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(71) Applicants:  
• **ES FiberVisions Co., Ltd.**  
**Osaka-shi, Osaka 530-6108 (JP)**

- **ES Fibervisions Hong Kong Limited**  
**Kowloon, Hong Kong (CN)**
- **ES FiberVisions LP**  
**Athens, Georgia 30601 (US)**
- **ES FiberVisions ApS**  
**6800 Varde (DK)**

(72) Inventor: **YONEDA Satoshi**  
**OSAKA-SHI, Osaka 530-6108 (JP)**

(74) Representative: **Becker, Eberhard**  
**Becker Kurig & Partner**  
**Patentanwälte mbB**  
**Bavariastraße 7**  
**80336 München (DE)**

(54) **HEAT-BONDABLE COMPOSITE FIBER, METHOD FOR PRODUCING SAME AND NONWOVEN FABRIC USING HEAT-BONDABLE COMPOSITE FIBER**

(57) The present invention addresses the problem of providing: a heat-bondable composite fiber which is capable of maintaining crimp stability even if high elongation remains, and which provides a nonwoven fabric with excellent bulkiness and shaping workability that enables following to a complicated shape or processing with a high fiber deformation stress; a method for producing this heat-bondable composite fiber; and a nonwoven fabric which uses this heat-bondable composite fiber. A heat-bondable composite fiber which comprises a first component that contains a polyester-based resin and a

second component that contains a polyolefin-based resin having a melting point that is lower than the melting point of the polyester-based resin by 15°C or more, and which has an eccentric core-sheath structure wherein, in a cross-section of the fiber perpendicular to the lengthwise direction, the second component occupies the outer periphery of the fiber. This heat-bondable composite fiber has an elongation at break of 200% or more, a three-dimensional apparent crimp, and a crimp elastic modulus of from 85% to 100%.

**Description**

## Technical Field

5 **[0001]** The present invention relates to a heat-bondable composite fiber, more specifically, to a heat-bondable composite fiber that is used to obtain a nonwoven fabric having excellent bulkiness and texture and having excellent shaping workability that can follow processing with a complicated shape and high fiber deformation stress, and still more specifically, a heat-bondable composite fiber that is used to obtain a nonwoven fabric having excellent bulkiness, texture and shaping workability suitable for applications such as absorbent articles for sanitary materials such as diapers, napkins, and pads, medical sanitary materials, everyday-life materials, general medical materials, bedding materials, filter materials, nursing care products, and pet products, a method for producing the same and a nonwoven fabric using this heat-bondable composite fiber.

## Background Art

15 **[0002]** In the related art, heat-bondable composite fibers, which can be molded by heat fusion using hot air or thermal energy from heating rollers, are used to easily obtain a nonwoven fabric having excellent bulkiness and flexibility, and are widely used for sanitary materials such as diapers, napkins, and pads, or daily commodities and industrial materials such as filters. Particularly, bulkiness and flexibility are very important for sanitary materials because they come into direct contact with the human skin and need to quickly absorb fluids such as urine and menstrual blood. There are two main methods for obtaining bulkiness and flexibility in nonwoven fabrics, one method being using bulky or flexible fibers, and the other method being processing for obtaining bulkiness and flexibility in a nonwoven fabric state (shaping working).

20 **[0003]** For example, Patent Literature 1 proposes a method of imparting an uneven shape to a nonwoven fabric by performing gear processing, which is one type of shaping working, on the nonwoven fabric, and imparting bulkiness and flexibility. While such processing is performed, strong stress is applied to the fibers, but if fibers with low elongation are used in this case, the fibers are broken and become fuzz on the surface of the nonwoven fabric and tactile sensation deteriorates, and therefore fibers that have followability with respect to processing and high elongation are required.

25 **[0004]** Patent Literature 2 proposes a fiber having high elongation obtained by performing a certain-length heat treatment at a ratio of 0.5 to 1.3 on a heat-fusible composite fiber undrawn yarn at a temperature higher than both the glass transition point of the main crystalline thermoplastic resin of the heat-fusible resin component and the glass transition point of the fiber-forming resin component, and then performing a heat treatment under no tension at a temperature higher than the certain-length heat treatment temperature by 5°C or more. However, since such fibers have a low draw magnification, there is a problem that the nonwoven fabric has low fiber stiffness and low bulkiness.

30 **[0005]** In Patent Literature 3, excellent bulkiness is achieved by drawing the undrawn fiber of the heat-bondable composite fiber at a draw magnification at break of 75% to 95%. However, such fibers have an elongation of 50% to 120%, and have problems that they have insufficient followability with respect to processing with a complicated shape and high fiber deformation stress and are difficult to perform shape-working on.

## Citation List

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## Patent Literature

**[0006]**

45 Patent Literature 1: Japanese Patent Laid-Open No. 2017-043853

Patent Literature 2: Japanese Patent Laid-Open No. 2007-204901

Patent Literature 3: Japanese Patent Laid-Open No. 2014-234559

## Summary of Invention

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## Technical Problem

**[0007]** Accordingly, a study to obtain a nonwoven fabric having excellent bulkiness according to physical fiber properties and a study to obtain a nonwoven fabric having excellent shaping working by increasing the elongation of the fiber and improving followability with respect to processing of the nonwoven fabric have been individually performed, but a synergistic effect of both is not intended, and nonwoven fabric fibers having both bulkiness and followability have not yet been obtained.

55 **[0008]** In view of the above related art, an objective of the present invention is to provide a heat-bondable composite

fiber that can maintain crimp stability even if high elongation is maintained, and impart excellent bulkiness and shaping workability that can follow processing with a complex shape and high fiber deformation stress to a nonwoven fabric, a method for producing the heat-bondable composite fiber and a nonwoven fabric using the heat-bondable composite fiber.

5 Solution to Problem

[0009] The inventors conducted extensive studies in order to address the above problems, and as a result, found that, when a composite fiber having an eccentric sheath-core structure composed of a first component containing a polyester-based resin and a second component containing a polyolefin-based resin is produced under appropriate drawing conditions and heat treatment conditions, it is possible to maintain crimp stability even if high elongation is maintained, and a heat-bondable composite fiber that imparts excellent bulkiness and shaping workability that can follow processing with a complex shape and high fiber deformation stress to a nonwoven fabric is obtained, and completed the present invention.

[0010] Specifically, the present invention includes the following aspects.

15 [1] A heat-bondable composite fiber which includes a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than a melting point of the polyester-based resin by 15°C or more, and which has an eccentric sheath-core structure in which, in a cross-section of a fiber orthogonal to a lengthwise direction of the fiber, the second component occupies an outer periphery of the fiber,

20 wherein the heat-bondable composite fiber has an elongation at break of 200% or more, a three-dimensional apparent crimp, and a crimp elastic modulus of 85% to 100%.

[2] The heat-bondable composite fiber according to [1], wherein a ratio of the elongation at break to fineness is 80%/dtex or more.

25 [3] The heat-bondable composite fiber according to [1] or [2], wherein a breaking strength is 0.5 to 1.5 cN/dtex.

[4] The heat-bondable composite fiber according to any one of [1] to [3], wherein a dry heat shrinkage at 120°C is 0% to 15%.

[5] A method for producing a heat-bondable composite fiber, including:

30 a process of melt spinning a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than a melting point of the polyester-based resin by 15°C or more to form an eccentric sheath-core cross-sectional shape in which the second component occupies an outer periphery of a fiber to obtain an undrawn fiber;

a process of drawing the undrawn fiber to obtain a drawn fiber; and

35 a process of heat-treating the drawn fiber,

wherein drawing efficiency represented by an equation below is 40% to 75%:

$$\text{drawing efficiency (\%)} = \left\{ \frac{\text{fineness (dtex) of undrawn fiber}}{\text{draw magnification (times) / fineness (dtex) of heat-bondable composite fiber}} \right\} \times 100$$

[6] The method for producing a heat-bondable composite fiber according to [5],

45 wherein the process of obtaining the drawn fiber is a process of drawing the undrawn fiber at a draw magnification of 1.5 or more.

