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(71) Applicants:
- **Daiwabo Holdings Co., Ltd.**
  Osaka-shi, Osaka 541-0056 (JP)
- **Daiwabo Polytec Co., Ltd.**
  Osaka 541-0056 (JP)

(72) Inventor: **OKAYA, Hiroshi**
Hyogo 675-0163 (JP)

(74) Representative: **Golding, Louise Ann**
Dehns
St Bride's House
10 Salisbury Square
London
EC4Y 8JD (GB)

(54) CRIMPED COMPOSITE FIBER, AND FIBROUS MASS AND TEXTILE PRODUCT USING THE SAME

(57) A crimped conjugate fiber of the present invention is a conjugate fiber containing a first component and a second component, the first component containing polybutene-1 and linear low density polyethylene, the linear low density polyethylene content being 2 to 25 mass%, the second component 2 containing a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher, when viewed from a fiber cross-section, the first component occupies at least 20% of the surface of the conjugate fiber 10 and the centroid position of the second component not overlapping the centroid position of the conjugate fiber, the conjugate fiber is an actualized crimping conjugate fiber in which three-dimensional crimps have been developed or a latently crimpable conjugate fiber in which three-dimensional crimps are developed by heating. Accordingly, a crimped conjugate fiber having high elasticity, a high level of bulk recovery properties, and high durability against repetitive compression as well as high elasticity, a high level of bulk recovery properties, and high durability when used at high temperatures, and a fiber assembly that uses the crimped conjugate fiber are provided.

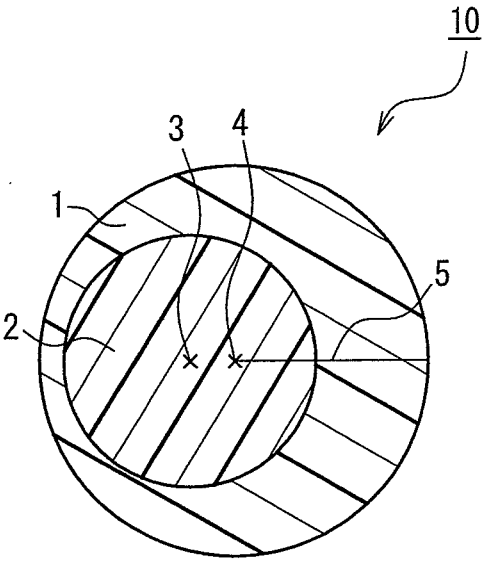

FIG. 1

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Description

Technical Field

[0001] The present invention mainly relates to an actualized crimping conjugate fiber and a latently crimp able conjugate fiber suitable for a fiber assembly having high elasticity and a high level of bulk recovery properties, in particular a nonwoven fabric, and to a fiber assembly and a fiber product that use such a conjugate fiber.

Background Art

[0002] Thermally bonded nonwoven fabrics containing a thermally fused conjugate fiber composed of a low-melting-point component that is exposed at least partially on the surface of the fiber and a high-melting-point component that has a melting point higher than that of the low-melting-point component are used in various applications, such as nonwoven fabrics used for hygienic materials, packaging materials, wet tissue, filters, wipers, and the like, nonwoven fabrics used for hard stuffing, chairs, and the like, and molded articles. In particular, as a urethane foam substitute, there is a growing demand for a nonwoven fabric having excellent elasticity and excellent bulk recovery properties, i.e., having excellent thickness-direction bulk recovery properties, and extensive research has been made on a nonwoven fabric having excellent bulk recovery properties and a conjugate fiber suitable for such a nonwoven fabric having excellent bulk recovery properties. Since a conjugate fiber suitable for a nonwoven fabric for use in such applications has itself excellent elasticity and shape recovery properties, research has been made on using the conjugate fiber itself as wadding for various pieces of bedding such blankets and mattresses as well as clothing articles.

[0003] Extensive research has been made on such a conjugate fiber that itself has excellent elasticity and a thermally bonded conjugate fiber that has excellent bulk recovery properties once it has been processed into a fiber assembly such as a nonwoven fabric. Patent Documents 1 and 2 below disclose a conjugate fiber composed of a polyester component having a melting point of 200°C or higher and a polyetherester block copolymer component, i.e., a so-called elastomer component, having a melting point of 180°C or lower. Use of the elastomer component as a sheath component enhances the degree of freedom of bonded points and durability against compression deformation, and thus a fiber having a high level of bulk recovery properties can be obtained.

[0004] Patent Document 3 discloses an actualized crimping conjugate fiber composed of a first component containing a polytrimethylene terephthalate (PTT)-based polymer and a second component that contains a polyolefin-based polymer, in particular, polyethylene, with crimping being obtained by arranging the centroid position of the first component so as not to overlap the centroid position of the fiber on the cross-section of the fiber. By including an actualized crimping conjugate fiber in which a polymer having large bending elasticity and small bending hardness is used as a first component, in which the cross-section of the fiber is eccentric, and in which the crimps are wavy, a nonwoven fabric that has a high level of bulk recovery properties, that is flexible, and that has a large initial bulk can be obtained.

[0005] Patent Documents 4 and 5 disclose a crimped conjugate fiber containing a sheath component containing polybutene-1 (hereinafter also referred to as PB-1) and a nonwoven fabric having excellent bulk recovery properties and improved initial bulk recovery properties that uses such a fiber.

[0006] In Patent Documents 1 and 2, a polyesterether elastomer is used as a sheath component, and a nonwoven fabric having a high level of bulk recovery properties is intended to be obtained by taking advantage of the fact that this polymer has rubber-like elasticity and a high degree of freedom from bonding point deformation. However, since this polyesterether elastomer is a copolymer of a hard polyester and a soft ether, and contains a soft component having low thermal resistance, this polyesterether elastomer is readily thermally softened, and the nonwoven fabric undergoes bulk reduction, or so-called sagging, during thermal processing. As a result, a conjugate fiber in which such a polyesterether elastomer is used as a sheath component is problematic in that the initial bulk when formed into a nonwoven fabric is small, only giving a highly dense nonwoven fabric, and its applications are thus limited. Furthermore, such a nonwoven fabric being compressed while being heated, or such a nonwoven fabric being repeatedly compressed is problematic in that, for example, the points where pieces of the fiber are bonded to each other and the fiber itself collapse or bend, and the fiber strength is impaired, and thus the hardness of the nonwoven fabric is significantly lower than that of the original nonwoven fabric.

[0007] In Patent Document 3, it is intended to obtain a nonwoven fabric having a high level of bulk recovery properties by selecting a specific polymer used for the core, a specific fiber cross-section, and a specific crimp state. However, while the initial thickness (initial bulk) of the nonwoven fabric is large, the bulk recovery properties, in particular the initial bulk recovery properties immediately after load removal, are not sufficient, and thus there is a problem in that its applications are limited.

[0008] The conjugate fiber disclosed in Patent Documents 4 and 5 is problematic in that, when a fiber web that uses the conjugate fiber is processed into a nonwoven fabric in which pieces of the component fiber are bonded to each other by thermal processing, or when pieces of the resulting nonwoven fabric are bonded to each other by thermal processing,

since the so-called sheath component that occupies for most of the fiber surface is composed of polybutene-1 and polypropylene, which has a higher melting point than polybutene-1, a phenomenon occurs in which the apparent melting point of the sheath component is increased, and thermal bonding properties in a heat treatment at a low temperature and the strength of the nonwoven fabric after thermal bonding are not sufficient, and it is also difficult to adjust the temperature conditions for thermal bonding processing.

[0009] In addition to Patent Documents 1 to 5, extensive research has been made on a nonwoven fabric having excellent bulk recovery properties, a conjugate fiber suitable for such a nonwoven fabric having excellent bulk recovery properties, a nonwoven fabric that uses such a fiber, and the like, but there is still a problem in that deterioration of bulk recovery properties is observed when a load is applied repetitively, and a fiber and a nonwoven fabric that are suitable for use in applications such as cushioning materials for which a high level of bulk recovery properties are needed even after being repetitively compressed are not obtained.

Citation List

Patent Documents

[0010]

Patent Document 1: JP H4-240219A
Patent document 2: JP H5-247724A
Patent document 3: JP 2003-3334A
Patent document 4: JP 2007-126806A
Patent document 5: JP 2008-248421A

Disclosure of the Invention

Problem to be Solved by the Invention

[0011] In order to solve the above-described problems of the conventional art, the present invention provides a crimped conjugate fiber having high elasticity, a high level of bulk recovery properties, and high durability against repetitive compression as well as having high elasticity, a high level of bulk recovery properties, and high durability when used at high temperatures, and a fiber assembly and a fiber product that use such a fiber.

Means for Solving the Problem

[0012] The crimped conjugate fiber of the present invention is a conjugate fiber containing a first component and a second component, the first component containing polybutene-1 and linear low density polyethylene, the content of the linear low density polyethylene in the first component is 2 to 25 mass%, the second component containing a polymer having a melting peak temperature at least 20°C higher than a melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher, when viewed from a fiber cross-section the first component occupies at least 20% of the surface of the conjugate fiber and the centroid position of the second component not overlapping the centroid position of the conjugate fiber, and the conjugate fiber is an actualized crimping conjugate fiber in which three-dimensional crimps have been developed or a latently crimpable conjugate fiber in which three-dimensional crimps are developed by heating. The melting initiation temperature as used herein refers to an extrapolated melting initiation temperature measured by differential scanning calorimetry (DSC) as defined in JIS-K-7121. Also, the melting peak temperature as used herein refers to a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121.

[0013] The fiber assembly of the present invention contains a crimped conjugate fiber in a proportion of 30 mass% or greater, and the crimped conjugate fiber is a conjugate fiber containing a first component and a second component, the first component containing polybutene-1 and linear low density polyethylene. The content of the linear low density polyethylene in the first component is 2 to 25 mass%. The second component contains a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher. When viewed from a fiber cross-section the first component occupies at least 20% of the surface of the conjugate fiber and the centroid position of the second component not overlapping the centroid position of the conjugate fiber, and the conjugate fiber is an actualized crimping conjugate fiber in which three-dimensional crimps have been developed or a latently crimpable conjugate fiber in which three-dimensional crimps are developed by heating.

[0014] The fiber product of the present invention at least partially contains the fiber assembly of the present invention

and is formed into hard stuffing, bedding, a vehicle seat, a chair, a shoulder pad, a brassiere pad, a garment, a hygienic material, a packaging material, a wet wipe, a filter, a sponge-like porous wiping material, a sheet-like wiping material, or wadding.

Effects of the Invention

[0015] In the crimped conjugate fiber of the present invention, the first component contains polybutene-1 and linear low density polyethylene, and the second component contains a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of the polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher, and accordingly the fiber exhibits excellent spinnability, stretchability, crimp formability, and like properties. Accordingly, use of the crimped conjugate fiber of the present invention enables a conjugate fiber that has excellent bulk recovery properties and excellent thermal processability with which pieces of the fiber can be strongly thermally bonded to each other even in low-temperature thermal bonding processing as well as a fiber assembly and a fiber product that use the conjugate fiber to be obtained.

[0016] A nonwoven fabric that uses the crimped conjugate fiber of the present invention has both excellent initial bulk and excellent bulk recovery properties, and can be suitably used for cushioning materials and like hard stuffing, hygienic materials, packaging materials, filters, materials for cosmetics, women's brassiere pads, shoulder pads, and like low-density nonwoven fabric products. Also, the crimped conjugate fiber of the present invention can be suitably used for wadding for various pieces of bedding such as mattresses and blankets and various clothes due to the sufficient elasticity and repulsive force of the fiber itself.

Brief Description of Drawings

[0017]

[Fig. 1] Fig. 1 shows the cross-section of a crimped conjugate fiber according to one embodiment of the present invention.
[Fig. 2] Figs. 2A to 2C show forms of crimps of a crimped conjugate fiber according to one embodiment of the present invention.
[Fig. 3] Fig. 3 shows a form of conventional mechanical crimps.
[Fig. 4] Fig. 4 shows a form of crimps of the crimped conjugate fiber of the present invention in which wavy crimps and serrated crimps are concomitantly present.

Description of the Invention

[0018] The crimped conjugate fiber of the present invention has high elasticity, a high level of bulk recovery properties, and high durability against repetitive compression as well as having high elasticity, a high level of bulk recovery properties, and high durability when used at high temperatures. In particular, a fiber assembly that uses the crimped conjugate fiber of the present invention that has actual crimps (hereinafter also referred to as an actualized crimping conjugate fiber) has large initial bulk. Afiber assembly that uses the crimped conjugate fiber of the present invention that has latent crimps (hereinafter also referred to as a latently crimpable conjugate fiber) develops crimps when multiple layers are placed one over another and thermally processed. Accordingly, entanglement of fibers between layers is enhanced, thus further increasing elasticity and bulk recovery properties.

First component

[0019] In the crimped conjugate fiber of the present invention, the first component contains polybutene-1 and linear low density polyethylene. Disposing the first component such that the first component occupies for at least 20% of the surface of the conjugate fiber enables a crimped conjugate fiber that makes use of the flexibility and the shape retainability (resilience after being deformed) of polybutene-1 to be obtained.

[0020] It was found in the present invention that the first component containing linear low density polyethylene in addition to polybutene-1 improves spinnability such as uniform fiber formation and stretchability during melt spinning as well as the spreadability of a staple fiber, the crimp formability of a staple fiber, and like properties. That is, it is thought that, when melt spinning is performed solely with polybutene-1, the viscosity of the polymer discharged from a nozzle is not likely to be stable, thus making it difficult to obtain a uniform fiber. Also, polybutene-1 has a high molecular weight, and the degree of freedom of its molecular chain is poor and it is thus difficult to perform a stretching step. In addition, polybutene-1 has very large heat shrinkability. Therefore, it is thought that the fiber would shrink during thermal processing, thus making it difficult to obtain a nonwoven fabric having good texture. However, since the first component contains

linear low density polyethylene in addition to polybutene-1, the aforementioned problems such as poor spinnability and poor stretchability of polybutene-1 can be solved. Polybutene-1 has a large molecular weight. That is, the molecular chain constituting polybutene-1 is long, and entanglement between molecules is extensive, and it is thought that the aforementioned problem, i.e., poor stretchability, is thus created. Here, it is presumed that when the polymer component contains linear low density polyethylene in addition to polybutene-1 as in the present invention, linear low density polyethylene enters between the molecular chains of polybutene-1 having high molecular weight, and adequately suppresses the entanglement of the molecular chains of polybutene-1, thus improving stretchability. In addition, due to the use of the polymer that contains linear low density polyethylene as the first component that occupies for most of the surface portion of the crimped conjugate fiber, a fiber assembly that uses the resulting crimped conjugate fiber exhibits excellent thermal processability (thermal treatment accomplished in a short period of time, uniform thermal bonding between component fibers) due to the linear low density polyethylene contained in the first component of the crimped conjugate fiber. That is, by adopting a configuration in which the principal component of the first component that occupies for most of the surface of the crimped conjugate fiber is polybutene-1, and linear low density polyethylene is added in a proportion of 2 to 25 mass% relative to the first component, the phenomenon of an increase of the apparent melting peak temperature of the first component resulting from addition of a high melting point polymer, which can occur when a polymer (for example, polypropylene) having a higher melting point than polybutene-1 is added to polybutene-1, does not occur. Accordingly, the crimped conjugate fiber of the present invention can be thermally bonded so as to attain sufficient bonding strength even when thermal processing is performed at a lower temperature for a shorter period of time, and thus the post-processability of a fiber assembly containing the crimped conjugate fiber is enhanced. Moreover, since linear low density polyethylene has excellent impact resistance, the fiber assembly of the present invention in which pieces of the component fiber are thermally bonded by the first component containing linear low density polyethylene of the crimped conjugate fiber of the present invention is unlikely to result in separation and delamination of bonded points of the fiber even when used in applications where a load is repetitively applied, and thus has excellent resistance to residual set from repetitive compression as well as resistance to residual set from compression.

