



US 20140342629A1

(19) **United States**

(12) **Patent Application Publication**  
**NAKATSUKA et al.**

(10) **Pub. No.: US 2014/0342629 A1**

(43) **Pub. Date: Nov. 20, 2014**

(54) **COMPOSITE FIBER, METHOD FOR  
PRODUCING POLYURETHANE  
ELASTOMER FABRIC, AND  
POLYURETHANE ELASTOMER FABRIC**

**Publication Classification**

(71) Applicant: **KURARAY CO., LTD.**, Kurashiki-shi  
(JP)

(51) **Int. Cl.**  
**D01F 8/16** (2006.01)  
**D06H 7/22** (2006.01)  
(52) **U.S. Cl.**  
CPC ..... **D01F 8/16** (2013.01); **D06H 7/228**  
(2013.01); **D10B 2331/10** (2013.01); **D10B**  
**2321/06** (2013.01)  
USPC ..... **442/181**; 428/373; 428/221; 442/304;  
28/168

(72) Inventors: **Hitoshi NAKATSUKA**, Kurashiki-shi  
(JP); **Nobuhiro KOGA**, Kurashiki-shi  
(JP); **Eiji AKIBA**, Osaka-shi (JP);  
**Shunichi HAYASHI**, Shibuya-ku (JP)

(73) Assignee: **KURARAY CO., LTD.**, Kurashiki-shi  
(JP)

(57) **ABSTRACT**

(21) Appl. No.: **14/448,194**

(22) Filed: **Jul. 31, 2014**

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2013/051575,  
filed on Jan. 25, 2013.

(30) **Foreign Application Priority Data**

Jan. 31, 2012 (JP) ..... 2012-017550

Provided is a composite fiber capable of forming a fabric giving a good wearing feeling to a human body. This composite fiber is composed of a polyurethane elastomer having a glass transition temperature of 15 to 50° C. as a component A, and a readily soluble thermoplastic polymer as a component B. In a cross section of the fiber, the component A constitutes a core, and the component B covers 70% or longer of the circumference of the component A. The component B may be, for example, a readily soluble polyester or thermoplastic polyvinyl alcohol-based polymer. The composite ratio (mass ratio) of the component A to the component B may be 90:10 to 40:60.