[7] The method for producing a heat-bondable composite fiber according to [5] or [6],

wherein the process of heat-treating is a process in which a heat treatment is performed in a temperature range higher than a glass transition temperature of the polyester-based resin constituting the first component by 10°C to 70°C and lower than the melting point of the polyolefin-based resin constituting the second component.

50 [8] The method for producing a heat-bondable composite fiber according to any one of [5] to [7], further including: a process of imparting two-dimensional mechanical crimps to the drawn fiber after the process of drawing.

[9] A nonwoven fabric obtained using the heat-bondable composite fiber according to any one of [1] to [4].

[10] The nonwoven fabric according to [9],

55 wherein elongation is 90% to 150%, and specific volume is 30 to 75 cm<sup>3</sup>/g.

Effects of Invention

[0011] Since the heat-bondable composite fiber of the present invention can maintain crimp stability even if high

elongation is maintained, it is possible to produce a nonwoven fabric having excellent bulkiness and shaping workability that can follow processing with a complex shape and high fiber deformation stress.

#### Brief Description of Drawings

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#### [0012]

Fig. 1 is a schematic view showing a drawing machine used for heat-bondable composite fibers of the present invention.

10 Fig. 2 is an optical microscopic image showing two-dimensional mechanical crimps of heat-bondable composite fibers.

Fig. 3 is a scanning electron microscopic image showing three-dimensional apparent crimps of heat-bondable composite fibers of the present invention.

#### 15 Description of Embodiments

[0013] The heat-bondable composite fiber of the present invention is a heat-bondable composite fiber which includes a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than the melting point of the polyester-based resin by 15°C or more, and which has an eccentric sheath-core structure in which, in a cross-section of the fiber orthogonal to a lengthwise direction of the fiber, the second component occupies the outer periphery of the fiber, and the heat-bondable composite fiber has an elongation at break of 200% or more, a three-dimensional apparent crimp, and a crimp elastic modulus of 85% to 100%. When such fibers are used, it is possible to produce a nonwoven fabric having excellent bulkiness and shaping workability that can follow processing with a complex shape and high fiber deformation stress.

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(First component)

[0014] The polyester-based resin constituting the first component of the present invention is not particularly limited, and examples thereof include polyalkylene terephthalates such as polyethylene terephthalate, polytrimethylene terephthalate, polypropylene terephthalate, and polybutylene terephthalate, biodegradable polyesters such as polylactic acid, polybutylene succinate, and polyglycolic acid, and copolymers of these and other ester-forming components. Other ester-forming components are not particularly limited, and examples thereof include glycols such as diethylene glycol and polymethylene glycol, and aromatic dicarboxylic acids such as isophthalic acid and hexahydroterephthalic acid. In the case of a copolymer with other ester-forming components, the composition of the copolymer is not particularly limited, and it is preferable that it not significantly impair the crystallinity, and in this regard, the content of the copolymer is 10 mass% or less, and more preferably 5 mass% or less. These may be used alone, or two or more thereof may be used in combination without any problem.

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[0015] Among these, in consideration of raw material cost, thermal stability of the obtained fiber, and the like, the polyester-based resin is preferably at least one selected from the group consisting of polyethylene terephthalate, polypropylene terephthalate, polybutylene terephthalate, polylactic acid, and polybutylene succinate, and more preferably an unmodified polymer composed of only polyethylene terephthalate.

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[0016] The first component is not particularly limited as long as it contains a polyester-based resin, and preferably contains 80 mass% or more of the polyester-based resin, and more preferably contains 90 mass% or more of the polyester-based resin. Additionally, additives such as an antioxidant, a light stabilizer, a UV absorber, a neutralizer, a nucleating agent, an epoxy stabilizer, a lubricant, an antibacterial agent, a flame retardant, an antistatic agent, a pigment and a plasticizer may be appropriately added as necessary as long as they do not interfere with the effects of the present invention.

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(Second component)

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[0017] The polyolefin-based resin constituting the second component of the present invention is not particularly limited as long as it satisfies a condition in which it has a melting point that is lower than the melting point of the polyester-based resin constituting the first component by 15°C or more, and examples thereof include low-density polyethylene, linear low-density polyethylene, high-density polyethylene, modified maleic anhydride products of these ethylene polymers, ethylene-propylene copolymers, ethylene-butene-propylene copolymers, polypropylene, modified maleic anhydride products of propylene polymers, and poly 4-methylpentene-1. These may be used alone, or two or more thereof may be used in combination without any problem.

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[0018] Among these, in order to reduce a phenomenon in which polyolefin-based resins exposed on the fiber surface

are not cooled or solidified during spinning and are fused together, at least one selected from the group consisting of low-density polyethylene, linear low-density polyethylene, high-density polyethylene, and polypropylene is preferable, and one composed of only high-density polyethylene is more preferable.

**[0019]** In addition, the melt mass flow rate (hereinafter abbreviated as MFR) of the polyolefin-based resin that can be suitably used is not particularly limited as long as it is within a spinnable range, and is preferably 1 to 100 g/10 min and more preferably 5 to 70 g/10 min. Physical properties of the polyolefin other than the MFR, for example, physical properties such as a Q value (weight-average molecular weight/number-average molecular weight), a Rockwell hardness, and the number of branched methyl chains, are not particularly limited as long as they satisfy requirements of the present invention.

**[0020]** The second component is not particularly limited as long as it contains a polyolefin-based resin, and preferably contains 80 mass% or more of the polyolefin-based resin, and more preferably contains 90 mass% or more of the polyolefin-based resin. Additives exemplified for the first component may be appropriately contained as necessary as long as they do not interfere with the effects of the present invention.

(Heat-bondable composite fiber)

**[0021]** A combination of the first component and the second component in the composite fiber of the present invention is not particularly limited as long as it satisfies a condition in which the polyolefin-based resin constituting the second component has a melting point that is lower than the melting point of the polyester-based resin constituting the first component by 15°C or more, and one selected from the first component and the second component described above can be used. Here, when the first component is a mixture of two or more polyester-based resins and/or the second component is a mixture of two or more polyolefin-based resins, the "polyolefin-based resin constituting the second component has a melting point that is lower than the melting point of the polyester-based resin constituting the first component by 15°C or more," means that the resin having the highest melting point in the mixture of polyolefin-based resins constituting the second component has a melting point that is lower than the melting point of the resin having the lowest melting point in the mixture of polyester-based resins constituting the first component by 15°C or more.

**[0022]** Specific examples of combinations of the first component/the second component include polyethylene terephthalate/polypropylene, polyethylene terephthalate/high-density polyethylene, polyethylene terephthalate/linear low-density polyethylene, and polyethylene terephthalate/low-density polyethylene. Among these, a more preferable combination is polyethylene terephthalate/high-density polyethylene.

**[0023]** The composite fiber of the present invention has an eccentric sheath-core structure in which, in a cross-section of the fiber orthogonal to a lengthwise direction of the fiber, the second component occupies the outer periphery of the fiber. The eccentric sheath-core structure may be an eccentric sheath-core solid type composite fiber or an eccentric sheath-core hollow type composite fiber.