[0021] The linear low density polyethylene is not particularly limited, and for example, copolymers with α-olefins polymerized using Ziegler catalysts and metallocene catalysts are usable. From the viewpoint of attaining a narrow molecular weight range and a uniform branch distribution, it is preferable to use copolymers with α-olefins polymerized using metallocene catalysts. Afeature of linear low density polyethylene polymerized using a metallocene catalyst is having a uniform distribution of molecular weight, composition, and crystallinity. Due to the foregoing feature, linear low density polyethylene polymerized using a metallocene catalyst is likely to be uniformly dispersed inside PB-1 even when added in an amount of 2 to 25 mass%, and it is thus presumed that linear low density polyethylene demonstrates an effect of improving the stretchability of PB-1. The α-olefins are not particularly limited, and examples include 1-butene, 1-hexene, 1-octene, 1-pentene, 3,3-dimethyl-1-butene, 4-methyl-1-pentene, 4,4-dimethyl-1-pentene, 1-decene, 1-dodecene, 1-tetradecene, 1-octadecene, and the like. As the copolymer polymerized with an α-olefin using a metallocene catalyst, commercially available products such as "Harmorex" (registered trademark) NJ744N, "Kernel" (registered trademark) KS560T and KC571 manufactured by Japan Polyethylene Corporation, and 420SD manufactured by Ube-Maruzen Polyethylene Co., Ltd., may be used.

[0022] It is preferable that the linear low density polyethylene in the first component has a ratio (Q value) of weight average molecular weight (Mw) to number average molecular weight (Mn) of 6 or less. A more preferable Q value is 2 to 5, and a particularly preferable Q value is 2.2 to 3.5. The stretchability of the crimped conjugate fiber of the present invention containing polybutene-1 in the first component is enhanced when the first component contains, in addition to polybutene-1, linear low density polyethylene, preferably linear low density polyethylene that is polymerized using a metallocene catalyst and that satisfies the foregoing Q value range. In addition, the first component that occupies for most of the fiber surface, which contains linear low density polyethylene, imparts a slide effect to the fiber surface, and the resulting crimped conjugate fiber exhibits enhanced crimper passability and, once cut so as to obtain a staple fiber having a desired fiber length, enhanced spreadability of the staple fiber, and thus such a first component is preferable.

[0023] From the viewpoint of attaining good compatibility with PB-1, it is preferable that the density measured according to JIS-K-7112 of the linear low density polyethylene is 0.930 g/cm^3 or less, more preferably 0.920 g/cm^3 or less, and particularly preferably 0.915 g/cm^3 or less. When the density is within the foregoing range, compatibility with PB-1 is good and heat resistance is high. The lower limit of the density of the linear low density polyethylene is not particularly limited, and it is preferably 0.870 g/cm^3 or greater, more preferably 0.880 g/cm^3 or greater, and particularly preferably 0.890 g/cm^3 or greater. When the density of the linear low density polyethylene is less than 0.870 g/cm^3, the heat resistance of the first component constituting the crimped conjugate fiber is likely to be impaired, and it is likely that bulk recovery properties and resistance to residual compression set at temperatures greater than room temperature, for example in the range of 40 to 80°C, are impaired.

[0024] From the view point of attaining good compatibility with PB-1 and good elasticity of the resulting fiber as well as good bulk recovery properties and resistance to residual compression set of a fiber assembly prepared using the resulting crimped conjugate fiber, it is preferable that the flexural modulus measured according to JIS-K-7171 of the

linear low density polyethylene is 800 MPa or less, more preferably 20 to 650 MPa, particularly preferably 25 to 300 MPa, and most preferably 30 to 180 MPa. When the flexural modulus is within the foregoing range, compatibility with PB-1 is good and heat resistance is high, and the resulting fiber assembly exhibits excellent bulk recovery properties and resistance to residual compression set. When the flexural modulus of the linear low density polyethylene is high, the flexibility of the polymer is lost, and the elasticity of the resulting crimped conjugate fiber tends to be impaired, and when the flexural modulus of the linear low density polyethylene exceeds 800 MPa, the bulk recovery properties and the resistance to residual compression set of a fiber assembly prepared using the resulting crimped conjugate fiber are likely to be impaired. Also, when the flexural modulus of the linear low density polyethylene is high, the melting peak temperature of the polymer tends to be low, and when the flexural modulus of the linear low density polyethylene is less than 20 MPa, heat resistance is impaired, and the bulk recovery properties of the resulting fiber assembly at high temperatures are likely to be impaired.

[0025] It is preferable that the linear low density polyethylene has a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121 of 70 to 130°C, more preferably 80 to 125°C, and even more preferably 90°C to 123°C. When the melting peak temperature is 70 to 130°C, heat resistance is high, and bulk recovery properties at high temperatures are good. The term "melting peak temperature" as used herein refers to a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121. Herein, the melting peak temperature obtained from a DSC curve is also referred to as a melting point.

[0026] It is preferable that the linear low density polyethylene has a melt flow rate (MFR; a measurement temperature of 190°C, a load of 2.16 kgf (21.18 N), hereinafter referred to as MFR190) according to JIS-K-7210 of 1 to 30 g/10 min, more preferably an MFR190 of 3 to 25 g/10 min, and even more preferably 5 to 20 g/10 min. When the MFR190 is 1 to 30 g/10 min, heat resistance is good and bulk recovery properties at high temperatures are favorable, and spun yarn retrievability and stretchability are good.

[0027] It is preferable that polybutene-1 for use in the present invention has a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121 of 115 to 130°C, and more preferably 120 to 130°C. When the melting peak temperature is 115 to 130°C, heat resistance is high, and bulk recovery properties at high temperatures are good.

[0028] It is preferable that the polybutene-1 has a melt flow rate (MFR; a measurement temperature of 190°C, a load of 2.16 kgf (21.18 N), hereinafter referred to as MFR190) according to JIS-K-7210 of 1 to 30 g/10 min, more preferably an MFR190 of 3 to 25 g/10 min, and even more preferably 3 to 20 g/10 min. When the MFR190 is 1 to 30 g/10 min, polybutene-1 has a high molecular weight, and thus heat resistance is good and bulk recovery properties at high temperatures are favorable, and thus this configuration is preferable. Also, spun yarn retrievability and stretchability are good.

[0029] In the first component, polybutene-1 is the principal component and is contained in a proportion of 70 mass% or greater relative to the entire first component. From the viewpoint of attaining good productivity, good cushioning properties, and good bulk recovery properties at high temperatures, it is preferable that polybutene-1 is contained in a proportion of 75 to 98 mass%, more preferably 80 to 97 mass%, particularly preferably 85 to 97 mass%, and most preferably 87 to 96 mass%.

[0030] By blending linear low density polyethylene that demonstrates a sufficient compatibilizing effect with polybutene-1 as described above, a problem that occurs because the spinnability and stretchability of polybutene-1 are not improved when the compatibilizing effect on polybutene-1 is excessively low, i.e., a uniform conjugate fiber is unlikely to be obtained, can be solved.

[0031] The amount of the linear low density polyethylene added to the first component is 2 to 25 mass%, when the entire first component being 100 mass%, more preferably 3 to 20 mass%, particularly preferably 3 to 15 mass%, and most preferably 4 to 12 mass%. When the amount is within the foregoing range, the flowability of PB-1 is enhanced, stable and uniform spinning can be performed, and stretchability is also improved.

[0032] The first component contains polybutene-1 and linear low density polyethylene as described above, and further may contain an ethylene-ethylenic unsaturated carboxylic acid copolymer. Since the ethylene-ethylenic unsaturated carboxylic acid copolymer, as with the linear low density polyethylene, shows, compatibility with polybutene-1, the first component further containing an ethylene-ethylenic unsaturated carboxylic acid copolymer is capable of improving spinnability such as uniform fiber formation when melt spinning, stretchability, and the like. Moreover, with a crimped conjugate fiber in which the first component further contains an ethylene-ethylenic unsaturated carboxylic acid copolymer in addition to polybutene-1 and linear low density polyethylene, when performing thermal processing such as thermal bonding on a fiber web or a nonwoven fabric containing the fiber, a phenomenon in which the sheath component undergoes shrinking and thermally bonded points shrink, i.e., "bonding point shrinkage" (hereinafter also simply referred to as bonding point shrinkage) is unlikely to occur at the points where pieces of the constituting fiber are thermally bonded to each other, even when the thermal processing is performed for a long period of time at high temperatures. Accordingly, pieces of the constituting fiber can be bonded firmly to each other, and a thermally bonded nonwoven fabric having greater bonding strength can be obtained.

[0033] The ethylenic unsaturated carboxylic acid constituting the ethylene-ethylenic unsaturated carboxylic acid copolymer for use in the crimped conjugate fiber of the present invention is not particularly limited, and examples include

acrylic acid, methacrylic acid, ethacrylic acid, fumaric acid, maleic acid, itaconic acid, monomethyl maleate, monoethyl maleate, maleic anhydride, itaconic anhydride, and the like.

[0034] Specific examples of the ethylene-ethylenic unsaturated carboxylic acid copolymer include ethylene-acrylic acid copolymer (EAA), ethylene-methacrylic acid copolymer (EMAA), ethylene-ethacrylic acid copolymer, ethylene-maleic acid copolymer, ethylene-fumaric acid copolymer, ethylene-itaconic acid copolymer, ethylene-maleic anhydride copolymer, ethylene-itaconic anhydride copolymer, and the like. Among such examples, ethylene-acrylic acid copolymer, ethylene-methacrylic acid copolymer, and ethylene-maleic acid copolymer are preferable, and ethylene-acrylic acid copolymer and ethylene-methacrylic acid copolymer are more preferable.

[0035] The ethylene-ethylenic unsaturated carboxylic acid copolymer is not limited to a copolymer composed of ethylene and an ethylenic unsaturated carboxylic acid, and may be a copolymer in which another component is copolymerized, including, for example, a terpolymer in which two or more components including an ethylenic unsaturated carboxylic acid are copolymerized with ethylene.

[0036] Examples of monomers for use as the other copolymerization components include ethylenic unsaturated carboxylic acid esters such as vinyl acetate, vinyl propionate, and like vinyl esters, methyl acrylate, ethyl acrylate, isopropyl acrylate, n-butyl acrylate, isobutyl acrylate, isooctyl acrylate, and like acrylic acid esters, methyl methacrylate, isobutyl methacrylate, and like methacrylic acid esters, and dimethyl maleate, diethyl maleate, and like maleic acid esters; carbon monoxide; sulfur dioxide; and the like.

[0037] The copolymer in which ethylene, an ethylenic unsaturated carboxylic acid, and an optional copolymerization component are copolymerized is not particularly limited, and an example may be an ethylene-acrylate-maleic acid polymer in which ethylene, maleic anhydride and an acrylic ester are copolymerized ("Bondine" (registered trademark) manufactured by Arkema Japan) or the like.

[0038] The content of the ethylenic unsaturated carboxylic acid in ethylene-ethylenic unsaturated carboxylic acid copolymer is 1 to 50 mass%, and preferably 1 to 29 mass%. In particular, in the case of acrylic acid, it is preferably 5 to 25 mass%, and in the case of methacrylic acid, it is preferably 5 to 20 mass%. The content of the other copolymerizable component in the ethylene-ethylenic unsaturated carboxylic acid copolymer is in the range of 0 to 30 mass%, and preferably 0 to 20 mass%.

[0039] In the present invention, as the ethylene-ethylenic unsaturated carboxylic acid copolymer, an ionomer in which carboxyl groups are partially or entirely in a metal salt form can be used other than the ethylene-ethylenic unsaturated carboxylic acid copolymer itself. Examples of metal species constituting metal ionomers include lithium, sodium, potassium, and like monovalent metals, magnesium, calcium, zinc, copper, cobalt, manganese, lead, iron, and like polyvalent metals, and the like, with monovalent metals or zinc being particularly preferable.

[0040] In the present invention, the ethylene-ethylenic unsaturated carboxylic acid copolymers may be used singly, or may be used in a combination of two or more.

[0041] The ethylene-ethylenic unsaturated carboxylic acid copolymers can be obtained by, although not particularly limited to, high pressure radical copolymerization. The ethylene-ethylenic unsaturated carboxylic acid copolymer ionomers can be obtained by ionizing the ethylene-ethylenic unsaturated carboxylic acid copolymers by an ordinary method.

[0042] As described above, the first component of the crimped conjugate fiber of the present invention contains an ethylene-ethylenic unsaturated carboxylic acid copolymer that demonstrates a sufficient compatibilizing effect on polybutene-1, and accordingly a problem that occurs due to the poor spinnability of polybutene-1 when the compatibilizing effect on polybutene-1 is excessively low, i.e., a uniform conjugate fiber is unlikely obtained, can be solved. Also, a problem that occurs when the compatibilizing effect on polybutene-1 is excessive, i.e., a conjugate fiber composed of a first component mainly containing polybutene-1 can be obtained but bonding point shrinkage occurs due to thermal processing when preparing a thermally bonded nonwoven fabric from the resulting conjugate fiber, can be solved. That is, by blending an ethylene-ethylenic unsaturated carboxylic acid copolymer that demonstrates a sufficient compatibilizing effect on polybutene-1, it is possible to obtain a uniform conjugate fiber containing them. Moreover, the thermal bonding properties of the resulting conjugate fiber is improved, and thus it is possible to overcome bonding point shrinkage, which can occur when bonding is performed by thermal processing at temperatures higher than the melting point of polybutene-1.

[0043] In the case where an ethylene-ethylenic unsaturated carboxylic acid copolymer is added to the first component, it is preferable that the amount of the copolymer added is 0.5 to 20 mass%, when the entire first component being 100 mass%, more preferably 1 to 15 mass%, even more preferably 3 to 10 mass%, and particularly preferably 4 to 9 mass%. When the amount is 0.5 mass% or greater, a crimped conjugate fiber having excellent thermal bonding properties can be obtained, the bonding strength between pieces of the fiber is not impaired at high temperatures, for example, a temperature of 190°C or higher, and the aforementioned bonding point shrinkage does not occur. Moreover, when the amount is 20 mass% or less, a fiber structure such as a nonwoven fabric that has good hardness retainability (bulk recovery properties) can be obtained.

[0044] It is preferable that the ethylene-ethylenic unsaturated carboxylic acid copolymer has an MFR190 measured according to JIS-K-7210 of 3 to 60 g/10 min. A more preferable MFR190 is 5 to 40 g/10 min, and even more preferably 5 to 30 g/10 min. With the MFR190 being 60 g/10 min or less, the effect of suppressing bonding point shrinkage that

can occur when performing thermal processing on a fiber web that contains the resulting crimped conjugate fiber can be enhanced. Moreover, with the MFR190 being 3 g/10 min or greater, it is easy to obtain a uniform crimped conjugate fiber that has excellent operability during a spinning step and a stretching step.

[0045] It is preferable that the ethylene-ethylenic unsaturated carboxylic acid copolymer has a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121 of 60°C or higher, more preferably 70°C or higher, and even more preferably 70 to 120°C. With the melting peak temperature being 60°C or higher, the effect of suppressing bonding point shrinkage is strong, and deterioration of cushioning properties such as deterioration of bulk recovery properties and an increase of a rate of compression set due to thermal processing are unlikely to occur. Moreover, with the melting peak temperature being 70 to 120°C, the effect of suppressing bonding point shrinkage, the effect of suppressing deterioration of cushioning properties, and like effects can be more readily demonstrated.