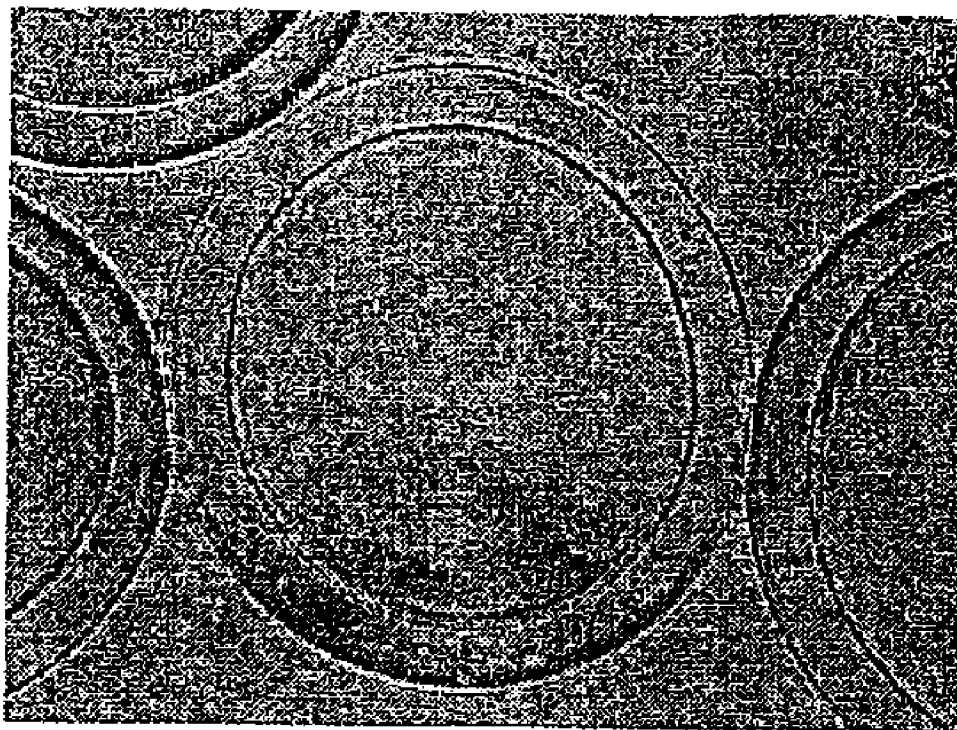


Fig. 1

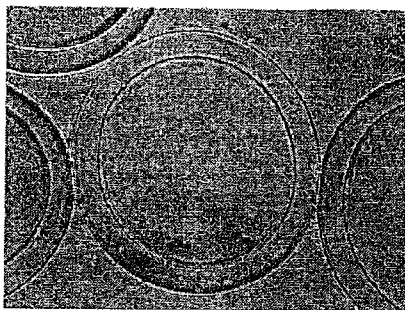


Fig. 2

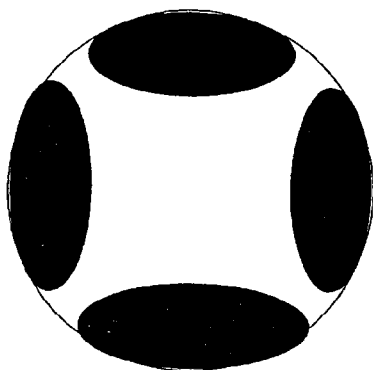


Fig. 3

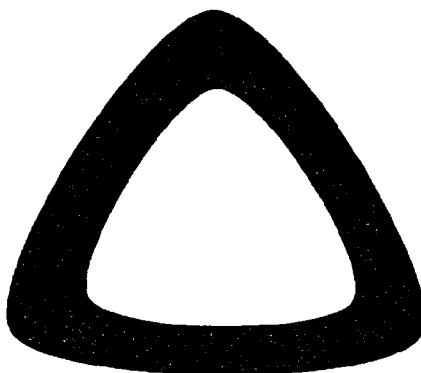
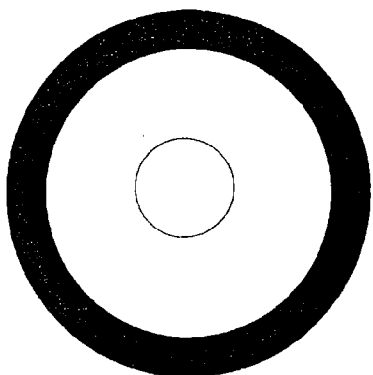


Fig. 4



# COMPOSITE FIBER, METHOD FOR PRODUCING POLYURETHANE ELASTOMER FABRIC, AND POLYURETHANE ELASTOMER FABRIC

## CROSS REFERENCE TO THE RELATED APPLICATION

[0001] This application is a continuation application, under 35 U.S.C. §111(a), of international application No. PCT/JP2013/051575, filed Jan. 25, 2013, which claims priority to Japanese Patent Application No. 2012-017550, filed on Jan. 31, 2012, the entire disclosure of which is herein incorporated by reference as a part of this application.

## FIELD OF THE INVENTION

[0002] The present invention relates to a composite fiber (conjugated or bicomponent or heterofil fiber) capable of forming a fabric which gives a good wearing feeling to a human body.

## BACKGROUND ART

[0003] Hitherto, foamed bodies made of a resin having a shape memory property have been known. In these resin foams a desired shape is memorized, for example, by following procedure: (i) deforming an object at a temperature equal to or higher than the glass transition temperature thereof, for example, a temperature such as a polymer flow starting temperature, and then (ii) cooling the object with keeping the deformed structure to a temperature of the glass transition temperature or lower. For example, Patent Document 1 discloses a shape-fitting resin foam which has a glass transition temperature of 10 to 35° C. and a loss tangent of 0.20 to 0.80 in a temperature range of 10 to 35° C., a ratio ( $G'_{\max}/G'_{\min}$ ) of 3.0 to 30 in which  $G'$  means a storage elastic modulus of the foam,  $G'_{\max}/G'_{\min}$  means a ratio of the maximum value ( $G'_{\max}$ ) relative to the minimum value ( $G'_{\min}$ ) in a temperature range of 10 to 35° C.

[0004] On the other hand, fabrics to be worn on human bodies are required to give a good wearing feeling. For example, Patent Document 2 discloses a fabric having a glass transition temperature of 15 to 35° C., a peak value of a mechanical dynamic loss tangent being present within this glass transition temperature range, and a peak value of the mechanical dynamic loss tangent of 0.2 to 1.0 both inclusive, and states that this fabric is produced from a single covered yarn in which a specific polyurethane elastomer is used as a bare yarn and nylon is used as a covering yarn.

## RELATED ART DOCUMENTS

### Patent Documents

[0005] [Patent Document 1] JP Laid-open Patent Publication No. 2009-35697 (Claim 1, and paragraphs [0009] to [0013])

[0006] [Patent Document 2] JP Laid-open Patent Publication No. 2011-149108 (Claim 1, and paragraphs [0025] to [0034])

## SUMMARY OF THE INVENTION

### Problems to be Solved by the Invention

[0007] The shape-fitting resin foam described in Patent Document 1 is wearable in contact to the human body surface

so that the resin foam fits the shape of the body surface; however, such a resin foam cannot follow a dynamic movement of a human body.

[0008] On the other hand, the fabric described in Patent Document 2 can follow a dynamic movement of a human body. However, a specific polyurethane elastomer yarn which constitutes such a fabric is low in glass transition temperature; thus, the elastomer yarn is poor not only in fiber-processability but also in fiber-to-fabric-processability during production process of the fabric. Accordingly, in fact, it is difficult to produce a fabric with such a polyurethane elastomer yarn.

[0009] Thus, an object of the present invention is to provide a yarn which can be used for fabrics including a knitted fabric, a woven fabric and a nonwoven fabric that give a good wearing feeling during a dynamic movement of a human body, as well as can have good processability during production process of a fabric.

### Means for Solving the Problems

[0010] The inventors of the present invention have made various investigations about a yarn suitable for clothing giving a good wearing feeling even during the dynamic movement of a human body, and have found that: having a low glass transition temperature in a specific range is important for a specific polyurethane elastomer yarn capable of giving a good wearing feeling to a human body in order to improve the wearing feeling; however, when the polyurethane elastomer has such a low glass transition temperature, it is very difficult to process a polyurethane elastomer yarn itself, and further to convert such a yarn into a fabric form. Accordingly, the inventors have made further advanced researches and finally found out that when a polyurethane elastomer is combined with a specific thermoplastic polymer to produce a composite fiber comprising two components into a conjugated form that the circumstance of the polyurethane elastomer core is covered with the thermoplastic polymer in a specific proportion, it is possible to make favorably the combined components to have a fiber form or fiber yarn as well as to make the fiber or yarn into a fabric form even by using a polyurethane elastomer having a low glass transition temperature. Thus, the present invention has been accomplished.