**[0024]** The eccentric sheath-core type refers to a type in which the centers of gravity of the core side and the sheath side differ in a cross-section of the fiber orthogonal to a lengthwise direction of the fiber, and the eccentricity ratio is preferably 0.05 to 0.50, and more preferably 0.15 to 0.30 in consideration of spinnability and development of three-dimensional apparent crimps (hereinafter simply referred to as "apparent crimps" in some cases). Here, the eccentricity ratio is represented by an equation below described in Japanese Patent Laid-Open No. 2006-97157. eccentricity ratio=d/R

**[0025]** Here, d and R are as follows.

d: distance between the center point of the composite fiber and the center point of the first component constituting the core

R: radius of composite fiber

**[0026]** The cross-sectional shape of the core can be not only a circular shape but also an irregular shape, and examples of irregular shapes include a star shape, an elliptical shape, a triangular shape, a quadrangular shape, a pentagonal shape, a multilobed shape, an array shape, a T shape, and a horseshoe shape. Among these, the cross-sectional shape of the core side is preferably a circular, semicircular, or elliptical shape in consideration of development of three-dimensional apparent crimps, and particularly preferably a circular shape in consideration of the strength of the nonwoven fabric.

**[0027]** In the composite fiber of the present invention, in a cross-section of the fiber orthogonal to a lengthwise direction thereof, a composite ratio of the first component (core component) and the second component (sheath component) in terms of volume fraction is preferably 10/90 to 90/10, more preferably 30/70 to 70/30, and particularly preferably 40/60 to 50/50. The composite ratio influences the elongation of undrawn fibers and the adhesion strength of fibers when processed into a nonwoven fabric. When the ratio of the first component increases, the elongation of undrawn fibers can be suitably maintained, and the elongation of the drawn fibers obtained in the drawing process can increase so that it is possible to suitably obtain shaping workability of the nonwoven fabric. In addition, when the ratio of the second component increases, it is possible to improve the adhesion strength of the fiber when processed into a nonwoven fabric, and it is possible to suitably obtain a nonwoven fabric that is unlikely to break.

5 [0028] The fineness of the composite fiber of the present invention is not particularly limited, and is preferably in a range of 0.9 to 8.0 dtex, and specifically, is more preferably 1.7 to 6.0 dtex and still more preferably in a range of 2.6 to 4.4 dtex with respect to fibers used in sanitary materials. If the fineness of the composite fiber is 0.9 dtex or more, this is preferable because the composite fiber with high elongation is easily obtained, and if the fineness is 8.0 dtex or less, this is preferable because the composite fiber with excellent crimp shape stability is easily obtained. When the fineness is set in such a range, it is possible to achieve both high elongation and crimp shape stability, and it is easy to achieve both excellent bulkiness and the followability in shaping working.

10 [0029] The elongation at break of the composite fiber of the present invention is 200% or more, preferably 250% to 500%, and more preferably 300% to 450%. When the elongation at break of the composite fiber is 200% or more, it is possible to obtain a nonwoven fabric that can be stretched without cutting the fibers in a nonwoven fabric state and has excellent shaping workability that enables following a complex shape. If the elongation at break is 500% or less, it is possible to increase the strength of the composite fiber and crimp shape stability, and stabilization of card passability in the carding process and a bulky nonwoven fabric can be easily obtained.

15 [0030] For the elongation at break in the present invention, a tensile test is performed with a sample grip interval of 20 mm using a tensile tester according to JIS L 1015, and the elongation at break is defined as the elongation at break of the fiber.

20 [0031] The ratio of the elongation at break to the fineness of the composite fiber of the present invention is not particularly limited, and is preferably 80%/dtex or more, more preferably 90%/dtex or more, and still more preferably 100%/dtex or more. If the ratio of the elongation at break to the fineness of the composite fiber is 80%/dtex or more, it is possible to obtain a nonwoven fabric with an excellent balance between shaping workability and texture.

25 [0032] The breaking strength of the composite fiber of the present invention is not particularly limited, and for example, is preferably 0.5 to 1.5 cN/dtex, more preferably 0.7 to 1.4 cN/dtex, and still more preferably 0.9 to 1.3 cN/dtex with respect to fibers used in sanitary materials. If the breaking strength is low, fiber breakage and entanglement can occur when fibers are conveyed in the production process, and if the breaking strength of the composite fiber is 0.5 cN/dtex or more, the strength becomes sufficient, and it is possible to reduce fiber breakage and entanglement. In addition, since the breaking strength is generally inversely proportional to elongation, if the breaking strength is 1.5 cN/dtex or less, the elongation sufficient for processing when the fiber is made into a nonwoven fabric can be maintained. When the breaking strength is set in such a range, it is possible to obtain fibers that do not cause trouble in the processes while the elongation is maintained.

30 [0033] The ratio of the breaking strength to the elongation at break (breaking strength [cN/dtex]/elongation at break [%]) of the composite fiber of the present invention is not particularly limited, and is preferably less than 0.005, more preferably less than 0.004, and still more preferably less than 0.0024. A high ratio of the breaking strength to the elongation at break means high strength and low elongation, and a small ratio of the breaking strength to the elongation at break means low strength and high elongation. When the nonwoven fabric using the fiber is subjected to shaping working, it is preferable that fibers in the nonwoven fabric follow the processing, and if the ratio is less than 0.005, when the nonwoven fabric is subjected to shaping working, it can be smoothly processed without causing single thread breakage, and if the ratio is less than 0.004, a favorable processing followability can be obtained, and if the ratio is less than 0.0024, this is preferable because a processing followability with a higher level can be obtained.

35 [0034] The dry heat shrinkage of the composite fiber of the present invention at 120°C is not particularly limited, and is preferably 0% to 15%, more preferably 0% to 10%, and still more preferably 0% to 5%. If the dry heat shrinkage is 0% or more, this is preferable because the elongation of fibers according to shrinkage is improved, and if the dry heat shrinkage is 15% or less, this is preferable because it is possible to secure thermal dimensional stability when the web using the composite fiber of the present invention is heated and processed into a nonwoven fabric. When the heat shrinkage is set in such a range, it is possible to achieve both the shaping working followability with a sufficient level and thermal dimensional stability. A method of calculating a dry heat shrinkage will be described in examples to be described below.

40 [0035] The web heat shrinkage of the composite fiber of the present invention at 145°C is not particularly limited, and is preferably 5% to 70%, more preferably 10% to 50%, and still more preferably 10% to 30%. If the web heat shrinkage is 5% or more, this is preferable because the elongation of fibers according to shrinkage is improved, and the shaping followability when a nonwoven fabric is subjected to shaping working is improved. On the other hand, the web heat shrinkage is preferably 70% or less in consideration of thermal dimensional stability when a nonwoven fabric is heated. When the web heat shrinkage is set in such a range, it is possible to achieve both the thermal dimensional stability and shaping followability of the nonwoven fabric. A method of calculating a web heat shrinkage will be described in examples to be described below.

45 [0036] The composite fiber of the present invention has three-dimensional apparent crimps.

50 [0037] The three-dimensional apparent crimp refers to, for example, a crimp having a three-dimensional crimp shape such as a spiral or ohmic shape (a shape in which the shapes of peaks and valleys are not acute but rounded and twisted three-dimensionally), and is not particularly limited and may be a single three-dimensional crimp shape or a mixed three-

dimensional crimp shape. It is easy to obtain a bulky and flexible nonwoven fabric with such a three-dimensional crimp shape.

5 [0038] The crimp shape of the composite fiber of the present invention is mainly three-dimensional apparent crimps, and may be a mixture of two-dimensional mechanical crimps imparted with a planar zigzag structure (bending shape). When the fiber has mechanical crimps, the number of three-dimensional apparent crimps preferably accounts for 50% or more, and more preferably accounts for 80% or more.

10 [0039] The number of crimps of the composite fiber of the present invention is not particularly limited, and is preferably 6 to 20 peaks/2.54 cm, and more preferably 8 to 16 peaks/2.54 cm. When the number of crimps is set in such a range, the card passability in the carding process in the nonwoven fabric processing process is stabilized, and a bulky and flexible nonwoven fabric can be easily obtained. Here, the number of crimps in the present invention is the sum of the number of three-dimensional apparent crimps and the number of two-dimensional mechanical crimps.