[0046] It is preferable that the ethylene-ethylenic unsaturated carboxylic acid copolymer has a softening temperature (Vicat softening point) as measured according to JIS-K-7206 of 40°C or higher, more preferably 50°C or higher, and particular preferably 50 to 100°C. With the softening temperature being 40°C or higher, the effect of suppressing bonding point shrinkage is strong, and deterioration of cushioning properties such as deterioration of bulk recovery properties and an increase of a rate of compression set due to thermal processing are unlikely to occur. With the softening temperature being 50 to 100°C, the effect of suppressing bonding point shrinkage, the effect of suppressing deterioration of cushioning properties, and like effects can be more readily demonstrated.

[0047] Examples of polymers that further can be blended with the first component, as long as the effect of the present invention is not impaired, include polyolefin-based polymers other than the aforementioned polyolefin-based polymers, copolymerizable polymers with olefins having a polar group such as a vinyl group, a carboxyl group, or maleic anhydride; polyolefin-based, styrene-based, polyester-based, and like various thermoplastic elastomers; and the like.

[0048] It is possible to add various known additives to the first component as long as the effect of the present invention is not impaired, or fiber productivity, nonwoven fabric productivity, thermal bonding properties, and texture are not affected. Depending on the application, the first component can be mixed with, for example, other polymers, known nucleating agents such as organic or inorganic substances (for example, calcium carbonate, talc, and the like), antistatic agents, pigments, delusterants, thermal stabilizers, photostabilizers, flame retardants (halogen-based, phosphorus-based, nonhalogen-based, antimony trioxide, and like inorganic compound-based flame retardants, and the like), bactericidal agents, lubricants, plasticizers, softening agents, and the like. Adding a nucleating agent as such an additive brings about the following advantages: an effect of preventing fusion between pieces of the fiber when spinning can be further enhanced, and a nonwoven fabric having soft texture can be obtained. The amount of nucleating agent added is not particularly limited, and it is preferable in light of fiber productivity to add a nucleating agent in a proportion of 20 mass% or less relative to the total mass of the first component, and it is more preferable to add in a proportion of 10 mass% or less.

[0049] The first component constituting the crimped conjugate fiber of the present invention has the above-described features. That is, the first component contains PB-1 as the principal component in a proportion of 70 mass% or greater, preferably 75 mass% or greater, and contains linear low density polyethylene in a proportion of 2 to 25 mass%. Accordingly, the melting point of the first component after spinning is low, and thus a phenomenon in which the apparent melting point of the first component is increased, which can occur in the case where polypropylene in place of linear low density polyethylene is added to PB-1, is unlikely to occur. This can be verified by performing measurement with a differential scanning calorimeter (DSC) using the obtained crimped conjugate fiber and then obtaining the melting point of each component after spinning from a heat of fusion curve obtained from the measurement. That is, regarding the crimped conjugate fiber of the present invention, the first component after spinning has a melting point (Tf1) obtained from a DSC curve measured according to JIS-K-7121 of 140°C or lower, preferably 90 to 135°C, more preferably 100 to 130°C, particularly preferably 115 to 130°C, and most preferably 120°C to 125°C. As long as the melting point (Tf1) of the first component after spinning is within this range, a thermally bonded fiber assembly having sufficient bonding strength can be obtained at a lower temperature in a shorter period of time when producing a fiber assembly such as a nonwoven fabric by thermal bonding processing. The higher the melting point of the first component after spinning, the less likely the above-described effect is obtained, and if multiple melting point peaks derived from the first component appear, e.g., if the first component has a so-called double peak, at a temperature lower than the melting point (Tf2) of the second component after spinning, which occurs when the melting point (Tf1) of the first component after spinning exceeds 140°C or when a polyolefin-based polymer (for example, polypropylene) having a high melting peak temperature is added, low-temperature thermal bonding properties are likely to be insufficient and a fiber assembly having sufficient bonding strength is unlikely to be obtained. The lower limit of the melting point (Tf1) of the first component after spinning is not particularly limited, but when the lower limit is lower than 90°C, heat resistance and bulk recovery properties at high temperatures are likely to be impaired. As described above, in the crimped conjugate fiber of the present invention, it is not preferable, regarding the melting point of the first component of the conjugate fiber after spinning, that the heat of fusion curve has a so-called double-peak shape having multiple peaks derived from the first component when performing thermal bonding processing. Therefore, linear low density polyethylene is preferable that has a melting point that mostly overlaps the

melting point of post-spinning PB-1, which is the principal component of the first component, and that has a so-called single peak having only one peak derived from the first component on a heat of fusion curve.

Second component

[0050] The second component of the crimped conjugate fiber of the present invention is not particularly limited as long as it is a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher. Polymers having excellent bending strength and bending elasticity are preferable, and examples include polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, polyethylene naphtahalate, polylactic acid, and like polyester-based polymers, Nylon 6, Nylon 66, Nylon 11, Nylon 12, and like polyamides, polypropylene, polymethylpentene, and like polyolefin-based polymers, polycarbonates, polystyrenes, and the like. When such polymers are used as the second component, polymers may be used singly or may be used as a combination of two or more. In the crimped conjugate fiber of the present invention, a polyester-based polymer or a polyolefin-based polymer is preferable as a polymer for use in the second component. The use of a polyolefin-based polymer as the second component together with the use of a polyolefin-based polymer as the first component as described above makes it easy to recycle the crimped conjugate fiber of the present invention. The crimped conjugate fiber of the present invention that uses the polyester-based polymer as the second component has a large melting point difference between the second component that constitutes near the center of the conjugate fiber and the first component that occupies for most of the fiber surface, and therefore even when the conjugate fiber, a fiber web, and a nonwoven fabric are subjected to thermal bonding at a temperature at which the first component undergoes sufficient thermal bonding, the second component maintains its shape, and sagging caused by thermal processing is unlikely to occur, and it is easy to manage the processing temperature in a thermal processing step, allowing a fiber assembly having high bonding strength to readily be obtained.

[0051] First, regarding the crimped conjugate fiber of the present invention, a conjugate fiber now will be described that uses a polyester-based polymer as a polymer constituting the second component. In the case where a polyester-based polymer is used as the second component of the crimped conjugate fiber of the present invention, the polymer is not particularly limited insofar as it is a polyester-based polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polyester-based polymer having a melting initiation temperature of 120°C or higher. Since polymers having excellent bending strength and bending elasticity are preferable, polyethylene terephthalate (hereinafter also referred to as PET), polytrimethylene terephthalate (hereinafter also referred to as PTT), and polybutylene terephthalate (hereinafter also referred to as PBT) are preferable, with polyethylene terephthalate or polytrimethylene terephthalate being more preferable. A polymer that has physical properties suitable for the application of the fiber is selected, and in the case where a polyester-based polymer is used as the second component in the crimped conjugate fiber of the present invention, it is most preferable to use polyethylene terephthalate in light of the availability, the high bulk recovery properties of the fiber, and like features.

[0052] It is preferable that the polyester-based polymer has a limiting viscosity [η] of 0.4 to 1.2, and more preferably 0.5 to 1.1. When the limiting viscosity is less than 0.4, the molecular weight of the polymer is excessively low, and therefore not only is spinnability inferior but also fiber strength is poor, and such a fiber is not practical. When the limiting viscosity exceeds 1.2, the molecular weight of the polymer is increased, and the melt viscosity is excessive. Therefore, single-yarn breakage and like phenomena occur, making it difficult to perform good spinning, and thus such limiting viscosity is not preferable. A limiting viscosity [η] within the foregoing range enables a conjugate fiber having excellent productivity and excellent bulk recovery properties to be obtained. The limiting viscosity [η] as referred to herein is measured with an Ostwald viscometer using an o-chlorophenol solution at 35°C and expressed as a value obtained according to Expression 1 below:

[0053]

Expression 1

$$[\eta] = \lim_{c \to 0} \frac{1}{\{C \times (\eta r - 1)\}}$$

[0054] In Expression 1 above, ηr is a value obtained by dividing the viscosity at 35°C of a diluted solution of a sample dissolved in o-chlorophenol having a purity of 98% or greater by the concentration of the entire solvent measured at the same temperature, and C is the weight value in grams of the solute in 100 ml of the aforementioned solution.

[0055] It is preferable that the polyester has a melting peak temperature obtained from a DSC curve measured according to JIS-K-7121 of 180°C to 300°C, and more preferably 200°C to 270°C. A melting peak temperature of 180 to 300°C

enables the weatherability to be increased and the flexural modulus of the resulting conjugate fiber to be increased.

[0056] Next, regarding the crimped conjugate fiber of the present invention, a conjugate fiber will now be described that uses a polyolefin-based polymer as a polymer constituting the second component. In the case where a polyolefin-based polymer is used as the second component of the crimped conjugate fiber of the present invention, the polymer is not particularly limited insofar as it is a polyolefin-based polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polyolefin-based polymer having a melting initiation temperature of 120°C or higher. Since polymers having excellent bending strength and bending elasticity are preferable, polypropylene (hereinafter also referred to as PP) is preferable. Such polypropylene is not particularly limited, and for example, homopolymers, random copolymers, block copolymers, or mixtures thereof, and insofar as properties required for nonwoven fabrics and cushioning materials, such as heat resistance and bulk recovery properties, are not impaired, polypropylene in which synthetic rubber or a like elastomer component is dispersed or mixed therewith may be used. In light of heat shrinkability, it is preferable that it is a homopolymer (homopolypropylene) or a block copolymer. In particular, homopolypropylene is advantageous in terms of the bulk recovery property and thus is preferable. Examples of the random copolymers and the block copolymers include copolymers of propylene and at least one α-olefin selected from the group consisting of ethylene and α-olefins having 4 or more carbon atoms. Such α-olefins having 4 or more carbon atoms are not particularly limited, and examples include 1-butene, 1-pentene, 3,3-dimethyl-1-butene, 4-methyl-1-pentene, 4,4-dimethyl-1-pentene, 1-decene, 1-dodecene, 1-tetradecene, 1-octadecene, and the like. In particular, from the viewpoint of attaining bulk recovery properties, one selected from the group consisting of propylene homopolymers, ethylene-propylene copolymers, and ethylene-butene-1-propylene terpolymers is preferable, and in light of heat resistance of the resulting crimped conjugate fiber, recycling efficiency after use, and economical efficiency (production costs), in the case where a polyolefin-based polymer is used as the second component, the polyolefin-based polymer is particularly preferably homopolypropylene. From the viewpoint of attaining bulk recovery properties, in the case where a mixture of a homopolymer, a random copolymer, and a block copolymer of polypropylene is used, the homopolypropylene content is 73 to 100 mass%, more preferably 75 to 100 mass%, particularly preferably 85 to 100 mass%, when the entire second component being 100 mass%.

[0057] When polypropylene is used as the second component, it is preferable that the polypropylene has a melt flow rate (MFR; a measurement temperature of 230°C, a load of 2.16 kgf (21.18 N), hereinafter referred to as MFR230) according to JIS-K-7210 of 3 to 40 g/10 min, and a more preferable MFR230 is 5 to 35 g/10 min. When the MFR230 is 3 to 40 g/10 min, heat resistance is good and bulk recovery properties at high temperatures are favorable, and spun yarn retrievability and stretchability are good.

[0058] When polypropylene is used as the second component, it is preferable that the polypropylene has a ratio (Q value) of weight average molecular weight (Mw) to number average molecular weight (Mn) of 2 or greater. A more preferable Q value is 3 to 12. Amore preferable value of the ratio (Q value) of the weight average molecular weight (Mw) to the number average molecular weight (Mn) of polypropylene in the second component can be selected according to the kind of three-dimensional crimps which are developed in the resulting crimped conjugate fiber. For example, in the case where an actualized crimping conjugate fiber in which a crimped conjugate fiber has actualized three-dimensional crimps is to be obtained, the Q value of polypropylene of the second component is preferably 4 to 12, and more preferably 5 to 9. In the case where a latently crimpable conjugate fiber that develops three-dimensional crimps once heated is to be obtained, the Q value is preferably 3 to 5.

[0059] When a polyolefin-based polymer such as polypropylene is used as the second component, in addition to the polyolefin-based polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1, a thermoplastic elastomer may also be contained. That is, in a constituent fiber of a fiber assembly suitable for applications where excellent bulk recovery properties and resistance to repetitive compression set are required, such as cushioning materials and clothing pads, and in a crimped conjugate fiber for use as wadding of various pieces of bedding such as blankets and mattresses and clothing articles in which elasticity, shape recovery properties, and lightweight properties of the fiber itself are required, the second component that contributes to the hardness, the bulk recovery properties, and the resistance to set of a crimped conjugate fiber itself and those of a fiber assembly containing the crimped conjugate fiber, or in other words, a component that is disposed more toward the center in a core-in-sheath conjugate fiber (also referred to as a core component in a core-in-sheath conjugate fiber, encompassing an eccentric conjugate fiber) preferably contains a thermoplastic elastomer. Known thermoplastic elastomers can be used, and styrene-based elastomers, olefin-based elastomers, ester-based elastomers, amide-based elastomers, urethane-based elastomers, and vinyl chloride-based elastomers are usable. Among such elastomers, in the crimped conjugate fiber of the present invention, in the case where a polyolefin-based polymer is used as the second component, in light of recycling efficiency after use, it is preferable to use a polypropylene homopolymer, a random copolymer, a block copolymer, or a mixture thereof as the polyolefin-based polymer that has a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1, and it is preferable to use an olefin-based thermoplastic elastomer as the thermoplastic elastomer. Olefin-based thermoplastic elastomers are thermoplastic elastomers that use a polyolefin resin such as polyethylene or polypropylene as a hard segment, and an ethylene-propylene-based rubber such as ethylene-

propylene rubber (EPM), ethylene-butene rubber (EBM), ethylene-propylene-diene rubber (EPDM) as a soft segment. Usable examples of commercially available olefin-based thermoplastic elastomers include "Milastomer" (registered trademark) and "Notio" (registered trademark) manufactured by Mitsui Chemicals, Inc., "Espolex" (registered trademark) manufactured by Sumitomo Chemical Co., Ltd., "Thermorun" (registered trademark) and "Zelas" (registered trademark) manufactured by Mitsubishi Chemical Corporation, and the like. In the crimped conjugate fiber of the present invention, it is presumed that, in the case where the second component constituting the crimped conjugate fiber is a polyolefin-based polymer, adding a suitable amount of a thermoplastic elastomer, such as an olefin-based thermoplastic elastomer, to the second component imparts bending elasticity that seems to be derived from the thermoplastic elastomer to the second component containing the polyolefin-based polymer, and recoverability from bending and resistance to repetitive bending fatigue, which are likely to be insufficient in a conjugate fiber in which the second component is composed solely of a polyolefin-based polymer, are enhanced, and durability against repetitive compression required in cushioning materials or the like are enhanced. Moreover, when the thermoplastic elastomer to be added is an olefin-based thermoplastic elastomer, the first component and the second component are both composed of polyolefin-based polymers, thus making it easy to recycle the fiber assembly after use.

[0060] In the crimped conjugate fiber of the present invention, in the case where the second component is a polyolefin-based polymer, it is preferable that the olefin-based thermoplastic elastomer added to the second component is an α-olefin-based thermoplastic elastomer containing an α-olefin-based rubber-like polymer as a soft segment. Moreover, it is preferable that the olefin-based thermoplastic elastomer and the α-olefin-based thermoplastic elastomer are olefin-based thermoplastic elastomers polymerized using metallocene catalysts.