[0011] That is, the present invention is a composite fiber, comprising a polyurethane elastomer having a glass transition temperature of 15 to 50° C. as a component A, and a readily soluble (or highly dissolvable to a solvent, readily removable with a solvent) thermoplastic polymer as a component B; the component A constituting a core in a cross section of the fiber, and the component B covering 70% or longer of the circumference (external boundary) of the component A.

[0012] In the fiber, the component B may comprise at least one selected from a readily soluble polyester and a thermoplastic polyvinyl alcohol-based polymer.

[0013] The composite fiber may have a single fiber fineness of about 0.3 to 50 dtex. The composite ratio (mass ratio) of the component A to the component B may be about A:B of 90:10 to 40:60.

[0014] The composite or conjugated structure of the composite fiber is not particularly limited to a specific one, as far as the component B attains the coverage percentage satisfying the above-mentioned range. Thus, the composite fiber may have various structures. Preferably, the composite fiber has a core-sheath structure in which the component A is a core component and the component B is a sheath component.

[0015] The present invention also includes a method for producing a polyurethane elastomer fabric, including: preparing a composite fiber such as described above; producing a fabric comprising the composite fiber by using the composite fiber; and removing the component B from the fabric so as to produce a polyurethane elastomer fabric (a fabric comprising a polyurethane elastomer monocomponent fiber).

[0016] The present invention also further includes a polyurethane elastomer fabric produced by the above-mentioned method. Such a fabric may comprise a polyurethane elastomer monocomponent fiber (single polymer of polyurethane elastomer in a single fiber or filament) having a single fiber fineness of 0.3 to 50 dtex.

[0017] Any combination of at least two constituent elements disclosed in the claims and/or the specification and/or the drawings is also included in the present invention. In particular, any combination of two or more claims recited in the scope of claims is included in the present invention.

#### Effects of the Invention

[0018] According to the present invention, since a specific polyurethane elastomer is combined with a specific thermoplastic polymer to be conjugate-spun so as to have a specific structure; even when the used polyurethane elastomer is low in glass transition temperature, fiber making processability with these components can be improved.

[0019] In another aspect of the present invention, a composite fiber excellent in spinnability can be obtained even when the fiber has a small single fiber fineness.

[0020] Furthermore, according to the present invention, a polyurethane elastomer fabric can be produced in an efficient way, the fabric being high in flexibility in a temperature range of 15 to 50° C., preferably of 15 to 45° C., more preferably of 15 to 35° C., as well as being capable of having a good wearing feeling and/or fitting during a dynamic movement of a human body.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The present invention will be more clearly understood from the following description of preferred embodiments thereof with reference to the accompanying drawings. However, the embodiments and the drawings are given only for the purpose of illustration and explanation, and should not be used to limit the scope of this invention. The scope of the present invention is determined by the appended claims.

[0022] FIG. 1 is a photograph of a fiber cross section that shows an example of a form of a composite fiber for obtaining the fiber of the present invention;

[0023] FIG. 2 is a drawing illustrating an example of a fiber cross section of a fiber of another embodiment of the present invention;

[0024] FIG. 3 is a drawing illustrating an example of a fiber cross section of a fiber of still another embodiment of the present invention; and

[0025] FIG. 4 is a drawing illustrating an example of a fiber cross section of a fiber of a yet another embodiment of the present invention.

#### DESCRIPTION OF EMBODIMENTS

[0026] Hereinafter, the present invention will be described in detail. The composite fiber of the present invention is a composite fiber comprising a component A comprising a polyurethane elastomer and a component B comprising a

readily soluble thermoplastic polymer capable of having a readily solubility in a solvent (or an easily soluble thermoplastic polymer); and the component A constitutes a core in a cross section of the fiber, and the component B covers 70% or longer of the circumference of the component A in the cross section.

[0027] The components A and B may be compatible with each other at the interface therebetween. Preferably, these components are incompatible with each other at the interface therebetween.

[0028] (Component A)

[0029] The polymer constituting the component A of the composite fiber of the present invention is a polyurethane elastomer having a glass transition temperature of 15 to 50° C. The polyurethane elastomer is not particularly limited to a specific one, as far as the elastomer has such a low glass transition temperature. The polyurethane elastomer having this property can be obtained, for example, by blending a bifunctional diisocyanate having a molecular weight of 160 to 310, a bifunctional polyol having a molecular weight of 400 to 2000, and a chain extender that is a diol or diamine having a molecular weight of 60 to 400 at a molar ratio of (diisocyanate):(polyol):(chain extender) of 2.00 to 1.10:1.00:1.00 to 0.10, and then polymerizing the monomers to be reacted in a prepolymer manner.

[0030] The bifunctional isocyanate may be appropriately selected from any bifunctional isocyanate that can be used for producing the polyurethane elastomer as described above, where the bifunctional isocyanate has a molecular weight of 160 to 310. Preferred examples of the bifunctional isocyanate include 2,4-toluene diisocyanate, 4,4'-diphenylmethane diisocyanate, carbodiimide-modified 4,4'-diphenylmethane isocyanate, hexamethylene diisocyanate and the like. These bifunctional isocyanates may be used singly or in combination of two or more.