15 [0040] The crimp percentage of the composite fiber of the present invention is not particularly limited, and preferably 5% to 25% and more preferably 6% to 20%. If the crimp percentage is 5% or more, the card passability will be a sufficient level, and if the crimp percentage is 6% or more, more suitable card passability can be obtained. In addition, if the crimp percentage is 25% or less, uniform texture can be obtained when a web is formed, and if the crimp percentage is 20% or less, this is preferable because more suitable uniform texture can be obtained.

20 [0041] The crimp elastic modulus of the composite fiber of the present invention is 85% to 100%, preferably 90% to 100%, and more preferably 95% to 100%. If the crimp elastic modulus is 85% or more, it is possible to maintain the shape of the crimp in the nonwoven fabric forming process, and thereby a bulky nonwoven fabric can be obtained. The composite fiber having such a crimp elastic modulus can be obtained, for example, by appropriately changing the drawing temperature and the draw magnification in a drawing process to be described below.

25 [0042] The crimp elastic modulus is defined as "a percentage of the difference between the length when the crimp of the fiber is elongated and the length after it is loosened and left for a predetermined time with respect to the difference between the elongated length and the original length" in JIS L 2080. A specific measurement method is specified in JIS L 1015.

30 [0043] In addition, inorganic fine particles are appropriately added as necessary to the composite fiber of the present invention as long as they do not interfere with the effects of the present invention in order to impart a feeling of drape and smooth tactile sensation derived from its own weight and to obtain a fiber having excellent flexibility by creating gaps such as voids and cracks inside and outside the fiber. The amount of inorganic fine particles added in the fiber is preferably 0 to 10 mass%, more preferably 0.1 to 10 mass%, and still more preferably in a range of 1 to 5 mass%.

35 [0044] The inorganic fine particles are not particularly limited as long as they have a high specific gravity and do not easily aggregate in the molten resin, and examples thereof include titanium oxide (a specific gravity of 3.7 to 4.3), zinc oxide (a specific gravity of 5.2 to 5.7), barium titanate (a specific gravity of 5.5 to 5.6), barium carbonate (a specific gravity of 4.3 to 4.4), barium sulfate (a specific gravity of 4.2 to 4.6), zirconium oxide (a specific gravity of 5.5), zirconium silicate (a specific gravity of 4.7), alumina (a specific gravity of 3.7 to 3.9), magnesium oxide (a specific gravity of 3.2) and a substance having a specific gravity approximately equal thereto, and among these, titanium oxide is preferably used. It is generally known that these inorganic fine particles are used by adding them to fibers in order to obtain concealing, antibacterial or deodorizing properties. The inorganic fine particles to be used preferably have a particle size and a shape that do not cause problems such as yarn breakage in the spinning process and the drawing process.

40 [0045] As a method of adding inorganic fine particles, a method of directly adding inorganic fine powder particles to a first component or a second component or a method of kneading inorganic fine particles into a resin, making a masterbatch, and adding it to a first component or a second component may be exemplified. Regarding the resin used for masterbatching, the same resin as in the first and second components is most preferably used, and the resin is not particularly limited as long as it satisfies requirements of the present invention, and a resin different from those in the first and second components may be used.

(Method for producing composite fiber)

45 [0046] A method for producing a composite fiber of the present invention includes a process of melt spinning a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than the melting point of the polyester-based resin by 15°C or more to form an eccentric sheath-core cross-sectional shape in which the second component occupies the outer periphery of the fiber to obtain an undrawn fiber (hereinafter referred to as a spinning process in some cases), a process of drawing the undrawn fiber under specific conditions to obtain a drawn fiber (hereinafter referred to as a drawing process in some cases), and a process of heat-treating the drawn fiber (hereinafter referred to as a heat treatment process in some cases), and in this case, the drawing efficiency represented by the following equation can be adjusted to be within a range of 40% to 75% for production.

drawing efficiency (%) = {fineness (dtex) of undrawn fiber / draw magnification (times) / fineness (dtex) of heat-bondable composite fiber} × 100

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**[0047]** In the related art, it was known that fibers with relatively high elongation could be obtained by drawing (flow drawing) polyester-based undrawn fibers at a temperature higher than the glass transition point, but because the fiber stiffness was low and the crimp shape stability was low, the nonwoven fabric obtained using the fibers had a low bulkiness. However, the inventors found that, when the flow-drawn composite fiber is additionally heated, the elongation becomes higher, and the crimp shape stability is improved. Although this does not correspond to any specific theory, it is thought to have been caused by the fact that, when a heat treatment is performed after flow drawing, the polyester-based resin constituting the first component is highly elongated by relaxing the orientation with heat from a low crystalline and highly oriented state, and additionally, the polyolefin-based resin constituting the second component is oriented and crystallized, which improves the fiber stiffness. This effect is considered to be based on a phenomenon in which, according to the heat treatment after flow drawing, the fineness increases and fibers shrink in the lengthwise direction. For example, the fineness of the drawn fiber after the heat treatment is 120% or more, preferably 125% or more, and more preferably 130% or more of the fineness of the drawn fiber before the heat treatment. The upper limit thereof is not particularly limited, and practically 200% or less. In addition, the length of the drawn fiber after the heat treatment is 90% or less, preferably 85% or less, and more preferably 80% or less of the length of the drawn fiber before the heat treatment. The lower limit thereof is not particularly limited, and practically 50% or more. That is, the drawing efficiency is 40% to 75%, more preferably 50% to 75%, and still more preferably 60% to 75%, and since the obtained composite fiber has both high elongation and crimp shape stability, it is possible to produce a nonwoven fabric that has excellent bulkiness and excellent shaping workability that can follow processing with a complex shape and high fiber deformation stress. The above effects are not expected in the related art, and are new effects found in the present invention.

**[0048]** The drawing efficiency can be controlled by appropriately selecting a spinning temperature, a spinning speed, a draw magnification, a drawing temperature, a heat treatment temperature and the like to be described below.

(Spinning process)

**[0049]** In the spinning process, the first component and the second component are each melt spun using a known spinning nozzle for an eccentric sheath-core type to form an eccentric sheath-core cross-sectional shape to obtain an undrawn fiber. The temperature during melt spinning (hereinafter referred to as a spinning temperature in some cases) is not particularly limited as long as it is a temperature at which the first component and the second component can be melted, and is preferably the melting point of the first component or higher, more preferably the melting point of the first component + 30°C or higher, and still more preferably the melting point of the first component + 50°C or higher. If the spinning temperature is the melting point of the first component + 30°C or higher, this is preferable because the number of times of yarn breakage during spinning can be reduced and an undrawn fiber that tends to retain elongation after drawing is obtained, and if the spinning temperature is the melting point of the first component + 50°C or higher, this is preferable because these effects become more significant. The upper limit of the temperature is not particularly limited as long as it is a temperature at which spinning can be suitably performed. In addition, the spinning speed is not particularly limited as long as it is within a range in which undrawn fibers can be obtained, and is preferably 300 to 1,500 m/min, and more preferably 550 to 1,000 m/min. If the spinning speed is 300 m/min or more, this is preferable because the single-hole discharge rate can increase when undrawn fibers having an arbitrary fineness are obtained, and satisfactory productivity can be obtained.

**[0050]** The fineness of undrawn fibers is not particularly limited, and is preferably 5 to 12 dtex, more preferably 6 to 11 dtex, and still more preferably in a range of 7 to 10 dtex. If the fineness of undrawn fibers is 5 dtex or more, it is possible to secure sufficient elongation with drawn fibers, and it is possible to suitably obtain shaping workability when processed into a nonwoven fabric. In addition, if the fineness is 12 dtex or less, this is preferable because the fineness of drawn fibers can be made sufficiently fine, and it is possible to secure sufficient texture when processed into a nonwoven fabric.

(Drawing process)

**[0051]** The undrawn fiber obtained under the above conditions is drawn in the drawing process. In the drawing process, when the temperature and the draw magnification are changed, and the orientation and crystallinity of molecular chains of the first component and/or the second component are controlled, it is possible to control physical properties such as the strength, elongation, and heat resistance of the composite fiber.