[0061] The α-olefin-based rubber-like polymer is not particularly limited, and for example, it is preferable to use a copolymer of ethylene and an α-olefin having 3 to 20 carbon atoms. Examples of the α-olefin include propylene, 1-butene, 1-pentene, 3,3-dimethyl-1-butene, 4-methyl-1-pentene, 4,4-dimethyl-1-pentene, 1-decene, 1-dodecene, 1-tetradecene, 1-octadecene, and the like. The hard segment contained in the olefin-based thermoplastic elastomer is not particularly limited, and for example, polyolefin-based polymers such as polypropylene and polypropylene are usable. The polypropylene is not particularly limited, and for example, homopolymers, random copolymers, block copolymers, or mixtures thereof are usable. Examples of the random copolymers and the block copolymers include copolymers of propylene and at least one α-olefin selected from the group consisting of ethylene and α-olefins having 4 or more carbon atoms. Such α-olefins having 4 or more carbon atoms are not particularly limited, and examples include 1-butene, 1-pentene, 3,3-dimethyl-1-butene, 4-methyl-1-pentene, 4,4-dimethyl-1-pentene, 1-decene, 1-dodecene, 1-tetradecene, 1-octadecene, and the like.

[0062] When a polyolefin-based polymer such as polypropylene is used as the second component, the content of the olefin-based thermoplastic elastomer added to the second component is preferably 3 to 25 mass%, more preferably 3 to 20 mass%, and particularly preferably 5 to 15 mass%, when the entire second component being 100 mass%. In the second component, when the olefin-based thermoplastic elastomer content is 3 mass% or greater, the second component as a whole exhibits elasticity due to the addition of the elastomer component to the second component, and the resistance to residual repetitive compression set and the resistance to residual compression set of a fiber assembly that uses the crimped conjugate fiber of the present invention can be increased. In the second component, when the olefin-based thermoplastic elastomer content is 25 mass% or less, a crimped conjugate fiber from which a fiber assembly that has excellent resistance to residual repetitive compression set and resistance to residual compression set is obtained is produced without adversely affecting the spinnability and the stretchability of the crimped conjugate fiber.

[0063] The density of the olefin-based thermoplastic elastomer is preferably 0.8 to 1.0 g/cm^3, and more preferably 0.85 to 0.88 g/cm^3. When the density is within the foregoing range, excellent heat resistance is obtained, and regarding a fiber assembly that uses the crimped conjugate fiber, a lighter fiber assembly can be obtained if the volume is the same, and is thus preferably used in applications where a light weight is required.

[0064] The Shore A hardness of the olefin-based thermoplastic elastomer measured according to ASTM D 2240 using a type A durometer is preferably 50 to 95, more preferably 60 to 90, and particularly preferably 65 to 85. When the Shore A hardness of the olefin-based thermoplastic elastomer added to the second component satisfies the foregoing range, the heat resistance and the durability against repetitive bending of a nonwoven fabric that uses the resulting crimped conjugate fiber is well-balanced. When the Shore A hardness is less than 50, the added olefin-based thermoplastic elastomer itself is excessively soft, and the resulting crimped conjugate fiber and a fiber assembly deform easily, and thus bending recovery properties and bulk recovery properties can be poor. When the Shore A hardness exceeds 95, the added olefin-based thermoplastic elastomer is excessively hard, bending elasticity attributable to the addition of the olefin-based thermoplastic elastomer to the second component is not demonstrated, and bending recovery properties and bulk recovery properties against repetitive compression tend to be impaired.

[0065] The melting peak temperature of the olefin-based thermoplastic elastomer used in the present invention is not particularly limited, but in light of the heat treatment performed when producing a fiber assembly from the resulting crimped conjugate fiber as well as the application of the fiber assembly and the heat resistance of the fiber assembly, the melting peak temperature of the olefin-based thermoplastic elastomer is preferably 70°C or higher and 170°C or

lower, more preferably 100°C or higher and 160°C or lower, and particularly preferably greater than or equal to the melting peak temperature of polybutene-1 contained in the first component and 160°C or lower. When the melting peak temperature of the olefin-based thermoplastic elastomer contained in the second component is 70°C or higher and 170°C or lower, heat resistance is high, and bulk is not likely to be reduced in a thermal treatment performed when obtaining a fiber assembly from the resulting crimped conjugate fiber, thus enabling a bulky fiber assembly to be readily obtained. In actual use of the fiber assembly, since the bulk recovery properties at high temperatures are good, the crimped conjugate fiber and the fiber assembly are particularly suitable for applications where heat resistance is required.

[0066] The melt flow rate of the olefin-based thermoplastic elastomer is not particularly limited, and it is preferable that a melt flow rate (MFR; a measurement temperature of 230°C, a load of 2.16 kgf(21.18 N), hereinafter referred to as MFR230) measured according to JIS-K-7210 of 1 to 30 g/10 min, and a more preferable MFR230 is 3 to 20 g/10 min, and a particularly preferable MFR 230 is 5 to 15 g/10 min. With the MFR230 of the olefin-based thermoplastic elastomer being within the foregoing range, spun yarn retrievability and stretchability are good. Also, in addition to the MFR230, with the melting peak temperature satisfying the foregoing range, the olefin-based thermoplastic elastomer used have good heat resistance, and therefore bulk is not likely to be reduced in a thermal treatment performed when obtaining a fiber assembly from the resulting crimped conjugate fiber, thus enabling a bulky fiber assembly to be readily obtained. In actual use of the fiber assembly, since the bulk recovery properties at high temperatures are good, the crimped conjugate fiber and the fiber assembly are particularly suitable for applications where heat resistance is required.

[0067] While there are a variety of olefin-based thermoplastic elastomers that satisfy the aforementioned density, Shore A hardness, melting peak temperature, and melt flow rate, among such olefin-based thermoplastic elastomers, it is preferable to use an olefin-based thermoplastic elastomer that is polymerized using a metallocene catalyst. In an olefin-based thermoplastic elastomer that is polymerized without using a metallocene catalyst, crystalline structure and amorphous structure portions having a size of 300 nm to 1 μm are scattered throughout the elastomer. With an elastomer in which such hard segments and soft segments having the aforementioned size are scattered throughout the polymer, the bending elasticity of the elastomer itself and the bending elasticity and the bulk recovery properties of a fiber and a nonwoven fabric that contain the elastomer tend to be poor, and in addition, it tends to be difficult to perform melt spinning. In contrast, in an olefin-based thermoplastic elastomer polymerized using a metallocene catalyst, crystalline structure and amorphous structure portions having a size of 5 to 50 nm are scattered throughout in the elastomer. By adding an elastomer having such a structure to the second component (core component) of a crimped conjugate fiber, it is likely that the resulting crimped conjugate fiber has ample heat resistance and excellent bulk recovery properties and resistance to set after repetitive deformation. An example of the olefin-based thermoplastic elastomer polymerized using a metallocene catalyst may be "Notio" (registered trademark) manufactured by Mitsui Chemicals, Inc., or the like, but the olefin-based thermoplastic elastomer is not limited thereto.

[0068] In the case where a polyester-based polymer is used as the principal component of the second component as well as in the case where a polyolefin-based polymer is used as the principal component of the second component, the second component can be further blended with a polymer insofar as the effect of the present invention is not impaired. In addition, known various additives can be added also to the second component insofar as the effect of the present invention is not impaired and insofar as fiber productivity, nonwoven fabric productivity, thermal bonding properties, and texture are not adversely affected. Known nucleating agents, antistatic agents, pigments, delusterants, thermal stabilizers, photostabilizers, flame retardants, bactericidal agents, lubricants, plasticizers, softening agents, and the like can be mixed as additives that can be added to the second component according to the applications.

[0069] In the crimped conjugate fiber of the present invention, the centroid position of the second component does not overlap the centroid position of the conjugate fiber. Fig. 1 shows a schematic diagram of the cross-section of a crimped conjugate fiber according to one embodiment of the present invention. A first component 1 is disposed around a second component 2, and the first component 1 occupies for at least 20% of the surface of a conjugate fiber 10. Accordingly, the surface of the first component 1 melts during thermal bonding. A centroid position 3 of the second component 2 does not overlap a centroid position 4 of the conjugate fiber 10. As seen in an enlarged image of the cross-section of the crimped conjugate fiber captured with an electron microscope or the like, the shift ratio (hereinafter also referred to as eccentricity) is a value represented by Expression 2 below, where the centroid position 3 of the second component 2 is C1, the centroid position 4 of the conjugate fiber 10 is Cf, and a radius 5 of the conjugate fiber 10 is rf:

[0070]

Expression 2

$$\text{Eccentricity}\ (\%) = [\,|\,Cf\text{-}c1\,|\,/rf] \times 100$$

[0071] The fiber cross-section in which the centroid position 3 of the second component 2 does not overlap the centroid position 4 of the conjugate fiber is preferably in an eccentric core-in-sheath type as shown in Fig. 1 or a parallel type. In

some cases, even when the cross-section is in a multi-core type, a fiber in which the centroid position of a multi-core portion as a whole does not overlap the centroid position of the fiber is usable. In particular, it is preferable that the fiber has an eccentric core-in-sheath cross-section because the desired wavy crimps and/or spiral crimps are readily developed. The eccentricity of the eccentric core-in-sheath conjugate fiber is preferably 5 to 50%, and more preferably 7 to 30%. The shape of the fiber cross-section of the second component 2 may be, other than being circular, oval, Y, X, #, polygonal, star, and various other shapes, and the shape of the cross-section of the conjugate fiber 10 may be, other than being circular, oval, Y, X, #, polygonal, star, and various other shapes, or hollow.

[0072] With the cross-section of the crimped conjugate fiber of the present invention as shows in Fig. 1, in the case of an eccentric core-in-sheath structure where the first component is disposed as a sheath component of the conjugate fiber, the second component is disposed as a core component, and the centroid position of the second component does not overlap the centroid position of the conjugate fiber. It is preferable that the second component and the first component (core/sheath) are combined in a volume ratio of 8/2 to 2/8, more preferably 7/3 to 3/7, and even more preferably 6/4 to 4/6. The second component that serves as a core component contributes mainly to bulk recovery properties, and the first component that serves as a sheath component contributes mainly to the strength of the nonwoven fabric and the hardness of the nonwoven fabric. A combination ratio of 8/2 to 2/8 enables the strength, the hardness, and the bulk recovery properties of the nonwoven fabric to be satisfied simultaneously. When the first component that serves as a sheath component is excessive, the strength of the nonwoven fabric is increased, but the resulting nonwoven fabric tends to be hard, and the bulk recovery properties tend to be poor. On the other hand, when the second component that serves as a core component is excessive, bonding points are excessively reduced, and the strength of the nonwoven fabric tends to be lowered, and the bulk recovery properties tend to be poor.

[0073] Fig. 2 shows forms of crimps of a crimped conjugate fiber according to one embodiment of the present invention. The phrase "conjugate fiber in which three-dimensional crimps have been developed" as used herein means that the crimp shape have been developed in the crimped conjugate fiber includes wavy crimps and/or spiral crimps. The term "wavy crimps" as used herein refers to crimps having curved crests as shown in Fig. 2A. The term "spiral crimps" refers to crimps having spirally curved crests as shown in Fig. 2B. Crimps in which wavy crimps and spiral crimps are concomitantly present as shown in Fig. 2C are encompassed within the crimp form of the three-dimensional crimps developed in the crimped conjugate fiber of the present invention. In the case of ordinary mechanical crimps as shown in Fig. 3, the crests of crimps are sharply angled, i.e., retaining serrated crimps, and it tends to be difficult to attain large initial bulk when processed into a nonwoven fabric. Moreover, planar elasticity against compression, i.e., a spring effect, is inferior, and in particular, sufficient initial bulk recovery properties are not likely to be obtained. Crimps in which acutely angled crimps by mechanical crimping and wavy crimps are concomitantly present as shown in Fig. 4 and, although not shown in the figures, crimps in which acutely angled crimps of mechanical crimping and spiral crimps are concomitantly present are also encompassed within the crimp form of the three-dimensional crimps which are developed in the crimped conjugate fiber of the present invention.

[0074] Regarding the crimped conjugate fiber of the present invention, crimps in which wavy crimps and spiral crimps are concomitantly present as shown in Fig. 2C are particularly preferable because cardability, initial bulk, and bulk recovery properties can be satisfied simultaneously.

[0075] Hereinbelow, a method for producing the crimped conjugate fiber of the present invention will now be described.

[0076] First, a method for producing an actualized crimping conjugate fiber, which is one embodiment of the crimped conjugate fiber of the present invention, will now be described.

[0077] First, a first component containing polybutene-1 and linear low density polyethylene and a second component containing a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher are provided. Next, the first component and the second component are supplied to a compound nozzle, for example, an eccentric core-in-sheath compound nozzle, such that on the fiber cross-section, the first component occupies for at least 20% of the surface of a conjugate fiber, and the centroid position of the second component does not overlap the centroid position of the conjugate fiber, and the second component is subjected to melt spinning at a spinning temperature of 220 to 350°C, and the first component at a spinning temperature of 200 to 300°C. The spinning temperature of the second component is selected according to the polymer, and it is preferable to perform melt spinning at a spinning temperature of 220°C to 330°C in the case where a polyolefin-based polymer such as polypropylene or polymethylpentene is used, and at a spinning temperature of 240 to 350°C in the case where a polyester-based polymer such as polyethylene terephthalate, polytrimethylene terephthalate, or polybutylene terephthalate is used.

[0078] The first component and the second component are supplied to an eccentric core-in-sheath compound nozzle at the aforementioned spinning temperatures, and retrieved at a retrieving rate of 100 to 1500 m/min to give an unstretched spinning filament having a fineness of 2 to 120 dtex. Next, a stretching treatment is carried out at a stretch ratio of 1.8 or greater at a stretching temperature of 40°C or higher and lower than the melting point of the first component. A more preferable lower limit of the stretching temperature is 50°C or higher, and a more preferable upper limit of the stretching temperature is a temperature 10°C lower than the melting point of the first component. When the stretching temperature

is lower than 40°C, crystallization of the first component barely proceeds, and thus thermal shrinkage tends to be increased and bulk recovery properties tend to be reduced. When the stretching temperature is greater than or equal to the melting point of the first component, pieces of the fiber tend to fuse to each other. A more preferable lower limit of the stretch ratio is 2. A more preferable upper limit of the stretch ratio is 4. When the stretch ratio is 1.8 or greater, the stretch ratio is not excessively small, making it easy to obtain a fiber in which the above-described wavy crimps and/or spiral crimps are developed, and the initial bulk and the rigidity of the fiber itself are not small, and nonwoven fabric processability such as cardability and bulk recovery properties are not inferior. The stretching method is not particularly limited, and known stretching treatments can be performed, such as wet stretching in which stretching is performed while heating with high temperature fluid such as hot water; dry stretching in which stretching is performed while heating in high temperature gas or with a high temperature metal roll; and water vapor stretching in which stretching is performed while heating a fiber by water vapor having a temperature of 100°C or higher under ordinary pressure or increased pressure. Among such methods, wet stretching using hot water is preferable because of its productivity and economical efficiency and because it allows the entire unstretched fiber bundle to be readily and uniformly heated. Before or after the above-described stretching, an annealing treatment may be performed as necessary under a dry heat, wet heat, or steaming atmosphere at 90 to 120°C.