[0031] The bifunctional polyol may be appropriately selected from any bifunctional polyol that can be used for producing the polyurethane elastomer as described above, where the bifunctional polyol has a molecular weight of 400 to 2000. Preferred examples of the bifunctional polyol include polypropylene glycol, 1,4-butaneglycol adipate, polytetramethylene glycol, polyethylene glycol, and a propylene oxide adduct of bisphenol A. The bifunctional polyol may be used to be further reacted with a bifunctional carboxylic acid or a cyclic ether to obtain a reaction product. Such a product is also treated as the bifunctional polyol. These bifunctional polyols may be used singly or in combination of two or more.

[0032] Each of the diol and the diamine that is used as the chain extender may be appropriately selected from any diol and any diamine that can be used for producing the polyurethane elastomer as described above, where the chain extender (i.e., diol, diamine) has a molecular weight of 60 to 400. Preferred examples of the diol include ethylene glycol, 1,4-butaneglycol, bis(2-hydroxyethyl)hydroquinone, an ethylene oxide adduct of bisphenol A, and a propylene oxide adduct of bisphenol A. Preferred examples of the diamine include ethylenediamine, 1,2-propylenediamine, 1,3-propylenediamine, m-xylylenediamine, p-xylylenediamine, 4,4'-diphenylmethanediamine, cyclohexylenediamine, 2,4-tolylenediamine, 2,6-tolylenediamine, and hexamethylenediamine. These chain extenders may be used singly or in combination of two or more.

**[0033]** The polyurethane elastomer is synthesized by using, as starting materials, the bifunctional isocyanate, the bifunctional polyol and the chain extender, and if necessary a catalyst, in a prepolymer manner. According to the above synthesis, the component A can be obtained in which the bifunctional isocyanate, the bifunctional polyol and the chain extender are blended with one another at a ratio of 2.00 to 1.10:1.00:1.00 to 0.10. If necessary, the component A may contain various additives, for example, a delustering agent (light-shielding agent) such as titanium oxide or zinc oxide, an antioxidant, an ultraviolet absorber, and others. As far as the polyurethane elastomer with a target property can be obtained, these additives can be appropriately used either by adding to the starting materials for the polymerization into the component A, or by adding at any stage of the polymerization.

**[0034]** As the polyurethane elastomers having a glass transition temperature of 15 to 50° C., for example, the following products are commercially available from SMP Technologies Inc.:

**[0035]** SMP MM-2520 (Tg=25±3° C.; 1,4-butanediol),

**[0036]** SMP MM-3520 (Tg=35±3° C.; 1,4-butanediol),

**[0037]** SMP MM-4520 (Tg=45±3° C.; 1,4-butanediol),

**[0038]** SMP MA-2520 (Tg=25±3° C.; 1,2-ethylenediamine),

**[0039]** SMP MA-3520 (Tg=35±3° C.; 1,2-ethylenediamine), and

**[0040]** SMP MA-4520 (Tg=45±3° C.; 1,2-ethylenediamine).

**[0041]** Since the component A obtained by the polymerization has a glass transition temperature of 15 to 50° C., the component A is high in flexibility at a normal or ambient temperature. When the glass transition temperature of the component A is within a range of 15 to 45° C., more preferably of 15 to 40° C., in particular preferably of 15 to 35° C., the glass transition temperature of the component A is in the same range with the surface temperature of human body. Thus, when such a component is used for applied to a human body, the composite fiber comprising the component A can give a good wearing feeling and/or close fitting during a dynamic movement of the human body.

**[0042]** The glass transition point denotes a temperature at which mechanical properties of the polymer elastomer change rapidly. In the present invention, the glass transition point is defined as a temperature at which the elastomer shows a peak with respect to the mechanical dynamic loss tangent (referred to also as the  $\tan \delta$  hereinafter). The  $\tan \delta$  is defined as the tangent of the ratio of the loss elastic modulus  $G''$  to the storage elastic modulus  $G'$  (i.e.,  $G''/G'$ ) at a frequency of 1 Hz. It should be noted that the preferred glass transition temperature (Tg) is in a temperature range of 25 to 40° C., which is close to the body surface temperature of any human body, and in particular preferably in a temperature range of 25 to 35° C.

**[0043]** (Component B)

**[0044]** The readily (or easily) soluble (removable or decomposable) thermoplastic polymer, which is the component B of the composite fiber of the present invention, may be any component as far as the component B is melt-spinnable, as well as is easily dissolvable or decomposable in/with a solvent or a chemical material in compare to a polyurethane elastomer constituting the component A.

**[0045]** The readily soluble polymer may be a thermoplastic polymer soluble/decomposable in/with, a solvent, for example, water including a hot water, an alkali, or an acid. The readily soluble polymer is preferably a readily soluble

polyester-based polymer which is soluble/decomposable in/with an alkali, or a readily soluble thermoplastic polyvinyl alcohol-based polymer which is soluble/decomposable in/with water.

**[0046]** When a readily soluble polyester-based polymer is used, the preferable polyester is highly soluble in alkali. The readily soluble polyester-based polymer may be, for example, a polar group-containing copolymerized polyester or an aliphatic polyester.