**[0052]** The draw magnification in the drawing process of the present invention is not particularly limited, and is preferably

1.5 times or more, more preferably in a range of 2 to 5 times, and still more preferably in a range of 3.6 to 4.5 times. If the draw magnification is 1.5 times or more, this is preferable because the crimp elastic modulus of the composite fiber increases, and the crimp shape stability can be improved, and if the draw magnification is 5 times or less, the elongation of the composite fiber can increase, and the actualization of latent crimps caused by the composite structure and the difference in stress strain that the first component and the second component receive, that is, the development of apparent crimps, can be reduced. This is preferable because it is possible to increase the development proportion of apparent crimps developed in the subsequent heat treatment process. In addition, the drawing temperature is not particularly limited, and is preferably in a temperature range higher than the glass transition temperature of the polyester-based resin constituting the first component by 10°C to 70°C and lower than the melting point of the polyolefin-based resin constituting the second component, more preferably in a temperature range higher than the glass transition temperature of the polyester-based resin constituting the first component by 35°C to 60°C and lower than the melting point of the polyolefin-based resin constituting the second component by 5°C or more, and still more preferably in a temperature range higher than the glass transition temperature of the polyester-based resin constituting the first component by 40°C to 50°C and lower than the melting point of the polyolefin-based resin constituting the second component by 10°C or more. If the drawing temperature is higher than the glass transition temperature of the polyester-based resin constituting the first component by 10°C or more, more preferably 35°C or more, and still more preferably 40°C or more, this is preferable because fibers with high elongation can be obtained even when drawn at a high ratio, and if the drawing temperature is higher than the glass transition temperature of the polyester-based resin constituting the first component by 70°C or less, more preferably 60°C or less, and still more preferably 50°C or less, it is possible to minimize cold crystallization of the first component, which is preferable because it is possible to minimize destabilization in a drawing procedure due to fusion between polyolefin-based resins that are the second component.

**[0053]** The drawing process of the present invention is not particularly limited as long as the effects of the present invention are not impaired, and it may be one-stage drawing, two-stage drawing in which the fiber that has been drawn once is drawn again, or multi-stage drawing in which the same procedure is repeated additionally. When a drawing treatment is performed twice or more, it may be continuously performed.

**[0054]** Hereinafter, one-stage drawing and two-stage drawing will be described in more detail with reference to Fig. 1, but the present invention is not limited thereto.

**[0055]** As shown in Fig. 1a, one-stage drawing is performed by a drawing machine 10 having a first draw frame 11 composed of a plurality of rollers and a second draw frame 12 composed of a plurality of rollers. Specifically, the fiber is drawn by making the speed of the fiber pulled by the second draw frame 12 higher than the speed of the fiber sent out by the first draw frame 11, and pulling the fiber F by the second draw frame 12. By drawing in this manner, the orientation and crystallinity of molecular chains are controlled, and thus it is possible to control physical properties such as the strength, elongation, and heat resistance of the composite fiber. Here, a steam chamber 13 may be provided between the first draw frame 11 and the second draw frame 12.

**[0056]** In such a drawing machine 10 in Fig. 1a, when drawing is performed with  $X_1$  that is the speed of the first draw frame 11 and  $X_2$  that is the speed of the second draw frame 12, the draw magnification of the fiber F is represented by  $X_2/X_1$ . In addition, the drawing temperature means the temperature of the fiber at the draw start position. That is, it means the temperature of the fiber in the first draw frame 11 in the drawing machine 10.

**[0057]** As shown in Fig. 1b, two-stage drawing is performed by a drawing machine 20 having a first draw frame 21, a second draw frame 22 composed of a plurality of rollers, and a third draw frame 23 composed of a plurality of rollers. Specifically, the fiber is drawn by making the speed of the fiber pulled by the second draw frame 22 higher than the speed of the fiber sent out by the first draw frame 21, and additionally, making the speed  $X_3$  of the fiber pulled by the third draw frame 23 higher than the speed of the fiber sent out by the second draw frame 22. That is, first drawing is performed between the first draw frame 21 and the second draw frame 22, and additionally, second drawing is performed between the second draw frame 22 and the third draw frame 23. Here, the reference numeral 24 is a steam chamber. However, for example, two drawing machines 10 in Fig. 1a may be arranged independently, and drawing may be performed twice.

**[0058]** For the draw magnification for each time, when drawing is performed with  $X_n$  that is the speed of the fiber by the draw frame on the upstream side, and  $X_{n+1}$  that is the speed of the fiber by the draw frame on the downstream side, the draw magnification of the fiber is represented by  $X_{n+1}/X_n$ . Here, the overall draw magnification of two-stage drawing is represented by the product of the first draw magnification and the second draw magnification. In addition, the drawing temperature means the temperature of the fiber at the initial drawing start position. That is, it means the temperature of the fiber in the first draw frame 21 in the drawing machine 20.

(Heat treatment process)

**[0059]** Next, the drawn fiber obtained in the drawing process is heated to impart three-dimensional apparent crimps, the orientation of the polyester-based resin constituting the first component is relaxed, the elongation of the composite

fiber increases, and furthermore, the degree of crystallinity of the polyolefin-based resin constituting the second component increases, and the crimp shape stability is improved.

5 [0060] The heat treatment process of the present invention is not particularly limited, and may be a heat treatment using heated air or steam or a heat treatment according to contact with a heating roller or the like. In addition, the heat treatment may be performed when fibers are constrained to a certain length or the heat treatment may be performed when fibers are relaxed. The heat treatment temperature is not particularly limited, and is preferably in a temperature range higher than the glass transition temperature of the polyester-based resin constituting the first component by 10°C to 70°C and lower than the melting point of the polyolefin-based resin constituting the second component, and more preferably in a temperature range higher than the glass transition temperature of the polyester-based resin constituting the first component by 30°C to 60°C and lower than the melting point of the polyolefin-based resin constituting the second component by 5°C or more. If the heat treatment temperature is higher than the glass transition temperature of the polyester-based resin constituting the first component by 10°C or more, and more preferably 30°C or more, this is preferable because it is possible to achieve development of apparent crimps, shape stabilization of crimps according to improvement in the crimp elastic modulus and high elongation, and if the heat treatment temperature is higher than the glass transition temperature of the polyester-based resin constituting the first component by 70°C or less, and more preferably 60°C or less, this is preferable because it is possible to minimize destabilization in a drawing procedure due to fusion between the polyolefin-based resins that are the second component. In addition, the heat treatment temperature is preferably a temperature that is equal to or higher than the drawing temperature. In addition, the heat treatment time is not particularly limited, and is preferably long as long as the workability is not impaired, specifically 5 seconds or longer, more preferably 30 seconds or longer, and still more preferably 3 minutes or longer.

10 [0061] The development of three-dimensional apparent crimps of the present invention is development derived from the composite structure of the composite fiber and the heat shrinkability difference between composite components, and caused by actualization of latent crimps inherent in the fiber, but compared to apparent crimps developed in the drawing process, apparent crimps developed in the heat treatment process have a larger crimp diameter, and the number of apparent crimps can be within an appropriate range.

25 (Mechanical crimp imparting process)

30 [0062] Here, in the present invention, before the heat treatment process, two-dimensional mechanical crimps may be imparted with a crimper or the like. When mechanical crimping is performed, it is possible to improve card passability. Such mechanical crimps have a two-dimensional crimp shape such as a planar zigzag structure (bending shape), and are different from three-dimensional apparent crimps.

[0063] The number of crimps in the two-dimensional mechanical crimps imparted in the crimping process is not particularly limited, and is preferably 5 to 10 peaks/2.54 cm and more preferably 7 to 9 peaks/2.54 cm.