[0079] In an actualized crimping conjugate fiber that is one embodiment of the crimped conjugate fiber of the present invention, in the case where the polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component constituting the actualized crimping conjugate fiber is a polyolefin-based polymer such as homopolypropylene, an ethylene-propylene copolymer, or an ethylene-butene-1-propylene terpolymer, the stretching temperature is preferably 40°C or higher and lower than or equal to the melting peak temperature of polybutene-1 contained in the first component, more preferably 50°C or higher and 100°C or lower, and particularly preferably 60°C or higher and 90°C or lower. In contrast, in an actualized crimping conjugate fiber that is one embodiment of the crimped conjugate fiber of the present invention, in the case where the polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component constituting the actualized crimping conjugate fiber is a polyester-based polymer such as polyethylene terephthalate, polytrimethylene terephthalate, or polybutylene terephthalate, the stretching temperature is preferably 60°C or higher and lower than or equal to the melting peak temperature of polybutene-1 contained in the first component, more preferably 70°C or higher and 100°C or lower, and particularly preferably 75°C or higher and 95°C or lower.

[0080] Next, before or after adding a fiber treating agent as necessary, 5 to 25 crimps per 25 mm are formed using a known crimper such as a stuffer-box crimper. A more preferable number of crimps is 8 to 20 per 25 mm, and a particularly preferable number of crimps is 10 to 18 per 25 mm. It is preferable that the shape of crimps after a fiber has passed through a crimper is serrated crimps and/or wavy crimps. When the number of crimps is less than 5 per 25 mm, cardability tends to be impaired, and the initial bulk and the bulk recovery properties of the nonwoven fabric tend to be poor. On the other hand, when the number of crimps is greater than 25 per 25 mm, the number of crimps is excessive, and not only does cardability tend to be impaired and the texture of the nonwoven fabric tend to deteriorate, but also the initial bulk of the nonwoven fabric tend to be reduced.

[0081] Moreover, after crimps are formed by the aforementioned crimper, it is preferable to perform an annealing treatment at a temperature at which an unstretched fiber bundle does not undergo thermal bonding and at which three-dimensional crimps are developed. For a conjugate fiber that is encompassed within the crimped conjugate fiber of the present invention and in which the first component is composed of a polymer containing polybutene-1, it is preferable to perform an annealing treatment in a dry heat, wet heat, or steaming atmosphere in a preferable temperature range of 90 to 120°C. Specifically, it is preferable that, after a fiber treating agent is added, crimps are formed by a crimper, and then an annealing treatment and simultaneously a drying treatment are performed in a dry heat atmosphere of 90 to 120°C because the process can be simplified. When an annealing treatment is performed at a temperature of 90°C or higher, dry thermal shrinkage is not large, specific actual crimps are readily obtained, the texture of the resulting nonwoven fabric is not roughened, and productivity can be increased. In the annealing treatment, a more preferable range of the treatment temperature is 90 to 115°C, and particularly preferably 95 to 110°C.

[0082] An actualized crimping conjugate fiber obtained by the above-described method mainly has at least one type of crimp selected from wavy crimps and spiral crimps shown in Fig. 2. Preferably, the actualized crimping conjugate fiber has at least one type of crimp selected from wavy crimps only, spiral crimps only, crimps where wavy crimps and spiral crimps are concomitantly present, and crimps where wavy crimps and serrated crimps are concomitantly present, and particularly preferably, the actualized crimping conjugate fiber has at least one type of crimp selected from wavy crimps only, spiral crimps only, and crimps where wavy crimps and spiral crimps are concomitantly present. The number of crimps of the actualized crimping conjugate fiber is preferably 5 per 25 mm or greater, and 25 per 25 mm or less, because a bulky nonwoven fabric can be obtained without reducing cardability. Then, the fiber is cut into a desired fiber length, giving an actualized crimping conjugate fiber. A more preferable number of crimps is 8 to 20 per 25 mm, and a

particular preferable number of crimps is 10 to 18 per 25 mm.

[0083] With the actualized crimping conjugate fiber, crimps appear on a conjugate fiber, and at least one type of three-dimensional crimps selected from wavy crimps and spiral crimps are developed and made visible, and therefore the actualized crimping conjugate fiber has actual crimps. In the state of the fiber, the crimps may be actualized crimps in which three-dimensional crimps fully have been developed, or may be actualized crimps in which slightly more crimping that will be developed (that will be developed when the fiber is heated) remains. However, if crimps are developed to such an extent that the number of crimps exceeds 25 per 25 mm when heat is applied to the fiber (for example, when heat is applied for processing into a nonwoven fabric as described later), cardability may deteriorate, and it is thus not preferable.

[0084] Next, a method for producing a latently crimpable conjugate fiber, which is another embodiment of the crimped conjugate fiber of the present invention, will now be described.

[0085] First, a first component containing polybutene-1 and linear low density polyethylene and a second component containing a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher are provided. Next, the first component and the second component are supplied to a compound nozzle, for example, an eccentric core-in-sheath compound nozzle, such that in the fiber cross-section, the first component occupies for at least 20% of the surface of a conjugate fiber, and the centroid position of the second component does not overlap the centroid position of the conjugate fiber, and the second component is subjected to melt spinning at a spinning temperature of 220 to 350°C, and the first component at a spinning temperature of 200 to 300°C. The spinning temperature of the second component is selected according to the polymer, and it is preferable to perform melt spinning at a spinning temperature of 220°C to 330°C in the case where a polyolefin-based polymer such as polypropylene or polymethylpentene is used, and at a spinning temperature of 240 to 350°C in the case were a polyester-based polymer such as polyethylene terephthalate, polytrimethylene terephthalate, or polybutylene terephthalate is used.

[0086] The first component and the second component are supplied to an eccentric core-in-sheath compound nozzle at the aforementioned spinning temperatures, and retrieved at a retrieving rate of 100 to 1500 m/min to give an unstretched spinning filament having a fineness of 2 to 120 dtex. Next, a stretching treatment is carried out at a stretch ratio of 1.5 or greater at a stretching temperature of 40°C or higher and lower than the melting point of the first component. A more preferable lower limit of the stretching temperature is 50°C or higher. A more preferable upper limit of the stretching temperature is a temperature 10°C lower than the melting point of the first component. When the stretching temperature is lower than 40°C, crystallization of the first component barely proceeds, and thus thermal shrinkage tends to be increased and bulk recovery properties tend to be reduced. When the stretching temperature is greater than or equal to the melting point of the first component, fibers each other tend to fuse. Amore preferable lower limit of the stretch ratio is 2. A more preferable upper limit of the stretch ratio is 4. When the stretch ratio is 1.5 or greater, the stretch ratio is not excessively small, crimps are likely to appear when a thermal treatment is performed, and the initial bulk and the rigidity of the fiber itself are not small, and nonwoven fabric processability such as cardability and bulk recovery properties are not inferior. The stretching method is not particularly limited, and known stretching treatments can be performed, such as wet stretching in which stretching is performed while heating with high temperature fluid such as hot water; dry stretching in which stretching is performed while heating in high temperature gas or with a high temperature metal roll; and water vapor stretching in which stretching is performed while heating a fiber by water vapor having a temperature of 100°C or higher under ordinary pressure or increased pressure. Among such methods, wet stretching using hot water is preferable because of its productivity and economical efficiency and because it allows the entire unstretched fiber bundle to be readily and uniformly heated.

[0087] In a latently crimpable conjugate fiber that is one embodiment of the crimped conjugate fiber of the present invention, in the case where the polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component constituting the latently crimpable conjugate fiber is a polyolefin-based polymer such as a propylene homopolymer, an ethylene-propylene copolymer, or an ethylene-butene-1-propylene terpolymer, the stretching temperature is preferably 40°C or higher and lower than or equal to the melting peak temperature of polybutene-1 contained in the first component, more preferably 50°C or higher and 100°C or lower, and particularly preferably 60°C or higher and 90°C or lower. In contrast, in a latently crimpable conjugate fiber that is one embodiment of the crimped conjugate fiber of the present invention, in the case where the polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component constituting the latently crimpable conjugate fiber is a polyester-based polymer such as polyethylene terephthalate, polytrimethylene terephthalate, or polybutylene terephthalate, the stretching temperature is preferably 60°C or higher and lower than or equal to the melting peak temperature of polybutene-1 contained in the first component, more preferably 70°C or higher and 100°C or lower, and particularly preferably 75°C or higher and 95°C or lower.

[0088] Next, before or after adding a fiber treating agent as necessary, 5 to 25 crimps per 25 mm are formed using a

known crimper such as a stuffer-box crimper. A more preferable number of crimps is 8 to 20 per 25 mm, and a particularly preferable number of crimps is 10 to 18 per 25 mm. When the number of crimps is less than 5 per 25 mm or the number of crimps exceeds 25 per 25 mm, cardability is likely to be impaired.

[0089] Furthermore, after crimps are formed by the aforementioned crimper, it is preferable to perform an annealing treatment in a dry heat, wet heat, or steaming atmosphere at 50 to 100°C, preferably 60 to 90°C, more preferably 60 to 80°C, and particularly preferably 60 to 75°C. Specifically, it is preferable that, after a fiber treating agent is added, crimps are formed by a crimper, and then an annealing treatment and simultaneously a drying treatment are performed in a dry heat atmosphere of 50 to 90°C because the process can be simplified. An annealing temperature of 50 to 90°C allows desired heat shrinkage to be obtained, and a latently crimpable conjugate fiber can be obtained in which crimps are developed during heating. Also, a fiber that has high cardability can be obtained.

[0090] The crimped conjugate fiber of the present invention, i.e., the actualized crimping conjugate fiber or the latently crimpable conjugate fiber of the present invention, is subjected to the aforementioned annealing treatment and dried, and then the filament is cut according to the application. The cut fiber length is 1 to 120 mm, but is selected according to the application. If a nonwoven fabric is produced by a known nonwoven fabric production method such as air-through, needle punching, or hydro-entanglement, after producing a fiber web with a carding machine, the filament is cut into fiber lengths of 20 to 100 mm, preferably 30 to 90 mm, and more preferably 40 to 80 mm. If a nonwoven fabric is produced by a fiber web production method by air spreading, i.e., a so-called air-laid method, the filament is cut into fiber lengths of 1 to 40 mm, preferably 1 to 30 mm, and more preferably 3 to 25 mm. If a wet nonwoven fabric is produced by a paper making method, the filament is cut into fiber lengths of 1 to 20 mm, preferably 1 to 10 mm, and more preferably 3 to 8 mm. It is also possible with the crimped conjugate fiber of the present invention that, depending on the application, the filament after an annealing treatment is not cut and used as it is.

[0091] The fineness of the crimped conjugate fiber of the present invention, i.e., the actualized crimping conjugate fiber or the latently crimpable conjugate fiber of the present invention, is not particularly limited. The crimped conjugate fiber is processed so as to have a fineness suitable for applications, for example, various nonwoven fabric applications such as hard stuffing that serves as a material substituted for urethane foam, mattresses for bedding, vehicle seats and various chairs, cushioning materials for clothing such as a shoulder pad and a brassiere pad, sanitary materials, packaging materials, wet wipes, filters, sponge-like porous wiping materials, sheet-like wiping materials; applications as wadding for various kinds of bedding such as blankets and mattresses and clothing articles that make use of the elasticity and the shape recovery properties of the conjugate fiber itself and like applications, but a fineness of 1 to 60 dtex is preferable because elasticity as well as bulk recovery properties and texture when processed into a nonwoven fabric are excellent. A more preferable fineness range is 2 to 50 dtex, particularly preferably 4 to 30 dtex, and most preferably 4 to 20 dtex.

[0092] The fiber assembly of the present invention contains at least 30 mass% of the crimped conjugate fiber. When the crimped conjugate fiber is contained in a proportion of 30 mass% or greater, the elasticity, the bulk recovery properties, and like properties of the fiber assembly can be maintained at a high level. Examples of the fiber assembly include knitted fabrics, woven fabrics, nonwoven fabrics, fillings, pads, fiber webs, and the like. It is preferable that the fiber assembly contains 30 to 100 mass% of the crimped conjugate fiber and 0 to 70 mass% of fibers other than the crimped conjugate fiber. Such fibers other than the crimped conjugate fiber contained in the fiber assembly are not particularly limited insofar as the performance of the crimped conjugate fiber is not impaired, including, for example, at least one fiber selected from synthetic fibers, chemical fibers, natural fibers, and inorganic fibers.

[0093] The method for producing a fiber assembly containing the crimped conjugate fiber of the present invention is not particularly limited. After forming a fiber web by a known method, the fiber web can be processed into a nonwoven fabric by a known nonwoven fabric production method such as air-through, needle punching, or hydro-entanglement. In addition, it is also possible that the crimped conjugate fiber is processed into a fiber ball, and the fiber ball is blown into a frame mold and subjected to a thermal treatment to give a fiber assembly having a specific shape as disclosed in JP 2001-207360A and JP2002-242061A. A production method is preferable in which a fiber web is formed and then processed into a nonwoven fabric. Examples of forms of the fiber web constituting the nonwoven fabric of the present invention include a parallel web, a semi-random web, a random web, a cross-laid web, a criss-cross web, an air-laid web, and the like. The fiber web demonstrates a greater effect when the first component is bonded due to a thermal treatment. If necessary, the fiber web may be subjected to needle punching or hydro-entanglement before thermal processing. The means of thermal processing is not particularly limited insofar as the function of the crimped conjugate fiber of the present invention is sufficiently demonstrated, and it is preferable to use a heating machine that does not impose much pressure such as wind pressure, for example, a heating machine that lets hot air through, a heating machine that vertically blows hot air, an infra-red heating machine, and the like.

[0094] Fibers that can be blended with a fiber web that uses the crimped conjugate fiber of the present invention (hereinafter also referred to as blend fibers) are not particularly limited insofar as the performance of the crimped conjugate fiber of the present invention is not impaired. Examples include single fibers of polyesters such as polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, polyethylene naphthalate, polylactate, and polybutylene succinate; single fibers of polyethylenes such as low density polyethylene, high density polyethylene, and linear

low density polyethylene; single fibers of isotactic, atactic, syndiotactic, and like polypropylenes polymerized using ordinary Ziegler-Natta catalysts and metallocene catalysts; single fibers of polyolefins such as polymers in which monomers of such polyolefins are copolymerized, or polyolefins for which metallocene catalysts (also referred to as Kaminsky catalysts) are used when polymerizing such polyolefins; single fibers ofpolyamides such as Nylon 6, Nylon 66, Nylon 11, and Nylon 12; single fibers of (poly)acryls composed of acrylonitrile; and single fibers of engineering plastics such as polycarbonate, polyacetal, polystyrene, and cyclic polyolefin. Here, the term "single fiber" refers to a fiber composed solely of one polymer component. As the blend fiber, a conjugate fiber containing at least one or more polymer components can also be used insofar as the performance of the crimped conjugate fiber of the present invention is not impaired. Examples of such a conjugate fiber include conjugate fibers in which different types of resins among polyesters, polyolefins, polyamides and engineering plastics, or resins composed of different polymer components of the same type (for example, polyethylene terephthalate and polytrimethylene terephthalate) are mutually combined. In the conjugate fiber, the combined state is not particularly limited. In terms of the cross-sectional shape of the fiber, core-in-sheath conjugate fibers, eccentric core-in-sheath conjugate fibers, parallel conjugate fibers, sectional conjugate fibers in which resin components having a shape of citrus fruit clusters are disposed alternately, and sea-island conjugate fibers may be used. In the crimped conjugate fiber of the present invention, in the case where the second component is a polyolefin-based polymer, most of the polymer components constituting the crimped conjugate fiber are polyolefin-based polymers, and thus use of a single fiber composed of a polyolefin-based polymer, or use of a conjugate fiber in which polyolefin-based polymers are mutually combined, as a blend fiber is preferable from the viewpoint of recycling efficiency of the fiber assembly.