**[0047]** The polar group-containing copolymerized polyester may be a copolymerized polyester obtained by copolymerizing the following components with one another: 1 to 5% by mole of an ester-formable sulfonic acid metal salt compound (for example, sodium 5-sulfoisophthalate or potassium 5-sulfoisophthalate); 5 to 30% by mass of a polyalkylene glycol (for example, a poly-C<sub>1-4</sub>-alkylene glycol such as a polypropylene glycol or a polyethylene glycol); and a diol component and a dicarboxylic acid component that are each conventionally used.

**[0048]** Examples of the aliphatic polyester include a polylactic acid; a polyester from an aliphatic diol and an aliphatic carboxylic acid, such as a poly(ethylene succinate), a poly(butylene succinate), and a poly(butylene succinate co-butylene adipate); a polyhydroxycarboxylic acid, such as a poly(glycolic acid), a poly(3-hydroxybutyric acid), a poly(3-hydroxyvaleric acid), and a poly(6-hydroxycaproic acid); and a poly( $\omega$ -hydroxyalkanoate) such as a poly( $\epsilon$ -caprolactone) and a poly( $\delta$ -valerolactone). Of these aliphatic polyesters, the preferred one includes a polylactic acid. The polylactic acid may be a poly D-lactic acid, a poly L-lactic acid, or a mixture thereof.

**[0049]** The readily soluble polyester-based polymer is more preferably a polyester which is readily soluble to alkali so that the polyester is substantially completely dissolved (decomposed), for example, in 60 minutes or less, preferably in 45 minutes or less, more preferably in 30 minutes or less, in particular preferably in 15 minutes or less when immersed in a 2% aqueous sodium hydroxide solution that has a temperature of 100° C. at a bath ratio of 1:30.

**[0050]** When a water-soluble thermoplastic polyvinyl alcohol-based polymer is used as the polymeric component B, the preferable polyvinyl alcohol polymer may be a polyvinyl alcohol having a viscosity-average polymerization degree of 200 to 500, a saponification degree of 90 to 99.99% by mole (preferably 95 to 99% by mole), and a melting point of 160 to 230° C. The polymer may be a homopolymer or a copolymer. The polymer is preferably a copolymerized polyvinyl alcohol comprising a modifying component such as an  $\alpha$ -olefin having 4 or less carbon atoms (e.g., ethylene or propylene) in a proportion of 0.1 to 20% by mole (preferably 5 to 15% by mole) from the viewpoint of the melt-spinnability and water-solubility thereof, as well as the physical properties of the obtained fibers.

**[0051]** The water-soluble thermoplastic polyvinyl alcohol-based polymer is preferably, for example, a thermoplastic polyvinyl alcohol-based polymer which is substantially completely dissolved (decomposed), for example, in 60 minutes less, preferably in 50 minutes or less, more preferably in 30 minutes or less, in particular preferably in 15 minutes or less when immersed in hot water of 100° C. at a bath ratio of 1:30.

**[0052]** (Method for Producing Composite Fiber)

**[0053]** The composite fiber of the present invention can be produced so as to be combined or conjugated by using a composite-spinning machine known in the prior art as far as

the combination of the polymeric component A and the polymeric component B has been decided. The composite fiber can be produced by any spinning method such as a method comprising melt-spinning these components at a low or middle speed to obtain an as-spun filament, and drawing the resultant filament; a direct spinning and drawing method comprising spinning these components at a high speed; or a method comprising spinning these components to obtain an as-spun filament, and drawing the filament simultaneously with or followed by false twisting.

**[0054]** The composite fiber of the present invention may have a composite ratio of the component A polymer to the component B polymer of preferably 90: to 40:60 (mass ratio), more preferably 85:15 to 60:40 (mass ratio). It is advisable to adjust the ratio between the two components in accordance with the desired shape of the fiber. If the proportion of the component A is too large, there is a possibility that the fiber-forming processability, in particular the process passing properties for producing fiber products may be deteriorated, since the spun fibers may be mutually stuck after winding. On the other hand, if the proportion of the component B is too large, the fiber may not gain a good wearing feeling to a human body, which feeling is a target of the product.

**[0055]** In any cross section of the composite fiber of the present invention, the component B does not need to cover the entire surface of the fiber. In order to ensure winding processability during fiber spinning, handle-ability after the winding, and process passability during fiber product production, it is important that the component A constitutes a core in the cross section of the fiber, and the component B covers 70% or more of the length of the circumference of the component A. The component B preferably covers 80% or more of the length, and in particular preferably covers 90% or more thereof.

**[0056]** The form of the conjugation in the present invention may be a concentric form, an eccentric form or a multicore form as far as the component B can be dissolved and removed by alkali treatment, water treatment or some other dissolving treatment while the component A is not cracked. The structure of the composite fiber may be a core-sheath conjugated structure as illustrated in FIG. 1 in which the component A constitutes a core component, and the component B constitutes a sheath component; a conjugated structure as illustrated in FIG. 2 in which the component A constitutes a core, and the component B intermittently covers the core; or a conjugated structure as illustrated in FIG. 3 in which the component A in a triangular form is covered with the component B. The component A may have a shape, in the cross section of the fiber, such as a circular cross-sectional shape, or an irregular cross-sectional shape such as a triangle, a flat shape or a multi-leaf shape. Furthermore, as illustrated in FIG. 4, the component A may have a hollow structure therein. The component A may have various cross-sectional shapes, for example, a one-hole hollow shape, and a multi-hole hollow shape such as a two-hole hollow shape, a hollow shape of more than two holes. The composite fiber preferably has, out of these conjugated structures, a core-sheath conjugated structure in which the component A constitutes a core component and the component B constitutes a sheath component.