35 [0064] If the crimp diameter of apparent crimps developed in the heat treatment process is small (crimps are fine), the fiber and the nonwoven fabric obtained using the fiber have a hard feeling, but when mechanical crimps of 5 to 10 peaks/2.54 cm are imparted, during mechanical crimp imparting, the fiber is heated and receives strong stress, and inside the fiber, with this shape of the fiber, thermodynamic and physical effects are stored and fixed. In the heat treatment process, since latent crimps are actualized while dragging thermodynamic and physical effects stored and fixed in advance inside the fiber, compared to when mechanical crimps are not imparted, under the influence of this storage and shape, apparent crimps with a large crimp diameter are likely to develop. When the crimp diameter increases, the flexibility of the fiber is improved, and when thermodynamic and physical effects are received in advance in the crimping process, the fiber obtained in the heat treatment process is particularly a fiber having excellent apparent crimp shape stability.

40 [0065] The number of mechanical crimps can be adjusted by, for example, appropriately changing the stuffing box pressure in the push-in crimper. In addition, before the mechanical crimps are imparted, as necessary, when an annealing treatment is performed under a dry heat, wet heat, or steam atmosphere, the heat history is improved, stress relaxation is minimized, and it is possible to finely adjust heat shrinkage in the heat treatment process.

50 (Fiber treatment agent adhering process)

[0066] In addition, the surface of the composite fiber of the present invention may be treated with various fiber treatment agents, and accordingly, it is possible to impart functions such as hydrophilicity, water repellency, antistatic properties, surface smoothness, and abrasion resistance.

55 [0067] Regarding the fiber treatment agent adhering process, a method of adhering a fiber treatment agent with a kiss roller when an undrawn fiber is taken up and an adhesion method by a touch roll method, an immersion method, or a spray method during drawing and/or after drawing may be exemplified.

(Cutting process)

**[0068]** The heated composite fiber may be cut into short fibers. The cut length can be selected depending on applications, and is not particularly limited, and when a carding treatment is performed, the length is preferably in a range of 20 to 102 mm and more preferably in a range of 30 to 51 mm.

(Nonwoven fabric)

**[0069]** In the nonwoven fabric of the present invention, since the composite fiber having both high elongation and crimp shape stability is used, the nonwoven fabric has excellent bulkiness and shaping workability that can follow processing with a complex shape and high fiber deformation stress. That is, the preferable range of the elongation of the nonwoven fabric is 90% to 150%, and the preferable range of the specific volume is 30 to 75 cm<sup>3</sup>/g. The nonwoven fabric processing conditions are not particularly limited, and for example, a method in which a carded web obtained using a roller card machine is heated at a melting point of the second component or higher to form a nonwoven fabric may be exemplified. The heat treatment method is not particularly limited, but a through-air processing method or the like is preferable because the flexibility of the nonwoven fabric can be favorably processed.

**[0070]** The nonwoven fabrics produced using the composite fiber of the present invention can be used to applications for various fiber products that require bulkiness and compression resistance, for example, absorbent articles such as diapers, napkins, and incontinence pads, medical sanitary materials such as gowns and surgical gowns, interior materials such as wall sheets, shoji paper, and flooring materials, life-related materials such as cover cloths, cleaning wipers, and garbage covers, toiletry products such as disposable toilets and toilet covers, pet products such as pet sheets, pet diapers, and pet towels, industrial materials such as wiping materials, filters, cushioning materials, oil adsorbents, and ink tank adsorbents, general medical materials, bedding materials, and nursing care products.

Examples

**[0071]** Hereinafter, the present invention will be described with references to examples, but the present invention is not limited to these examples. Here, physical properties in examples were evaluated by the following methods.

<MFR of polyolefin-based resin>

**[0072]** The MFR was measured according to JIS K 7210.

<Fineness, breaking strength, elongation at break, and ratio of elongation at break to fineness>

**[0073]** According to JIS L 1015, the fineness of undrawn fibers, the fineness of the composite fiber, the breaking strength, and the elongation at break were measured. In addition, the ratio of the elongation at break to the fineness was calculated by dividing the elongation at break [%] by the fineness [dtex].

<Total number of crimps>

**[0074]** The length of a 25 mm (or 20 mm) sample fiber was measured when an initial load of 0.18 mN/tex was applied, the number of crimps at this time was measured, and the number of crimps per 25 mm (or 20 mm) was obtained.

<Crimp elastic modulus>

**[0075]** The length of a 25 mm (or 20 mm) sample fiber was measured when an initial load of 0.18 mN/tex was applied. Next, the length when an initial load of 4.41 mN/tex was applied was measured. Then, the entire load was removed, and after the sample was left for 2 minutes, an initial load was applied, the length was measured, and the crimp elastic modulus (%) was calculated.

<Dry heat shrinkage>

**[0076]** A heat-bondable composite fiber was cut into a length of about 500 mm and heated in a circulating oven at 120°C for 5 minutes, and the dry heat shrinkage was calculated by the following equation.

dry heat shrinkage (%)=(fiber length before heat treatment-fiber length after heat treatment)÷fiber length before heat treatment×100

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<Web heat shrinkage>

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**[0077]** A heat-bondable composite fiber was applied to a roller card machine, a web sheet having a basis weight of about 200 g/m<sup>2</sup> was collected and cut into a square of about 25 cm, and the length A0 of the fiber in the flow direction was measured. The sample was left in a hot air circulation dryer heated to 145°C for 5 minutes and heated, the length A1 of the fiber in the flow direction of the sheet after a shrinkage treatment was measured, and the web heat shrinkage was calculated by the following equation.

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$$\text{web heat shrinkage (\%)} = [(A0 - A1) / A0] \times 100$$

<Specific volume of nonwoven fabric>

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**[0078]** The thickness of the nonwoven fabric obtained by applying a heat-bondable composite fiber to a roller card machine and heating the obtained web was measured using a digimatic indicator (commercially available from Mitutoyo) when a load of 3.5 g/cm<sup>2</sup> was applied. The specific volume was calculated from the measured thickness using the following equation.

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specific volume of nonwoven fabric (cm<sup>3</sup>/g)=thickness of nonwoven fabric (mm)/basis weight of nonwoven fabric (g/m<sup>2</sup>)×1000

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**[0079]** The bulkiness was evaluated from the value of the obtained specific volume.

<Elongation of nonwoven fabric>

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**[0080]** The nonwoven fabric obtained by applying a heat-bondable composite fiber to a roller card machine and heating the obtained web was cut into a size of 15 cm×5 cm with the long side in the machine direction. The cut-out nonwoven fabric sample was pulled by Autograph AGS-J (commercially available from Shimadzu Corporation) at a sample length of 100 mm and a test speed of 100 m/min, and the elongation when the nonwoven fabric was broken was defined as the elongation of the nonwoven fabric.

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<Evaluation of followability>

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**[0081]** The nonwoven fabric obtained by applying a heat-bondable composite fiber to a roller card machine and heating the obtained web was cut into a size of 15 cm×5 cm with the long side in the machine direction. The cut-out nonwoven fabric sample was drawn by Autograph AGS-J (commercially available from Shimadzu Corporation). The sample length was 10 cm, the tensile speed was 100 m/min, a drawing treatment of 10 cm was performed, and a sample for followability evaluation was produced. The followability of the obtained sample was determined in the following three stages.

[Evaluation criteria]

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**[0082]**

- ⊙: the nonwoven fabric was drawn as a whole, and no partial breakage of the nonwoven fabric was observed.
- ⊙: the nonwoven fabric was locally drawn, and no partial breakage of the nonwoven fabric was observed.
- ×: the nonwoven fabric was broken in the drawing treatment or partial breakage of the nonwoven fabric was observed.