[0095] Since the crimped conjugate fiber of the present invention has excellent thermal bonding properties, the crimped conjugate fiber exhibits thermal bonding properties for not only synthetic fibers having the thermoplastic resins as the components, but also natural fibers including cellulose-based fibers, semi-synthetic fibers (also referred to as regenerated fibers) such as viscose rayon, Tencel (registered trademark), Lyocel (registered trademark), and cuprammonium rayon, inorganic fibers such as glass fibers, and carbon fibers. Examples of the natural fibers include vegetable-based natural fibers and animal-based natural fibers. Examples of vegetable-based natural fibers include fibers of ramie (China grass), linen (flax), kenaf, abaca (Manila hemp), henequen (sisal hemp), jute, hemp (cannabis), coconut, palm, paper mulberry, paper bush, bagasse, and the like. Examples of animal-based natural fibers include fibers of silk, sheep wool, angora, cashmere, mohair, and the like. As a fiber to be blended with the crimped conjugate fiber of the present invention, a vegetable-based natural fiber and an animal-based natural fiber can both be used, but a vegetable-based natural fiber is preferable since the cost of cultivation is inexpensive.

[0096] A fiber web containing the crimped conjugate fiber of the present invention can be processed into a bulky fiber assembly by performing thermal processing on the fiber web in a monolayer state, but a fiber assembly having superior sulkiness can be readily obtained by forming a laminate web in which fiber webs are stacked before performing thermal processing, or a laminate of fiber assemblies by stacking fiber assemblies after thermal processing. It is preferable that in the fiber assembly, fibers constituting the fiber assembly are arranged parallelly in the thickness direction of the fiber assembly, or in other words, fibers are arranged in the longitudinal direction of the fiber assembly. This is because fibers constituting the fiber assembly arranged parallelly in the thickness direction afford good bulk recovery properties and cushioning properties against pressure applied in the thickness direction. Herein, the phrase "fibers constituting the fiber assembly are arranged parallelly in the thickness direction of the fiber assembly (arranged in the longitudinal direction of the fiber assembly)" means that the sharp angle formed by the fibers constituting the fiber assembly and the thickness direction of the fiber assembly is 45° or less, or in other words, when the fiber assembly is cut in the thickness direction and the cut surface is viewed with an optical microscope or a scanning electron microscope for enlargement, the sharp angle formed by the fibers constituting the fiber assembly and the thickness direction of the fiber assembly is 45° or less. It is more preferable that 80% or greater of the total number of the entire fibers constituting the fiber assembly viewed on a specific area of the cut surface are arranged in the longitudinal direction of the fiber assembly. The fiber assembly described above in which fibers constituting the fiber assembly are arranged parallelly in the thickness direction can be produced by a known production method, and examples include so-called Strute nonwoven fabrics produced by shaping a fiber web into a wave form and subjecting it to thermal bonding while compressing it in the length direction, but the fiber assembly is not limited thereto.

[0097] In the case where the crimped conjugate fiber contained in a fiber web is the actualized crimping conjugate fiber, the temperature of thermal processing on the fiber web is set so as to be within a range in which the developed wavy crimps and/or spiral crimps of the crimped conjugate fiber do not disappear during thermal processing. For example, if the melting peak temperature of polybutene-1 is Tm, the thermal processing temperature is Tm -10 (°C) to lower than the melting peak temperature of the second component, preferably Tm -10 (°C) to Tm + 80 (°C), particularly preferably Tm (°C) to Tm + 50 (°C), and most preferably 130 to 160°C. Due to the thermal processing, at least one resin component contained in the first component of the actualized crimping conjugate fiber melts, and pieces of the constituent fiber are thermally fused to each other. In particular, it is preferable that when pieces of the constituent fiber are thermally fused to each other by allowing at least polybutene-1 of the actualized crimping conjugate fiber to melt, more rigid intersections

where pieces of the fiber meet each other can be formed, and bulk recovery properties are enhanced.

[0098] In the case where the crimped conjugate fiber contained in a fiber web is the latently crimpable conjugate fiber, the temperature is set so as to be within a range in which crimps are developed. For example, if the melting peak temperature of polybutene-1 is Tm, the temperature is set so as to be within a range of Tm -10 (°C) to lower than the melting point of the second component, preferably Tm -10 (°C) to Tm + 60 (°C), particularly preferably Tm (°C) to Tm + 50 (°C), and most preferably 130 to 160°C. Due to the thermal processing, at least one resin component contained in the first component of the latently crimpable conjugate fiber melts, and pieces of the constituent fiber are thermally fused to each other. In particular, it is preferable that when pieces of the constituent fiber are thermally fused to each other by allowing at least polybutene-1 of the latently crimpable conjugate fiber to melt, more rigid intersections where pieces of the fiber meet each other can be formed, and bulk recovery properties are enhanced.

[0099] It is preferable that the nonwoven fabric has a residual compression set rate measured according to JIS-K-6400-4 A of 45% or less, and more preferably 35% or less. The residual compression set rate shows the extent of change of the hardness of the nonwoven fabric when heated to 70°C. The smaller the value, the more the deterioration of the fiber or the nonwoven fabric by heat is suppressed, thus indicating excellent bulk recovery properties.

[0100] It is preferable that the nonwoven fabric has a residual repetitive compression set rate measured according to JIS-K-6400-4 B of 15% or less, and more preferably 12% or less. The residual repetitive compression set rate shows the extent of change of the hardness of the nonwoven fabric when 50% compression is repeated 80000 times. The smaller the value, the more the deterioration of the fiber or the nonwoven fabric caused by compression is suppressed, thus indicating excellent bulk recovery properties.

[0101] The fiber product of the present invention at least partially contains the fiber assembly, and is formed into hard stuffing, bedding, vehicle seats, chairs, shoulder pads, brassiere pads, garments, sanitary materials, packaging materials, wet wipes, filters, sponge-like porous wiping materials, sheet-like wiping materials, and wadding. Examples

[0102] The present invention shall be described in more detail below by way of examples. However, the present invention is not limited to these examples.

[0103] The measurement methods and the evaluation methods used in the examples are as follows.

Q value

I. Analyzers used

(i) Cross-fractionation apparatus "CFC T-100" (hereinafter referred to as CFC) manufactured by DIA Instruments Co., Ltd.

(ii) Fourier transform infrared absorption spectrometer (FT-IR) "1760X" manufactured by PerkinElmer, Inc.

[0104] A fixed wavelength infrared spectrophotometer attached as a detector of the CFC was removed and replaced by the FT-IR spectrometer, and the FT IR spectrometer was used as a detector. The transfer line from the outlet for a solution eluted from the CFC to the FT-IR spectrometer was 1 m, and the temperature was maintained at 140°C during measurement. The flow cell attached to the FT-IR spectrometer had an optical path length of 1 mm and an optical path diameter of 5 mm ∅, and the temperature was maintained at 140°C during measurement.

(iii) Gel permeation chromatography (GPC)

[0105] Three GPC columns "AD806MS" manufactured by Showa Denko K.K. connected in series were used in the latter portion of the CFC.

II. CFC measurement conditions

[0106]

(i) Solvent: ortho-dichlorobenzene (ODCB)
(ii) Sample concentration: 1 mg/ml
(iii) Injection amount: 0.4 ml
(iv) Column temperature: 140°C
(v) Solvent flow rate: 1 ml/min

III. FT-IR measurement conditions

[0107] After the beginning of elution of a sample solution from the GPC in the latter portion of the CFC, FT-IR meas-

urement was performed under the following conditions, and GPC-IR data was collected.

(i) Detector: MCT
(ii) Resolution: 8 cm^{-1}
(iii) Measurement interval: 0.2 min (12 sec)
(iv) Number of scans per measurement: 15

IV Post-processing and analysis of measurement results

[0108] The molecular weight distribution was determined using the absorbance at 2945 cm^{-1} obtained by the FT-IR spectrometer as a chromatogram. The retention volume was converted to the molecular weight using a standard curve prepared in advance with standard polystyrenes. The standard polystyrenes used were "F380", "F288", "F128", "F80", "F40", "F20", "F10", "F4", "F1", "A5000", "A2500", and "A1000", all manufactured by Tosoh Corporation. A calibration curve was created by injecting 0.4 ml of a solution in which 0.5 mg/ml of a standard polystyrene was dissolved in ODCB (containing 0.5 mg/ml of BHT). The calibration curve employed a cubic equation obtained by approximation using the least-squares method. The conversion to the molecular weight employed a universal calibration curve in reference to Sadao Mori, "Size Exclusion Chromatography" (Kyoritsu Shuppan). The following numerical values were used in the viscosity formula ($[\eta]=K\times M\alpha$) used herein.

(i) In formation of calibration curve using standard polystyrenes
K = 0.000138, α = 0.70
(ii) In measurement of polypropylene samples
K = 0.000103, α = 0.78

[0109] Above, measurements were performed according to gel permeation chromatography (GPC), but measurements may be performed using another model. In such a case, measurements are performed simultaneously with "MG03B" manufactured by Japan Polypropylene Corporation as described in the 2005 Catalogue for Commercial Transaction of Plastic Molding Materials (Chemical Daily Co., Ltd., published on Aug. 30, 2004), the value when the MG03B shows 3.5 is used as a blank condition, and the conditions are adjusted to perform the measurements.

Spinnability during melt spinning

[0110] The spinnability of each crimped conjugate fiber was evaluated based on the conditions of occurrence and the frequency of occurrence of a thread break when melt spinning was continuously performed for 30 minutes using the following criteria:

A: The number of thread breaks was 0 to 2 during continuous melt spinning for 30 minutes, and spinnability was good.
B: The number of thread breaks was 3 to 5 during continuous melt spinning for 30 minutes, but not detrimental to the processing.
C: The number of thread breaks was 6 or greater during continuous melt spinning for 30 minutes, or a large number of thread breaks occurred, making it impossible to carry out spinning.

Stretchability

[0111] The stretchability of a crimped conjugate fiber was evaluated based on the conditions of occurrence of a thread break in a stretching step and the passability through a stuffer-box crimper used for importing crimps using the following criteria:

A: Few thread breaks occurred in a stretching step, and a thread readily passed through a stuffer-box crimper, and thus there was absolutely no productivity problem.
B: Thread breaks occurred in a stretching step or stuffer-box crimper clogging occurred, but not detrimental to productivity.
C: Thread breaks occurred frequently, and a thread wound around a stretching bath and a stretching roll, or clogging inside a stuffer-box crimper or at the outlet frequently occurred, and thus severely impaired productivity.

Staple fiber spreadability

[0112] The staple fiber spreadability of a crimped conjugate fiber was evaluated based on the card processability

(cardability, conditions of nep generation, and texture of resulting web) when collecting a web by subjecting 100 mass% of a crimped conjugate fiber to a parallel card using the following criteria:

A: A fiber easily passed through a parallel card, few neps were produced, and thus a web having good texture was obtained.
B: Some neps were generated, but the texture of a web was not affected that much.
C: Cardability was poor, or large amounts of neps were generated, and thus no web was obtained.

Staple fiber crimp formability of actualized crimping conjugate fiber

[0113] A tow after completion of a drying step (annealing and drying step at 100°C for 15 minutes) was visually inspected, and the staple fiber crimp formability of actualized crimping conjugate fibers was evaluated using the following criteria:

A: Three-dimensional crimps were developed, and it was easy to identify the shape of spiral crimps and/or wavy crimps.
B: Three-dimensional crimps were developed, but it was fairly difficult to identify the shape of spiral crimps and/or wavy crimps, and serrated crimps were also concomitantly present.
C: It was not possible to identify either mechanical crimps (serrated crimps) or three-dimensional crimps (spiral crimps and/or wavy crimps), and most of the crimps had disappeared.

Staple fiber crimp formability of latently crimpable conjugate fiber

[0114] A tow after completion of a drying step (annealing and drying step at 100°C for 15 minutes) was visually inspected, and the staple fiber crimp formability of latently crimpable conjugate fibers was evaluated using the following criteria:

A: Mechanical crimps imparted by a stuffer-box crimper had not disappeared, and it was easy to identify the serrated shape.
B: Mechanical crimps imparted by a stuffer-box crimper had slightly disappeared, and there were portions where the serrated shape was not observed.
C: It was not possible to identify either mechanical crimps (serrated crimps) or three-dimensional crimps (spiral crimps and/or wavy crimps), and most of the crimps had disappeared.

Crimp formability after thermal processing of actualized crimping conjugate fiber

[0115] Each crimped conjugate fiber (100 mass%) was subjected to a parallel card to collect a web, and the web was treated at a processing temperature of 150°C for 30 seconds with a convection heating machine and then visually inspected in order to evaluate the crimp formability after thermal processing of an actualized crimping conjugate fiber using the following criteria:

A: Developed three-dimensional crimps had not disappeared, and it was easy to identify the shape of spirals crimp and/or wavy crimps.
B: Developed three-dimensional crimps had partially disappeared, but it was possible to identify the shape of spiral crimps and/or wavy crimps.
C: Developed three-dimensional crimps had mostly disappeared, and it was difficult to identify the shape of crimps.

Crimp formability after thermal processing of latently crimpable conjugate fiber

[0116] A crimped conjugate fiber (100 mass%) was subjected to a parallel card to collect a web, and the web was treated at a processing temperature of 150°C for 30 seconds with a convection heating machine and then visually inspected in order to evaluate the crimp formability after thermal processing of a latently crimpable conjugate fiber using the following criteria:

A: Three-dimensional crimps were developed due to thermal treatment, and it was easy to identify the shape of spiral crimps and/or wavy crimps.
B: Three-dimensional crimps were poorly developed, or three-dimensional crimps developed due to heat were partially disappeared, but it was possible to identify the shape of spiral crimps and/or wavy crimps.

C: Three-dimensional crimps were poorly developed, or three-dimensional crimps were developed due to heat were mostly disappeared, and it was difficult to identify the shape of crimps.

Measurement of melting points (Tf1, Tf2) of each component after spinning

[0117] Using a DSC manufactured by Seiko Instruments Inc., a sample in an amount of 3.2 mg was heated at a heating rate of 10°C/min from ordinary temperature to 200°C (provided that the temperature was increased to 300°C in the case where a polyester-based polymer was used as the second component), and then cooled at a cooling rate of 10°C/min to 40°C. From the resulting heat of fusion curve, the melting point Tf1 of the first component after spinning and the melting point Tf2 of the second component after spinning were obtained. Regarding the melting point after spinning, in the case where two peaks appeared, the peak on the lower temperature side was regarded as the melting point (Tf1) of the first component, and the peak on the higher temperature side was regarded as the melting point (Tf2) of the second component. In the case where three or more peaks appeared when measuring the melting point after spinning, the last peak, i.e., the peak on the higher temperature side, was regarded as the melting point (Tf2) of the second component, and the other peaks were regarded as the melting points (Tf1) after spinning of the respective polymers constituting the first component.

Residual compression set rate

[0118] The set rate after compression at a temperature of 70°C ± 1°C at a compression rate of 50% for 22 hours was measured according to JIS-K-6400-4 A and was regarded as a residual compression set rate. All the thickness measurement was carried out while no load was applied to the test pieces in the thickness direction, and a metal bench rule as specified in JIS-B-7516 was used for measurement.

Residual repetitive compression set rate

[0119] The set rate after compression 80000 times at a temperature of 23°C at a compression rate of 50% was measured according to JIS-K-6400-4 B and was regarded as a residual repetitive compression set rate. All the thickness measurement was carried out while no load was applied to the test pieces in the thickness direction, and a metal bench rule as specified in JIS-B-7516 was used for measurement.

