4	0.85	178	99.0	160

[0311] Sample WR-1 made from a general thermoadhesive conjugate fiber was soft and had a tendency of creasing. In contrast, Sample WR-2 made from the thermoadhesive conjugate fiber of the present invention had a higher rigidity than Sample WR-1. Further, this sample presented high crease resistance such that, when the sample was released from folded state, the sample opened instantly and returned to an original shape without crease. The nonwoven having such high crease resistance is suitable for a constituent for a hygiene product such as a menstrual sanitary product and a paper diaper (for example, a sheet for retaining a shape of the hygiene product) and an interfacing.

Experimental Example 8

Production of Molded Article

[0312] A parallel carded web was made from the fiber of Sample 12 produced in Experimental Example 1 and the webs were laminated using a cross layer to give a laminated web having a mass per unit area of 200 g/m^2. Then, the laminated web was cut into a size of 20 cm×20 cm.

[0313] Two hemisphere tea strainers made of metal mesh were prepared, one being of a dimension of 060 mm×a depth of 60 mm, and the other being of a dimension of 050 mm×a depth of 55 mm. The two tea strainers were stacked with the laminated web interposed between the strainers. The web sandwiched with the two tea strainers was subjected to a thermal treatment at 161° C. for 15 minutes with a batch-type hot air-through thermal treating machine. After the thermal treatment, the tea strainers were removed, and thereby a cup-shaped molded article having a wall thickness of 5 mm and a round bottom was obtained. Such a molded article is suitable for being used as, for example, a filter.

INDUSTRIAL APPLICABILITY

[0314] The thermoadhesive conjugate fiber of the present invention is one wherein the respective components are formed from polyoxymethylene-based polymers, whereby a fiber assembly (particularly a nonwoven) wherein the fibers are bonded only with a polyoxymethylene-based polymer can be produced. Further, the thermoadhesive conjugate fiber of the present invention confers, to the fiber assembly, high water retentivity, high slippability, crease resistance, and bulk recoverability and favorable wiping-ability. Therefore, the thermoadhesive conjugate fiber of the present invention is useful for producing the fiber assembly applicable to various uses for which heat resistance and chemical resistance are desired.

1. A thermoadhesive conjugate fiber comprising a first component as a thermoadhesive component which comprises a polyoxymethylene-based polymer A and a second component which comprises a polyoxymethylene-based polymer B, wherein the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

which fiber satisfies:

$30 < MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)),

a before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is not less than 10 seconds and less than 30 seconds, and

$Tf_B > Tf_A + 10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121.

2. (canceled)

3. The thermoadhesive conjugate fiber according to claim **1**, wherein an after-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is from 10 seconds to 100 seconds.

4. A thermoadhesive conjugate fiber comprising a first component as a thermoadhesive component which comprises a polyoxymethylene-based polymer A and a second component which comprises a polyoxymethylene-based polymer B, wherein:

the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

a before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is not less than 10 seconds and less than 30 seconds, and

$Tf_B > Tf_A + 10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121.

5. A thermoadhesive conjugate fiber comprising a first component as a thermoadhesive component which comprises a polyoxymethylene-based polymer A and a second component which comprises a polyoxymethylene-based polymer B, wherein:

the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

an after-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is from 10 seconds to 100 seconds, and

$Tf_B > Tf_A + 10$ wherein Tf_A and Tf_B are after-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121.

6. The thermoadhesive conjugate fiber according to claim **4**, wherein a before-spinning Z-average molecular weight of the polyoxymethylene-based polymer B is 500,000 or less.

7. The thermoadhesive conjugate fiber according to claim **5**, wherein an after-spinning Z-average molecular weight of the conjugate fiber is 350,000 or less.

8. The thermoadhesive conjugate fiber according to claim **4**, which is a sheath-core conjugate fiber consisting of the first component and the second component, the first component being a sheath component and the second component being a core component.

9. The thermoadhesive conjugate fiber according to claim **8**, which has an eccentric sheath-core cross section in which a center position of the second component is shifted from the center position of the fiber.

10. A method for producing a thermoadhesive conjugate fiber which comprises:

providing two kinds of polyoxymethylene-based polymers A and B which satisfy:

$30 < MI_A$ wherein MI_A is a before-spinning melt index (g/10 min) of the polyoxymethylene-based polymer A, which is determined according to JIS K 7210 (conditions: 190° C., load: 21.18N (2.16 kg)),

a before-spinning 150° C. ½ crystallization time of the polyoxymethylene-based polymer B is not less than 10 seconds and less than 30 seconds, and

$T_B > T_A + 10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively, which are determined according to JIS K 7121,

compositely spinning a first component comprising the polyoxymethylene-based polymer A and a second component comprising the polyoxymethylene-based polymer B such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

subjecting the spun fiber to a drawing treatment, and

subjecting the drawn fiber to an annealing treatment at a temperature of from 60° C. to 110° C.

11. (canceled)

12. A method for producing a thermoadhesive conjugate fiber, which comprises:

providing two kinds of polyoxymethylene-based polymers A and B, the polymer B having a before-spinning 150° C. ½ crystallization time of not less than 10 seconds and less than 30 seconds, and the polymers satisfying $T_B>T_A+10$ wherein T_A and T_B are before-spinning fusion peak temperatures of the polyoxymethylene-based polymers A and B respectively which temperatures are determined according to JIS K 7121,

compositely spinning a first component comprising the polyoxymethylene-based polymer

A and a second component comprising the polyoxymethylene-based polymer B such that the first component is exposed with an exposed length of not less than 20% relative to a peripheral length of the fiber,

subjecting the spun fiber to a drawing treatment, and

subjecting the drawn fiber to an annealing treatment at a temperature of from 60° C. to 110° C.

13. The method for producing a thermoadhesive conjugate fiber according to claim **12**, wherein the annealing is conducted at a temperature of from 60° C. to 90° C.

14. The method for producing a thermoadhesive conjugate fiber according to claim **12**, wherein spinning is conducted at a draft ratio of from 100 times to 1000 times and the drawing is conducted at a draw ratio of from 4 times to 10 times.

15. A fiber assembly comprising the thermoadhesive conjugate fiber according to claim **4** in an amount of 10 mass % or more.

16. The fiber assembly according to claim **15**, wherein the fibers are thermally bonded to each other.

17. The fiber assembly according to claim **15**, which is a nonwoven.

18. A wiper which comprises the nonwoven according to claim **17**.

19. The fiber assembly according to claim **15**, which is a molded article.

* * * * *