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[Examples 1 to 4 and Comparative Examples 1 and 2]

<Production of heat-bondable composite fiber>

- 5 **[0083]** A polyethylene terephthalate (abbreviated symbol PET) having an intrinsic density of 0.64 and a glass transition temperature of 70°C was placed on the core side and a high-density polyethylene (abbreviated symbol PE) having a density of 0.96 g/cm<sup>3</sup>, an MFR (190°C, a load of 21.18 N) of 16 g/10 min, and a melting point of 130°C was placed on the sheath side, and using an eccentric sheath-core nozzle, these were combined in a cross-sectional form of the first component (core)/the second component (sheath)=50/50 (volume fraction), and under the condition of a spinning speed of 900 m/min, an undrawn fiber having a fineness of 8.0 dtex was obtained. Next, the obtained undrawn fiber was drawn, mechanically crimped and heated under the conditions shown in Table 1 to obtain a heat-bondable composite fiber.

[Comparative Example 3]

- 15 **[0084]** A polyethylene terephthalate (abbreviated symbol PET) having an intrinsic density of 0.64 and a glass transition temperature of 70°C was placed on the core side and a high-density polyethylene (abbreviated symbol PE) having a density of 0.96 g/cm<sup>3</sup>, an MFR (190°C, a load of 21.18 N) of 16 g/10 min, and a melting point of 130°C was placed on the sheath side, and using a concentric sheath-core nozzle, these were combined in a cross-sectional form of the first component (core)/the second component (sheath)=60/40 (volume fraction), and under the condition of a spinning speed of 600 m/min, an undrawn fiber having a fineness of 8.0 dtex was obtained. Next, the obtained undrawn fiber was drawn, mechanically crimped and heated under the conditions shown in Table 1 to obtain a heat-bondable composite fiber.

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[Table 1]

	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
Drawing conditions	Draw magnification (times)	3.5	3.8	4.0	4.0	3.5	3.2
	Drawing temperature (°C) relative to glass transition point of first component	+45	+45	+45	+40	+30	+45
Fineness (dtex) after drawing		2.5	2.2	2.1	2.1	2.5	2.6
Presence of	mechanical crimps	Yes	Yes	Yes	Yes	Yes	Yes
Heat treatment conditions	Heat treatment method	Hot air circulation	Hot air circulation	Hot air circulation	Hot air circulation	Hot air circulation	Hot air circulation
	Heat treatment temperature (°C)	115	115	115	115	115	115
Heat treatment time (min)		5	5	5	5	5	5
Ratio (%) of fineness after heat treatment to fineness before heat treatment		136	141	138	133	112	146
Drawing efficiency (%)		67	68	69	71	82	66

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**[0085]** Table 2 shows physical properties of the composite fibers and nonwoven fabrics obtained in Examples 1 to 4 and Comparative Examples 1 to 3.

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[Table 2]

	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3	
Physical properties of composite fiber	Fineness (dtex)	3.4	3.1	2.9	2.8	2.7	3.8	
	Breaking strength (cN/dtex)	0.9	1.1	0.9	1.4	2.8	1.0	
	Elongation at break (%)	421	340	389	305	69	503	
	Ratio of elongation at break to fineness (%/dtex)	124	110	134	109	21	132	
	Ratio of breaking strength to elongation at break (cN/dtex/%)	0.0019	0.0032	0.0023	0.0046	0.0542	0.0020	
	Crimp elastic modulus (%)	96	98	96	96	100	86	
	Presence of three-dimensional apparent crimps	Yes	Yes	Yes	Yes	Yes	No	
	Number of crimps (peaks/2.54 cm)	10.0	11.2	13.7	11.9	11.6	12.7	
	Dry heat shrinkage (%)	5	3	3	2	2	6	1
	Web heat shrinkage (%)	23	13	16	17	6	14	2
Physical properties of nonwoven fabric	Basis weight (g/m <sup>2</sup> )	25	25	25	25	25	25	
	Elongation (%)	129	93	105	90	62	201	
	Specific volume (cm <sup>3</sup> /g)	35	50	41	59	93	66	
	Followability	⊙	°	⊙	°	×	×	

**[0086]** As shown in the above results, Examples 1 to 4 according to the present invention had an elongation at break of 200% or more, had three-dimensional crimps and a crimp elastic modulus of 85% to 100%. Here, the nonwoven fabric produced using this composite fiber had a large specific volume, a large elongation, and excellent bulkiness and followability.

**[0087]** In the composite fibers of Comparative Examples 1 and 2, the elongation at break was less than 200%, the elongation of the nonwoven fabric was small, and the followability was poor.

**[0088]** The composite fiber of Comparative Example 3 had a very high elongation at break, the nonwoven fabric produced using this composite fiber had high elongation and excellent followability, but no three-dimensional apparent crimps were developed, and the bulkiness was low.

#### Industrial Applicability

**[0089]** Since the heat-bondable composite fiber of the present invention has both high elongation and crimp shape stability, it is possible to produce a nonwoven fabric that has excellent bulkiness and excellent shaping workability that can follow processing with a complex shape and high fiber deformation stress. Taking advantages of these characteristics, it can be suitably used for applications such as absorbent articles for sanitary materials such as diapers, napkins, and pads, medical sanitary materials, life-related materials, general medical materials, bedding materials, filter materials, nursing care products, and pet products.

#### Reference Signs List

##### **[0090]**

- 10 Drawing machine
- 11 First draw frame
- 12 Second draw frame
- 13 Steam chamber
- 20 Drawing machine
- 21 First draw frame
- 22 Second draw frame
- 23 Third draw frame
- 24 Steam chamber
- F Fiber

#### Claims

1. A heat-bondable composite fiber which comprises a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than a melting point of the polyester-based resin by 15°C or more, and which has an eccentric sheath-core structure in which, in a cross-section of a fiber orthogonal to a lengthwise direction of the fiber, the second component occupies an outer periphery of the fiber, wherein the heat-bondable composite fiber has an elongation at break of 200% or more, a three-dimensional apparent crimp, and a crimp elastic modulus of 85% to 100%.
2. The heat-bondable composite fiber according to claim 1, wherein a ratio of the elongation at break to fineness is 80%/dtex or more.
3. The heat-bondable composite fiber according to claim 1 or 2, wherein a breaking strength is 0.5 to 1.5 cN/dtex.
4. The heat-bondable composite fiber according to any one of claims 1 to 3, wherein a dry heat shrinkage at 120°C is 0% to 15%.
5. A method for producing a heat-bondable composite fiber, comprising:
  - a process of melt spinning a first component containing a polyester-based resin and a second component containing a polyolefin-based resin having a melting point that is lower than a melting point of the polyester-

based resin by 15°C or more to form an eccentric sheath-core cross-sectional shape in which the second component occupies an outer periphery of a fiber to obtain an undrawn fiber; a process of drawing the undrawn fiber to obtain a drawn fiber; and a process of heat-treating the drawn fiber, wherein drawing efficiency represented by an equation below is 40% to 75%:

$$\text{drawing efficiency (\%)} = \left\{ \frac{\text{fineness (dtex) of undrawn fiber}}{\text{draw magnification (times) \times fineness (dtex) of heat-bondable composite fiber}} \right\} \times 100.$$

6. The method for producing a heat-bondable composite fiber according to claim 5, wherein the process of obtaining the drawn fiber is a process of drawing the undrawn fiber at a draw magnification of 1.5 or more.
7. The method for producing a heat-bondable composite fiber according to claim 5 or 6, wherein the process of heat-treating is a process in which a heat treatment is performed in a temperature range higher than a glass transition temperature of the polyester-based resin constituting the first component by 10°C to 70°C and lower than the melting point of the polyolefin-based resin constituting the second component.
8. The method for producing a heat-bondable composite fiber according to any one of claims 5 to 7, further comprising: a process of imparting two-dimensional mechanical crimps to the drawn fiber after the process of drawing.
9. A nonwoven fabric obtained using the heat-bondable composite fiber according to any one of claims 1 to 4.
10. The nonwoven fabric according to claim 9, wherein elongation is 90% to 150%, and specific volume is 30 to 75 cm<sup>3</sup>/g.