Polymers used in the examples are as follows:

[0120]

(1) PET ("T200E" manufactured by Toray Industries, Inc., melting peak temperature (melting point): 255°C, IV value: 0.64)
(2) PP-A ("SA03E" manufactured by Japan Polypropylene Corporation, melting peak temperature (melting point): 160°C, MFR230:20 g/10 min, Q value: 5.6)
(3) PP-B ("SA01A" manufactured by Japan Polypropylene Corporation, melting peak temperature (melting point): 160°C, MFR230:9 g/10 min, Q value: 3.2)
(4) PB-1 ("DP0401M" manufactured by SunAllomer Ltd., melting peak temperature (melting point): 123°C, MFR190: 20 g/10 min)
(5) LLDPE-A ("Kernel" (registered trademark) "KS560T" manufactured by Japan Polyethylene Corporation [linear low density polyethylene synthesized by a high-pressure method using a metallocene catalyst], melting peak temperature (melting point): 90°C, MFR190: 16.5 g/10 min, density: 0.898 g/cm^3, Q value: 2.5, flexural modulus: 62 MPa)
(6) LLDPE-B ("420SD" manufactured by Ube Maruzen Polyethylene Co., Ltd. [linear low density polyethylene synthesized by a gas phase method using a metallocene catalyst], melting peak temperature (melting point): 118°C, MFR190°C: 7 g/10 min, density: 0.918 g/cm^3, Q value: 3.0, flexural modulus: 280 MPa)
(7) LLDPE-C ("Kernel" (registered trademark) "KC571" manufactured by Japan Polyethylene Corporation [linear low density polyethylene synthesized by a high-pressure method using a metallocene catalyst], melting peak temperature (melting point): 100°C, MFR190: 12 g/10 min, density: 0.907 g/cm^3, Q value: 2.2, flexural modulus: 110 MPa)
(8) LLDPE-D ("Harmorex" (registered trademark) "NJ744N" manufactured by Japan Polyethylene Corporation [linear low density polyethylene synthesized by a gas phase method using a metallocene catalyst], melting peak temperature (melting point): 120°C, MFR190: 12 g/10 min, density: 0.911 g/cm^3, Q value: 2.5, flexural modulus: 120 MPa)
(9) LLDPE-E ("631J" manufactured by Ube Maruzen Polyethylene Co., Ltd. [linear low density polyethylene synthesized by a gas phase method using a metallocene catalyst], melting peak temperature (melting point): 121°C, MFR190: 20 g/10 min, density: 0.931 g/cm^3, Q value: 2.9, flexural modulus: 600 MPa)

(10) LDPE ("LJ802" manufactured by Japan Polyethylene Corporation, melting peak temperature (melting point): 106°C, MFR190: 22 g/10 min, density: 0.918 g/cm^3)
(11) PPR^{-1} (polypropylene-based thermoplastic elastomer, "Notio" (registered trademark) "2070" manufactured by Mitsui Chemicals, Inc., [olefin-based thermoplastic elastomer synthesized using a metallocene catalyst], melting peak temperature (melting point): 138°C, Shore A hardness (ASTMD 2240): 75, MFR230: 6 g/10 min, density: 0.867 g/cm^3)
(12) PPR-2 (polyolefin-based thermoplastic elastomer, "Adflex V109F" manufactured by Basell, melting peak temperature (melting point): 143°C, Shore D hardness (ASTM D 2240): 41, MFR230: 12 g/10 min, density: 0.880 g/cm^3)
(13) BP (butene-propylene copolymer, "5C37F" manufactured by SunAllomer Ltd., melting peak temperature (melting point): 132°C, MFR230: 6 g/10 min)
(14) EMAA ("Nucrel" (registered trademark) manufactured by Du Pont-Mitsui, density: 0.940 g/cm^3, melting peak temperature (melting point): 88°C, MFR190: 10 g/10 min)

[0121] Above, the IV value refers to the above-described limiting viscosity, and MFR230 refers to a melt flow rate measured at 230°C under 21.18N (2.16kgf) in accordance with JIS-K-7210. MFR190 refers to a melt flow rate measured at 190°C under 21.18N (2.16kgf) in accordance with JIS-K-7210.

[0122] A description of the manufacturing conditions of crimped conjugate fibers is as follows.

(A) Extrusion temperature: 300°C for the second component polymer, 250°C for the first component polymer, nozzle spinneret temperature: 270°C
(B) Withdrawing rate: 500 m/min
(C) Number of nozzle holes: 600
(D) Combination ratio: core/sheath = 55/45 (volume ratio)
(E) Unstretched fiber fineness: 10 dtex
(F) Stretching temperature: wet 80°C
(G) Stretch ratio: 2.3
(H) Crimps: 12 to 16 per 25 mm
(I) Annealing temperature (drying temperature), time: 100°C, 15 min
(J) Product fineness (single fiber): 6.0 dtex
(K) Fiber length: 51 mm

Production conditions of nonwoven fabric

[0123] A crimped conjugate fiber (100 mass%) was subjected to a parallel card to collect a web, and the web was treated at a processing temperature of 150°C for 30 seconds with a convection heating machine, thus giving a nonwoven fabric having a unit weight of 500 g/m^2.

Example 1

[0124] A crimped conjugate fiber was prepared under the above-described crimped conjugate fiber production conditions using only PP-A as the second component and a mixture of PB-1 andLLDPE-Ahaving a mass ratio of PB-1/LLDPE-A= 92/8 as the first component. Next, a nonwoven fabric was prepared under the above-described nonwoven fabric production conditions using the resulting crimped conjugate fiber.

Example 2

[0125] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-Ahaving a mass ratio of PB-1/LLDPE-A= 97/3 was used as the first component.

Example 3

[0126] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-Ahaving a mass ratio of PB-1/LLDPE-A= 95/5 was used as the first component.

Example 4

[0127] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component.

Example 5

[0128] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-Ahaving a mass ratio of PB-1/LLDPE-A= 80/20 was used as the first component.

Example 6

[0129] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-B having a mass ratio of PB-1/LLDPE-B = 92/8 was used as the first component.

Example 7

[0130] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-C having a mass ratio of PB-1/LLDPE-C = 92/8 was used as the first component.

Example 8

[0131] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 95/5 was used as the second component.

Example 9

[0132] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 75/25 was used as the second component.

Example 10

[0133] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-B and PPR-1 having a mass ratio of PP-B/PPR-1= 85/15 was used as the second component.

Example 11

[0134] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-2 having a mass ratio of PP-A/PPR-2 = 85/15 was used as the second component.

(Example 12)

[0135] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PB-1 and LLDPE-D having a mass ratio of PB-1/LLDPE-D = 92/8 was used as the first component.

Example 13

[0136] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PB-1 and LLDPE-E having a mass ratio of PB-1/LLDPE-E = 92/8 was used as the first component.

Example 14

[0137] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PB-1, LLDPE-D, and EMAA having a mass ratio of PB-1/LLDPE-D/EMAA= 90/5/5 was used as the first component.

Example 15

[0138] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that only PET was used as the second component and a mixture of PB-1 and LLDPE-D having a mass ratio of PB-1/LLDPE-D = 92/8 was used as the first component.

Example 16

[0139] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that only PET was used as the second component.

Example 17

[0140] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that only PET was used as the second component and a mixture ofPB-1, LLDPE-D, and EMAA having a mass ratio of PB-1/LLDPE-D/EMAA= 90/5/5 was used as the first component.

Example 18

[0141] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that only PET was used as the second component and a mixture of PB-1, LLDPE-A, and EMAA having a mass ratio of PB-1/LLDPE-A/EMAA= 90/5/5 was used as the first component.

Comparative Example 1

[0142] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and only PB-1 1 was used as the first component.

Comparative Example 2

[0143] An attempt was made to prepare a crimped conjugate fiber in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and LLDPE-Ahaving a mass ratio of PB-1/LLDPE-A= 70/30 was used as the first component, but spinnability was poor, and thread breaks frequently occurred immediately below the spinning nozzle, and it was thus not possible to prepare a spun filament.

Comparative Example 3

[0144] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 99/1 was used as the second component and a mixture of PB-1 and LDPE having a mass ratio of PB-1/LDPE = 90/10 was used as the first component.

Comparative Example 4

[0145] An attempt was made to prepare a crimped conjugate fiber and a nonwoven fabric in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and EMAAhaving a mass ratio of PB-1/EMAA= 94/6 was used as the first component, but the stretchability of the spun filament was poor. In addition, crimp formability after performing thermal processing in order to form a nonwoven fabric was poor, and it was thus not possible to prepare thermally adhered nonwoven fabric having good cushioning properties.

Comparative Example 5

[0146] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that a mixture of PP-A and PPR-1 having a mass ratio of PP-A/PPR-1= 85/15 was used as the second component and a mixture of PB-1 and BP having a mass ratio of PB-1/BP = 85/15 was used as the first component.

Comparative Example 6

[0147] An attempt was made to prepare a crimped conjugate fiber and a nonwoven fabric in the same manner as in Example 1 except that only PET was used as the second component and a mixture of PB-1, PP-A, and EMAA having a mass ratio of PB-1/PP-A/EMAA= 85/10/5 was used as the first component. Although a conjugate fiber having high spinnability, stretchability, and crimp formability was obtained, pieces of the constituent fiber did not thermally bond sufficiently to each other in thermal bonding processing at 150°C, and thus it was not possible to obtain a thermally bonded nonwoven fabric.

Comparative Example 7

[0148] A crimped conjugate fiber and a nonwoven fabric were prepared in the same manner as in Example 1 except that only PET was used as the second component and a mixture of PB-1 and EMAAhaving a mass ratio of PB-1/EMAA= 92/8 was used as the first component.

[0149] Tables 1 to 4 below show the results of the eccentricity, spinnability during melt spinning, staple fiber spreadability, staple fiber crimp formability, and crimp formability after thermal processing of the resulting crimped conjugate fibers as well as the initial thickness, unit weight, residual repetitive compression set, and residual compression set of the nonwoven fabrics of Examples 1 to 18 and Comparative Examples 1 to 7. The crimped conjugate fibers of Examples 1 to 4, 6 to 9, and 11 to 18 were actualized crimping conjugate fibers, have wavy crimps as shown in Fig. 2A or spiral crimps, or have both wavy crimps and spiral crimps, and the number of crimps was 12 to 18 per 25 mm. The crimped conjugate fibers of Examples 5 and 10 were latently crimpable conjugate fibers in which three-dimensional crimps have been developed due to thermal processing performed when preparing a nonwoven fabric, have at least one of the wavy crimps as shown in Fig. 2A and the spiral crimps.

[0150]

Table 1

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
Second component (Core resin)	Resin 1	PP-A	PP-A	PP-A	PP-A	PP-A	PP-A
	Resin 2	-	PPR-1	PPR-1	PPR-1	PPR-1	PPR-1
	Resin 1: Resin2	100:0	85:15	85:15	85:15	85:15	85:15
	Melting point (Tf2) after spinning (°C)	163.5	-	-	-	-	162.9
First component (Sheath resin)	Resin 1	PB-1	PB-1	PB-1	PB-1	PB-1	PB-1
	Resin 2	LLDPE-A	LLDPE-A	LLDPE-A	LLDPE-A	LLDPE-A	LLDPE-B
	Resin 3	-	-	-	-	-	-
	Resin 1: Resin2: Resin 3	92:8	97:3	95:5	92:8	80:20	92:8
	Melting point (Tf1) after spinning (°C)	123.2	-	-	-	-	121.7
Eccentricity	(%)	25	25	25	25	25	25
Spun thread break	A-C	A	A	A	A	B	A
Stretchability	A-C	A	A	A	A	A	A

(continued)

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
Staple fiber spreadability	A-C	A	A	A	A	B	A
Staple fiber crimp formability	A-C	A	A	A	A	A	A
Crimp formation after thermal processing	(A-C) Actual or latent	A Actual crimps	A Actua lcrimps	A Actual crimps	A Actual crimps	A Actua lcrimps	A Actual crimps
Initial thickness	(mm)	25	25	25	25	25	25
Unit weight	(g/m^2)	500	500	500	500	500	500
Residual repetitive compression set	(%)	11.7	10.3	11.2	9.7	11.8	11.9
Residual compression set	(%)	33.4	26.1	29.2	30.0	33.5	33.7

[0151]

Table 2

		Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12
Second component (Core resin)	Resin 1	PP-A	PP-A	PP-A	PP-B	PP-A	PP-A
	Resin 2	PPR-1	PPR-1	PPR-1	PPR-1	PPR-2	-
	Resin 1: Resin2	85:15	95:5	75:25	85:15	85:15	100:0
	Melting point (Tf2) after spinning (°C)	162.6	-	-	-	-	162.0
First component (Sheath resin)	Resin 1	PB-1	PB-1	PB-1	PB-1	PB-1	PB-1
	Resin 2	LLDPE-C	LLDPE-A	LLDPE-A	LLDPE-A	LLDPE-A	LLDPE-D
	Resin 3	-	-	-	-	-	-
	Resin 1: Resin2: Resin 3	92:8	92:8	92:8	92:8	92:8	92:8
	Melting point (ni) after spinning (°C)	123.5	-	-	-	-	121.9
Eccentricity	(%)	25	25	25	25	25	25

(continued)

		Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12
Spun thread break	A-C	A	A	A	A	A	A
Stretchability	A-C	A	A	A	A	A	A
Staple fiber spreadability	A-C	A	A	A	A	B	A
Staple fiber crimp formability	A-C	A	A	A	A	A	A
Crimp formation after thermal processing	(A-C) Actual or latent	A crimps	Actual crimps	A crimps	A Latent crimps	A Actual crimps	A Actual crimps
Initial thickness	(mm)	25	25	25	25	25	25
Unit weight	(g/m^2)	500	500	500	500	500	500
Residual repetitive compression set	(%)	9.5	10.5	10.7	11.4	11.2	11.0
Residual compression set	(%)	28.5	30.0	31.3	31.8	29.2	31.4

[0152]

Table 3

		Ex.13	Ex.14	Ex. 15	Ex. 16	Ex. 17	Ex. 18
Second component (Core resin)	Resin 1	PP-A	PP-A	PET	PET	PET	PET
	Resin 2	-	-	-	-	-	-
	Resin 1: Resin2	100:0	100:0	100:0	100:0	100:0	100:0
	Melting point (Tf2) alter spinning (°C)	163.0	-	-	-	-	-

(continued)

		Ex.13	Ex.14	Ex. 15	Ex. 16	Ex. 17	Ex. 18
First component (Sheath resin)	Resin 1	PB-1	PB-1	PB-1	PB-1	PB-1	PB-1
	Resin 2	LLDPE-E	LLDPE-D	LLDPE-D	LLDPE-A	LLDPE-D	LLDPE-A
	Resin 3	-	EMAA	-	-	EMAA	EMAA
	Resin 1: Resin2: Resin 3	92:8	90:5:5	92:8	92:8	90:5:5	90:5:5
	Melting point (Tf1) after spinning (°C)	120.8	-	-	-	-	-
Eccentricity	(%)	25	25	25	25	25	25
Spun thread break	A-C	A	A	A	A	A	A
Stretchability	A-C	A	A	A	A	A	A
Staple fiber spreadability	A-C	A	A	A	A	A	A
Staple fiber crimp formability	A-C	A	A	A	A	A	A
Crimp formation after thermal processing	(A-C) Actual or latent	A Actual crimps	A Actual crimps	A Actual crimps	A Actual crimps	A Actual crimps	A Actual crimps
Initial thickness	(mm)	25	25	25	25	25	25
Unit weight	(g/m^2)	500	500	500	500	500	500
Residual repetitive compression set	(%)	12.2	10.8	10.1	10.4	9.8	9.7
Residual compression set	(%)	35.0	31.2	39.8	39.8	39.5	39.8