**[0057]** The single fiber fineness of the composite fiber of the present invention may be appropriately decided in accordance with a purpose thereof, and is not particularly limited. The fineness is selectable in a range of, for example, 0.3 to 50 dtex (preferably 0.3 to 40 dtex). The fineness is preferably 0.3 to 10 dtex (preferably 0.3 to 5 dtex) to improve the close-

fitting between human body and the fiber product. It should be noted that, according to the composite fiber of the present invention, a fiber having a small fineness of 6 dtex or smaller can be obtained while preventing fiber breakage. Such a fiber is usable in the form of a long fiber (i.e., continuous filament), a short fiber (i.e., staple), or a short-cut fiber.

**[0058]** The composite fiber of the present invention obtained as described above can be used as various fiber aggregates. The fiber aggregates may be, for example, various fabrics, such as a woven fabric, a knitted fabric, and a non-woven fabric.

**[0059]** By removing the component B from the fiber aggregate, a final product (i.e., a polyurethane elastomer fabric) suitable for human body can be usually obtained.

**[0060]** For example, such a polyurethane elastomer fabric can be obtained by a production method including a preparing step of preparing a composite fiber as described above; a producing step of producing a fabric comprising the composite fiber by using the composite fiber; and a removing step of removing, from the fabric, the component B to obtain a polyurethane elastomer fabric (a fabric comprising a polyurethane elastomer monocomponent fiber).

**[0061]** It should be noted that the composite fiber fabric may consist essentially of the composite fiber of the present invention; or may be a woven, knitted or nonwoven fabric comprising a part consisting essentially of the fiber of the present invention (for example, a woven or knitted fabric comprising a fiber of the present invention and another fiber other than the fiber of the present invention such as a natural fiber, chemical fiber or synthetic fiber; a woven or knitted fabric comprising a blended yarn or a combined filament yarn comprising a fiber of the present invention and another fiber other than the fiber of the present invention; or a cotton-mixed nonwoven fabric). When the composite fiber of the present invention is used in a combination with another fiber in a woven, knitted or nonwoven fabric, the proportion of the component A of the fiber in the woven fabric, knitted fabric or nonwoven fabric may be, for example, 14% by mass or more, preferably 15% by mass or more, preferably 18% by mass or more, more preferably 23% by mass or more. When the composite fiber of the present invention is used as a blended yarn or a combined filament yarn, the proportion of the component A in this yarn may be, for example, 14 to 95% by mass, and may be preferably 20% by mass or more, preferably 30% by mass or more, more preferably 40% by mass or more.

**[0062]** The polyurethane elastomer fabric obtained by removing the component B from the composite fiber fabric by alkali treatment, water treatment or some other treatment has a glass transition temperature close to the temperature of the surface of human body so as to be excellent in fitting during a dynamic movement of the human body.

**[0063]** Moreover, the composite fiber according to the present invention is advantageously used to produce a polyurethane elastomer monocomponent fiber comprising a polyurethane elastomer monocomponent fiber having a single fiber fineness in a range of, for example, 0.3 to 50 dtex (preferably 0.3 to 40 dtex). When the polyurethane elastomer monocomponent fiber having a small fineness is desirable, the polyurethane elastomer monocomponent fiber may have a small fineness of 0.3 to 10 dtex, preferably 0.3 to 5 dtex.

**[0064]** The composite fiber fabric or the polyurethane elastomer fabric comprising the polyurethane elastomer monocomponent fiber may be optionally subjected to a napping

treatment, for example, cloth-carding napping, or any other finishing treatment after the process for producing the fabric.

[0065] It should be noted that the polyurethane elastomer fabric may have a peak value of mechanical dynamic loss tangent ( $\tan \theta$ ) of, for example, 0.2 to 1.0 both inclusive, preferably 0.3 to 0.8 both inclusive, more preferably 0.4 to 0.7 both inclusive in order for the fabric to have dynamic viscoelastic properties and static viscoelastic properties comparable to those of human body surface. As described above, such a fabric preferably contains the component A in the specific proportion (for example, 14% by mass or more).

#### EXAMPLES

[0066] Hereinafter, the present invention will be described in detail by way of working examples. However, the present invention is never limited by the examples. In the examples, the word "part(s)" and the symbol "%" denote part(s) by mass and % by mass, respectively, unless otherwise specified.

##### Example 1

[0067] As a component A was used a polyurethane elastomer named SMP MM-3520 (manufactured by SMP Technologies Inc.; T<sub>g</sub> of 35±3° C.; obtained by polymerizing a bifunctional diisocyanate having a molecular weight of 160 to 310, a bifunctional polyol having a molecular weight of 400 to 2000, and 1,4-butanediol diol at a molar ratio of 2.00 to 1.10:1.00:1.00 to 0.10 in a prepolymer manner). As a component B was used a polyethylene terephthalate having an intrinsic viscosity [ $\eta$ ] of 0.52 and obtained by copolymerizing 8% by mass of a polyethylene glycol having a molecular weight of 2000 and 5% by mole of sodium 5-sulfoisophthalate as copolymerizable components. The composite ratio of the component A to the component B was set to a mass ratio of 3:1, and these components were melted in different extruders, respectively, and then the melted components were extruded from a conjugate spinning nozzle (spinneret) to give composite filaments each having a cross section shown in FIG. 1.