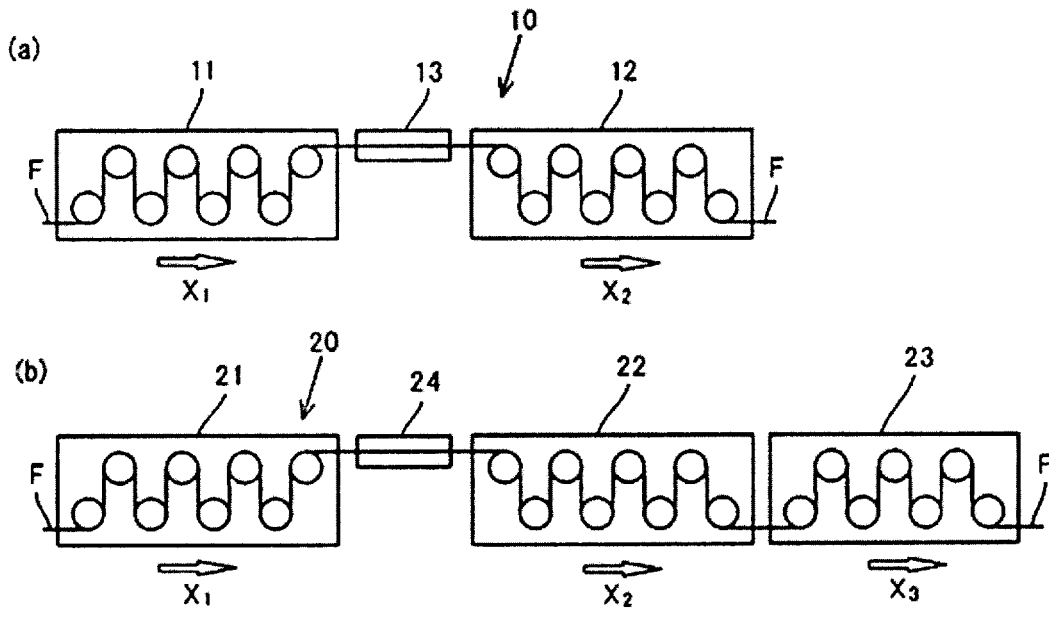


FIG. 1

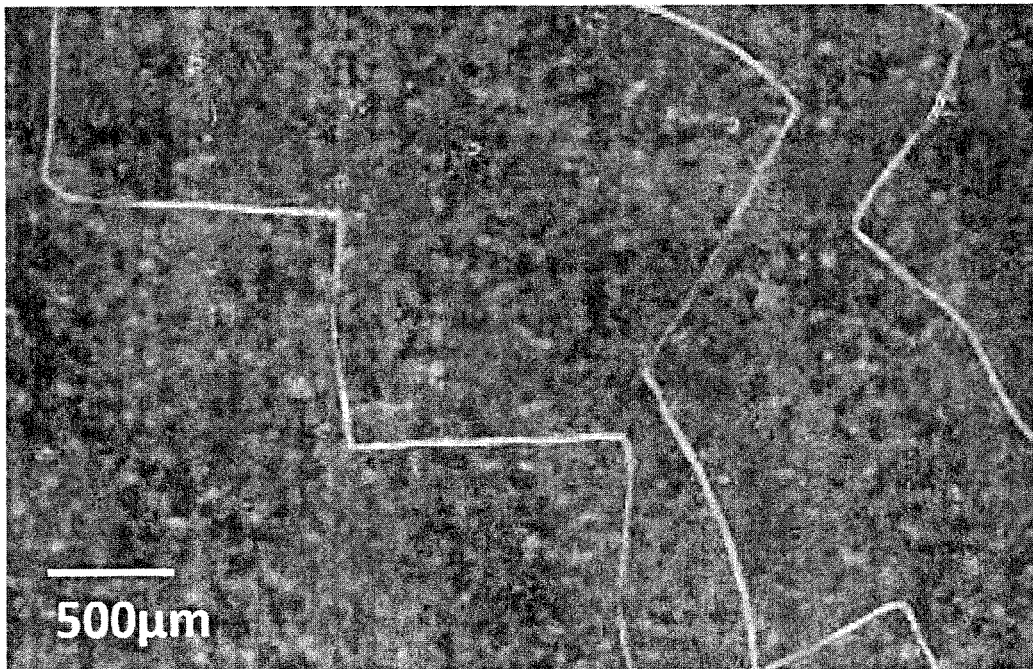


FIG. 2

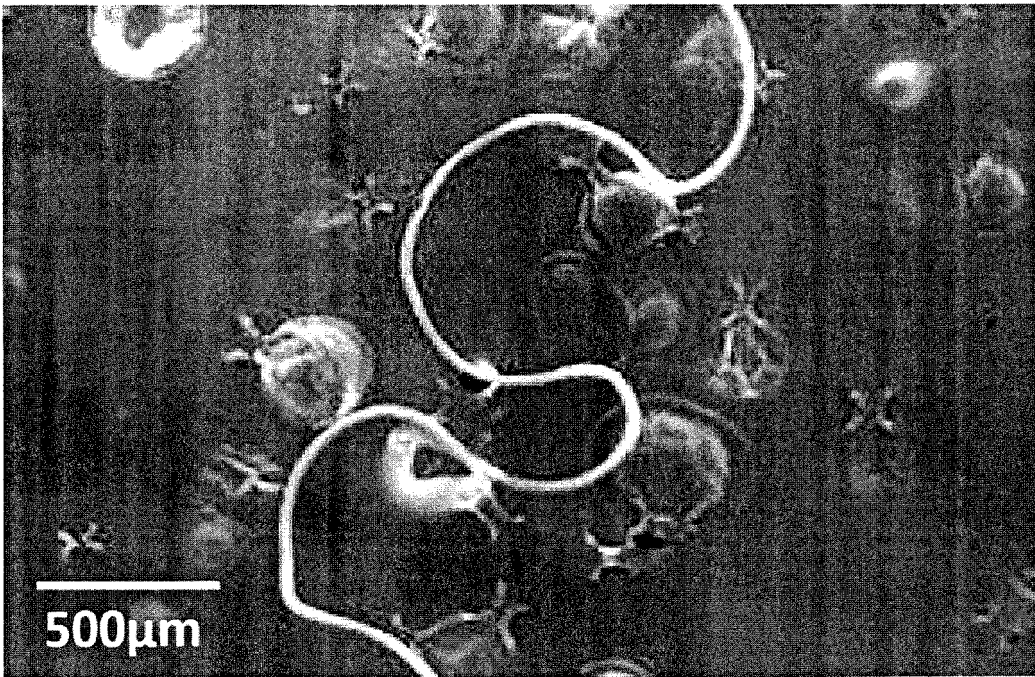


FIG. 3

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/034354

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<b>A. CLASSIFICATION OF SUBJECT MATTER</b>	
<i>D01F 8/06</i> (2006.01)i; <i>D01F 8/14</i> (2006.01)j; <i>D04H 1/541</i> (2012.01)i; <i>D04H 1/542</i> (2012.01)j FI: D01F8/14 Z; D01F8/06; D04H1/541; D04H1/542	
According to International Patent Classification (IPC) or to both national classification and IPC	
<b>B. FIELDS SEARCHED</b>	
Minimum documentation searched (classification system followed by classification symbols) D01F8/00-8/18; D04H1/00-18/04	
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched	
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<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>	
Category*	Citation of document, with indication, where appropriate, of the relevant passages
A	JP 2014-234559 A (ES FIBERVISIONS CO., LTD.) 15 December 2014 (2014-12-15) examples 4-6, paragraph [0053], claims
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"P" document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search	Date of mailing of the international search report
<b>11 October 2021</b>	<b>26 October 2021</b>
Name and mailing address of the ISA/JP	Authorized officer
<b>Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan</b>	
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