[0153]

Table 4

		Comp. Ex.1	Comp. Ex.2	Comp. Ex.3	Comp. Ex.4	comp. Ex.5	comp. Ex.6	Comp. Ex.7
Second component (Core resin)	Resin 1	PP-A	PP-A	PP-A	PP-A	PP-A	PET	PET
	Resin 2	PPR-1	PPR-1	PPR-1	PPR-1	PPR-1	-	-
	Resin 1: Resin2	85:15	85:15	99:1	85:15	85:15	100:0	100:0
	Melting point (Tf2) after spinning (°C)	-	-	-	-	-	250.4	-
First component (Sheath resin)	Resin 1	PB-1	PB-1	PB-1	PB-1	PB-1	PB-1	PB-1
	Resin 2	-	LLDPE-A	LDPE	EMAA	BP	PP-A	EMAA
	Resin 3	-	-	-	-	-	EMAA	-
	Resin 1: Resin2: Resin 3	100:0	70:30	90:10	94:6	85:15	85:10:5	92:8
	Melting point (Tf1) after spinning (°C)	-	-	-	-	-	162.7 119.0	-
Eccentricity	(%)	25	25	25	25	25	25	25
Spun thread break	A-C	A	C	A	B	B	A	B
Stretchability	A-C	B	-	A	B	B	A	C
Staple fiber spreadability	A-C	A	-	B	A	B	A	A
Staple fiber crimp formability	A-C	A	-	A	A	B	A	A
Crimp formation after thermal processing	(A-C) Actual or latent	A Latent crimps	-	A Latent crimps	C	A Latent crimps	A Actual crimps	A crimps
Initial thickness	(mm)	25	-	25	-	-	-	25
Unit weight	(g/m^2)	500	-	500	-	-	-	500
Residual repetitive compression set	(%)	11.6	-	12.4	-	-	-	9.7

(continued)

	Comp. Ex.1	Comp. Ex.2	Comp. Ex.3	Comp. Ex.4	comp. Ex.5	comp. Ex.6	Comp. Ex.7
Residual compression set (%)	33.8	-	34.7	-	-	-	39.8

[0154] Acomparison of Examples 1 to 18 of Tables 1 to 3 with Comparative Examples 1 to 7 of Table 4 confirms that, with crimped conjugate fibers in which the first component contained PB-1, addition of linear low density polyethylene to PB-1 brought about the effect of enhancing the stretchability, the staple fiber spreadability, the staple fiber crimp formability, and like properties of PB-1. This can be confirmed from the fact that conjugate fibers in which the first component was composed solely of PB-1 and conjugate fibers in which polymers other than linear low density polyethylene were added to PB-1 as shown in Comparative Examples 1, 4, 5, and 7 of Table 4 had poor stretchability (B evaluation), whereas stretchability was good (A evaluation) in all Examples. The conjugate fiber to which low density polyethylene (LDPE) was added to the first component did not have good staple fiber spreadability, thus confirming that addition of linear low density polyethylene as a polymer to be added to the first component containing polybutene-1 as the main ingredient enables crimped conjugate fibers having not only good spinnability and stretchability but also good staple fiber crimp formability, and crimp formability after thermal processing, i.e., all such properties were good, to be obtained.

[0155] It can be confirmed from Examples 1 to 18 that, with the crimped conjugate fiber of the present invention, when the first component was a resin component containing polybutene-1 and linear low density polyethylene, a nonwoven fabric that used the resulting conjugate fiber had little residual repetitive compression set irrespective of whether the second component was either a polyolefin-based polymer or a polyester-based polymer. Therefore, in the crimped conjugate fiber of the present invention, the second component that constitutes the inner portion of the conjugate fiber is not particularly limited, and it appears that the second component, while not being limited to a polyester-based polymer or a polyolefin-based polymer, is usable insofar as it is a polymer having a melting peak temperature at least 20°C higher than the melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher and having excellent bending strength and bending plasticity.

[0156] Regarding crimped conjugate fibers in which the first component contained PB-1, for adding linear low density polyethylene to the first component, conjugate fibers in which linear low density polyethylene was added in a proportion of 20 mass% relative to the first component had good spinnability, whereas conjugate fibers to which linear low density polyethylene was added in a proportion of 30 mass% to the first component had very poor spinnability. Therefore, it can be presumed from a comparison of Example 5 and Comparative Example 2 that there is an upper limit to the amount of linear low density polyethylene added, and the upper limit to the amount is less than 30 mass%, and preferably 25 mass% or less.

[0157] It can be confirmed that, with the crimped conjugate fibers of Examples 1 to 18, the crimp formability of the resulting crimped conjugate fibers and the resistance to residual repetitive compression set and the resistance to residual compression set of nonwoven fabrics that used the crimped conjugate fibers were enhanced. In particular, it can be confirmed that the crimped conjugate fibers of Examples 2 to 4, 7 to 9, 11, 12 and 14 and nonwoven fabrics that used the crimped conjugate fibers had a rate of residual repetitive compression set of 11.5% or less and a rate of residual compression set of 31.5% or less, which were significantly more improved than those of the nonwoven fabric of Comparative Example 1. A comparison of Examples 2 to 4, 7 to 9, 11, 12, and 14 with Examples 6 and 13 shows that the residual repetitive compression set and the residual compression set of nonwoven fabrics that used the crimped conjugate fibers of Examples 6 and 13 in which linear low density polyethylenes having a relatively high density and a high flexural modulus were used were increased, and therefore it is presumed that it is preferable for the crimped conjugate fiber of the present invention that linear low density polyethylene to be added to the first component is linear low density polyethylene having a lower density and a lower flexural modulus insofar as thermal bonding properties and heat resistance are not affected.

[0158] As shown in Comparative Example 6, it can be confirmed that regarding a crimped conjugate fiber in which the first component containing PB-1, the spinnability and the stretchability of PB-1 were enhanced also in a conjugate fiber in which polypropylene was added to the first component, and a crimped conjugate fiber having excellent staple fiber spreadability, staple fiber crimp formability, and staple fiber crimp formability after thermal processing was obtained. However, since polypropylene, which had a higher melting point than PB-1, was added to the first component in the crimped conjugate fiber of Comparative Example 6, the apparent melting point of the first component was increased. As a result, it was confirmed that pieces of the conjugate fiber were not sufficiently bond to each other under this thermal bonding processing condition. Therefore, a comparison of the melting points (Tf1) of the first components after spinning

of Examples 1 to 18 and Comparative Example 6, in particular Examples 1, 6, 7, 12, and 13 and Comparative Example 6 confirms that, in the case of performing thermal bonding processing at lower temperatures or thermal processing to attain higher bonding strength in a shorter period of time, it is most suitable to add linear low density polyethylene to the first component in a crimped conjugate fiber in which the first component contains PB-1.

Industrial Applicability

[0159] Afiber assembly that uses the crimped conjugate fiber of the present invention has both excellent initial bulk and bulk recovery properties and is preferably used in applications such as cushioning materials and like hard stuffing, sanitary materials, packaging materials, materials for cosmetic products, low-density non-woven fabric products such as women's brassiere pads and shoulder pads, wiping materials for people and non-human objects for which urethane foam and urethane sponge have generally been used, powdery or liquid cosmetic coating materials, heat insulating materials, and sound absorbing materials. Moreover, the crimped conjugate fiber of the present invention has excellent elasticity and shape recoverability, and is therefore preferably used as wadding for various kinds of bedding such as blankets and mattresses and clothing articles. In the crimped conjugate fiber of the present invention in which a polyolefin-based polymer is used as the second component, which is one embodiment of the crimped conjugate fiber of the present invention, all the resin components constituting the conjugate fiber are composed of polyolefin-based polymers, and therefore after being used as the hard stuffing, wadding, and low-density nonwoven fabric products, it is easy to collect the crimped conjugate fiber as a component composed of polyolefin-based polymers, reuse it as a resin material, or reuse it as a polyolefin-based fiber, and preferably is used as various fiber assembly products for which separate collection after use and reuse of components are desired.

List of Reference Numerals

[0160]

1 First component
2 Second component
3 Centroid position of second component
4 Centroid position of conjugate fiber
5 Radius of conjugate fiber
10 Conjugate fiber

Claims

1. A crimped conjugate fiber comprising a first component and a second component,
the first component comprising polybutene-1 and linear low density polyethylene,
the content of the linear low density polyethylene in the first component is 2 to 25 mass%,
the second component comprising a polymer having a melting peak temperature at least 20°C higher than a melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher,
when viewed from a fiber cross-section, the first component occupies at least 20% of a surface of the conjugate fiber, and a centroid position of the second component not overlapping a centroid position of the conjugate fiber, and
the conjugate fiber is an actualized crimping conjugate fiber in which three-dimensional crimps have been developed or a latently crimpable conjugate fiber in which three-dimensional crimps are developed by heating.

2. The crimped conjugate fiber according to claim 1, wherein the three-dimensional crimps are at least one selected from wavy crimps and spiral crimps.

3. The crimped conjugate fiber according to claim 1 or 2, wherein the linear low density polyethylene is a copolymer polymerized with α-olefin using a metallocene catalyst.

4. The crimped conjugate fiber according to any of claims 1 to 3, wherein the linear low density polyethylene has a melting peak temperature obtained from DSC measured according to JIS-K-7121 of 80 to 130°C and a density measured according to JIS-K-7112 of 0.88 to 0.92 g/cm^3.

5. The crimped conjugate fiber according to any of claims 1 to 4, wherein the linear low density polyethylene has a flexural modulus measured according to JIS-K-7171 of 20 to 300 MPa.

6. The crimped conjugate fiber according to any of claims 1 to 5, wherein the polymer having a melting peak temperature at least 20°C higher than a melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component is a polyolefin-based polymer.

7. The crimped conjugate fiber according to claim 6, wherein the polyolefin-based polymer contained in the second component is homopolypropylene, and the homopolypropylene is contained in the second component in a proportion of 75 to 100 mass%, when the entire second component being 100 mass%.

8. The crimped conjugate fiber according to any of claims 1 to 5, wherein the polymer having a melting peak temperature at least 20°C higher than a melting peak temperature of polybutene-1 or the polymer having a melting initiation temperature of 120°C or higher contained in the second component is a polyester-based polymer.

9. Afiber assembly comprising a crimped conjugate fiber in a proportion of 30 mass% or greater,
the crimped conjugate fiber comprising a first component and a second component,
the first component comprising polybutene-1 and linear low density polyethylene,
the content of the linear low density polyethylene in the first component is 2 to 25 mass%,
the second component comprising a polymer having a melting peak temperature at least 20°C higher than a melting peak temperature of polybutene-1 or a polymer having a melting initiation temperature of 120°C or higher,
when viewed from a fiber cross-section, the first component occupies at least 20% of a surface of the conjugate fiber, and a centroid position of the second component not overlapping a centroid position of the conjugate fiber, and
the conjugate fiber is an actualized crimping conjugate fiber in which three-dimensional crimps have been developed or a latently crimpable conjugate fiber in which three-dimensional crimps are developed by heating.

10. The fiber assembly according to claim 9, comprising, in addition to the crimped conjugate fiber, at least one fiber selected from synthetic fibers, chemical fibers, natural fibers, and inorganic fibers.

11. Afiber product at least partially contains the fiber assembly of claim 9 or 10 and formed into hard stuffing, bedding, a vehicle seat, a chair, a shoulder pad, a brassiere pad, a cloth, a hygienic material, a packaging material, a wet wipe, a filter, a sponge-like porous wiping material, a sheet-like wiping material, or wadding.

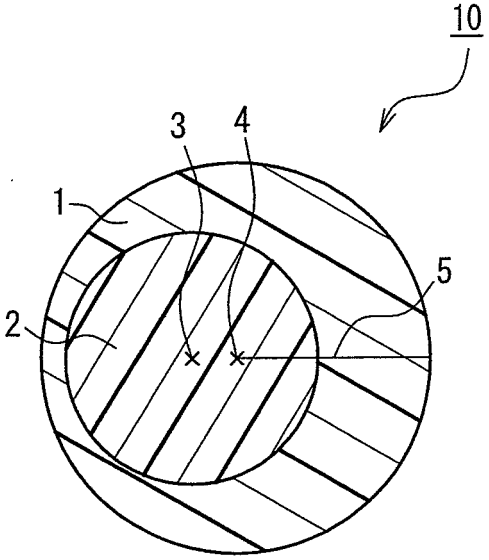

FIG. 1

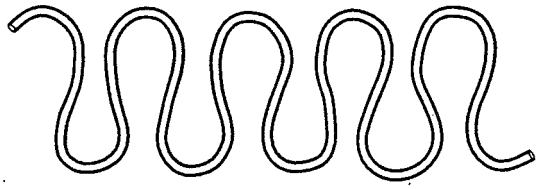

FIG. 2A

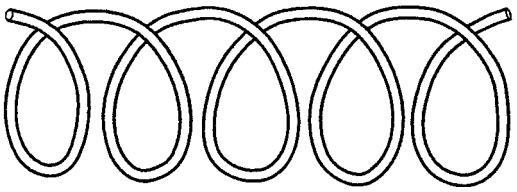

FIG. 2B

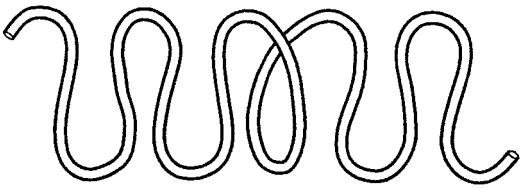

FIG. 2C

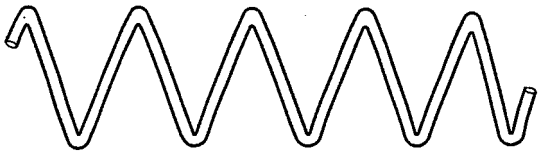

FIG. 3

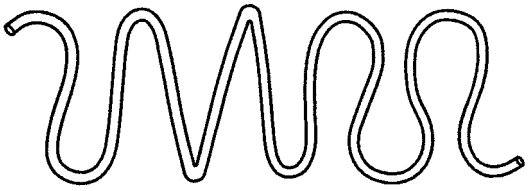

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/062103

A. CLASSIFICATION OF SUBJECT MATTER
D01F8/06(2006.01)i, *D04H1/42*(2006.01)i, *D04H1/54*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D01F8/06, D04H1/42, D04H1/54

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/041384 A1 (Daiwabo Co., Ltd.), 10 April 2008 (10.04.2008), entire text & EP 2083100 A1	1-11
A	JP 2008-274473 A (Daiwabo Co., Ltd.), 13 November 2008 (13.11.2008), entire text (Family: none)	1-11
A	JP 3-167313 A (Daiwabo Create Co., Ltd.), 19 July 1991 (19.07.1991), entire text (Family: none)	1-11

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October, 2010 (18.10.10)	26 October, 2010 (26.10.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/062103

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-18121 A (Chisso Corp.), 22 January 1992 (22.01.1992), entire text (Family: none)	1-11
P,A	JP 2010-59585 A (Daiwabo Holdings Co., Ltd.), 18 March 2010 (18.03.2010), entire text (Family: none)	1-11

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2003003334 A **[0010]**
- JP 2007126806 A **[0010]**
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- JP 2001207360 A **[0093]**
- JP 2002242061 A **[0093]**

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- Commercial Transaction of Plastic Molding Materials. Chemical Daily Co., Ltd, 30 August 2004 **[0109]**