[0068] Next, the extruded filaments from the spinneret were quenched with a transversely-blowing type cooling wind machine having a length of 1.0 m, and continuously introduced into a tube heater, 1.0 m in length and 30 mm in inner diameter (internal temperature: 180° C.) positioned directly downward from the spinneret by 1.3 m, so as to be drawn inside the tube heater. An oil was then applied to the drawn filaments from the tube heater, and subsequently wound at a winding speed of 3000 m/minute by aid of rollers to produce composite fibers of 111 dtex/24 filaments.

[0069] Thus obtained composite fiber was good in fiber making processability and also knitting processability. A circular knitting machine (28 gauges) was used to produce a circular knitted fabric from the resultant composite fiber. This knitted fabric was scoured, and then immersed in an aqueous alkali solution (liquid temperature: 100° C.) having a sodium hydroxide concentration of 20 g/L at a bath ratio of 1:30 for 30 minutes so as to dissolve the component B selectively to be removed from the composite fiber fabric. The obtained knitted fabric made of polyurethane elastomer monocomponent fibers gave a good wearing feeling.

[0070] [Coverage Ratio of Component B in Fiber Cross Section]

[0071] From a photograph of a cross section of the fiber, 10 filaments were selected at random. The length of the fiber-

coverage-region of each of the filaments was measured to calculate the percentage (coverage ratio) of the length of the coverage-region based on the circumferential length in the fiber cross section. The average of the respective coverage ratios of the filaments was calculated out.

[0072] [Spinnability Evaluation]

[0073] The spinnability was evaluated in accordance with generation status of fluffs and fiber breakage when 100 kg of the fiber composition was spun to be wound, and was also evaluated in accordance with generation status of fluffs and fiber breakage when 1 kg of the as-spun fibers were further unwound.

[0074] A: Fluffs and fiber breakage were not generated during fiber spinning, as well as during fiber unwinding so that the spinnability was good.

[0075] B: Fluffs and fiber breakage were not generated during fiber spinning but were generated less than two times during fiber unwinding so that the spinnability was good.

[0076] C: Fluffs and fiber breakage were generated less than two times during fiber spinning, and were generated less than five times during fiber unwinding.

[0077] D: Fluffs and fiber breakage were generated three or more times during fiber spinning, and were generated six or more times during fiber unwinding.

[0078] [Knitted Fabric Producibility Evaluation]

[0079] The knitted fabric producibility of the fiber was evaluated in accordance with generation status of fluffs and fiber breakage when 10 kg of the fiber was knitted.

[0080] A: Fluffs and fiber breakage were not generated so that this property was good.

[0081] B: Fluffs and fiber breakage were generated less than two times so that this property was good.

[0082] C: Fluffs and fiber breakage were generated two or more times but less than five times.

[0083] D: Fluffs and fiber breakage were generated six or more times

[0084] [Evaluation of Wearing Feeling]

[0085] Ten panelists each made a sensory evaluation about the wearing feeling of the resultant knitted fabric. In the sensory evaluation, each of the panelists evaluated the fabric by giving two points, one point or zero point when the fabric was very good in wearing feeling, was good in wearing feeling, or was poor in wearing feeling, respectively. The total points thereof were calculated to evaluate the wearing feeling.

[0086] A: The total points were 15 points or more.

[0087] B: The total points were 11 to 14 points.

[0088] C: The total points were 7 to 10 points.

[0089] D: The total points were 6 points or less.

##### Example 2

[0090] The same way as in Example 1 was performed except that the ratio between the components A and B of the composite fiber was changed as shown in Table 1, so as to produce a fiber and a knitted fabric. The evaluations were performed.

[0091] The composite fiber was good in fiber making processability and knitted fabric producing processability, and the resultant knitted fabric was very good in wearing feeling.

##### Example 3

[0092] The same way as in Example 1 was performed except that polylactic acid (6200D, manufactured by Cargill

Dow LLC) was used as the component B of the fiber, so as to produce a fiber and a knitted fabric. The evaluations were performed.

[0093] The composite fiber was good in fiber making processability and knitted fabric producing processability, and the resultant knitted fabric was very good in wearing feeling.

#### Example 4

[0094] The same way as in Example 1 was performed to produce a fiber and a knitted fabric except that the component B was changed into a thermoplastic modified polyvinyl alcohol (manufactured by Kuraray Co., Ltd.; saponification degree: 98.5, ethylene content: 8.0% by mole, and polymerization degree: 380) while using as the component A the same polymer in Example 1, and that the spinning oil was changed into a water-free oil composed of an antistatic agent component and a lubricant component. Thereafter, the knitted fabric was treated in hot water of 100° C. at a bath ratio of 1:30 for 40 minutes so as to dissolve the component B selectively to be removed from the composite fiber fabric.

[0095] The composite fiber was good in fiber making processability and knitted fabric producing processability. The obtained knitted fabric made of polyurethane elastomer monocomponent fibers gave a good wearing feeling.

#### Examples 5 to 6

[0096] The same way as in Example 1 was performed to produce each of the fibers, and each of the knitted fabrics except that a cross-sectional shapes of the fibers were changed as shown in Table 1 so as to make the evaluations.

[0097] In Examples 5 to 6, a non-circular nozzle was used as a spinneret to produce the fiber.

[0098] Both of the examples showed the composite fiber good in fiber making processability and knitted fabric producing processability, and the obtained knitted fabric made of polyurethane elastomer monocomponent fibers was very good in wearing feeling.

#### Comparative Example 1

[0099] The same way as in Example 1 was performed except that the component B shown in Table 1 was not used. The fiber making processability was bad. The obtained knitted fabric made of polyurethane elastomer monocomponent fibers was poor in wearing feeling.

#### Comparative Example 2

[0100] The same way as in Example 1 was performed except that a component A shown in Table 1 was used but no component B was used. The fiber making processability was bad. The obtained knitted fabric made of polyurethane elastomer monocomponent fibers was poor in wearing feeling.

#### Comparative Example 3

[0101] The same way as in Example 1 was performed except that the components A and B were conjugated into a side-by-side composite fiber in which the component A constituted a core and the component B covered 50% of the length of the entire circumference of the component A in a cross section thereof. The resultant fiber was poor in spinnability and knitted fabric producibility. The obtained knitted fabric made of polyurethane elastomer monocomponent fibers was poor in wearing feeling.

#### Comparative Example 4

[0102] The same way as in Example 1 was performed except that the component B shown in Table 1 was not used. The fiber making processability was bad. Furthermore, the obtained elastomer monocomponent fibers were fed to an ordinary single covered yarn producing machine in order to obtain a blended yarn in which each of the elastomer monocomponent fibers was covered with a cotton spun yarn 20/1. However, unwinding of the elastomer monocomponent fibers was insufficiently attained by the adhesion of the fibers to

TABLE 1

	Component A	Component B	A/B	Cross section	Outer-circumference coverage ratio (%) of component B	Spinnability	Knitted fabric producibility	Evaluation of feeling of worn fabric
Example 1	SMP MM-3520	Copolymerized polyester	3/1	FIG. 1	100	A	A	A
Example 2	SMP MM-3520	Copolymerized polyester	4/1	FIG. 1	100	A	A	A
Example 3	SMP MM-3520	Polylactic acid	3/1	FIG. 1	100	A	A	A
Example 4	SMP MM-3520	Modified polyvinyl alcohol	3/1	FIG. 1	100	A	A	A
Example 5	SMP MM-3520	Copolymerized polyester	3/1	FIG. 2	77	B	B	A
Example 6	SMP MM-3520	Copolymerized polyester	3/1	FIG. 3	100	A	B	B
Comparative Example 1	SMP MM-3520	—	—	Circular cross section	0	D	D	D
Comparative Example 2	SMP MM-3520	—	—	Circular cross section	0	D	D	D
Comparative Example 3	SMP MM-3520	Copolymerized polyester	1/1	Side-by-side	50	D	D	D
Comparative Example 4	SMP MM-3520	—	—	Circular cross section	0	D	D	D
Comparative Example 5	SMP MM-3520	—	—	Circular cross section	0	D	D	D

each other, so that the processability was bad. The obtained knitted fabric made of blended yarns was poor in wearing feeling.

#### Comparative Example 5

[0103] The same way as in Example 1 was performed except that the component B shown in Table 1 was not used. The fiber making processability was bad. Furthermore, the obtained elastomer monocomponent fiber was fed to an ordinary single covered yarn producing machine in order to obtain a blended yarn in which each of the elastomer monocomponent fiber was covered with nylon 6 filaments 33T12. However, unwinding the elastomer monocomponent fibers was insufficiently attained by the adhesion of the fibers to each other, so that the processability was bad. The obtained knitted fabric made of blended yarns was poor in wearing feeling.

#### INDUSTRIAL APPLICABILITY

[0104] The composite fiber of the present invention can be used mainly in a long (or continuous) fiber form or a short fiber form. The composite fiber having a long fiber form can be used, alone or as a part, to produce a woven or knitted fabric or the like comprising polyurethane elastomer monocomponent fibers so as to be made into a clothing material providing with a good wearing feeling. This clothing material is suitably used for fields in which a wearing feeling close to human skin is required as a property for the material of underwear. The fiber may be, in a short fiber form, used as staples for clothing, or used for dry nonwoven fabric or wet nonwoven fabric, or for some other. The fiber is high in flexibility in a range of 15 to 50° C., preferably 15 to 45° C., more preferably 15 to 35° C.; thus, the fiber is usable for not only clothing but also for non-clothing, for example, for cleaning fabrics, materials for filters, various residential materials, and industrial materials.

[0105] As described above, the preferred embodiments of the present invention have been described. However, referring to the present specification, those skilled in the art would easily conceive various changes and modifications from the embodiments within a scope self-evident therefrom. Accordingly, such changes and modifications are interpreted to fall within the scope of the present invention, which is specified by the claims.

What is claimed is:

1. A composite fiber comprising:
  - a polyurethane elastomer having a glass transition temperature of 15 to 50° C. as a component A, the component A constituting a core in a cross section of the fiber, and
  - a readily soluble thermoplastic polymer as a component B, the component B covering 70% or longer of the circumference of the component A in the cross section.
2. The composite fiber according to claim 1, wherein the component B comprises at least one selected from the group consisting of a readily soluble polyester and a thermoplastic polyvinyl alcohol-based polymer.
3. The composite fiber according to claim 1, which has a single fiber fineness of 0.3 to 50 dtex.
4. The composite fiber according to claim 1, wherein the composite ratio (mass ratio) of the component A to the component B is 90:10 to 40:60.
5. The composite fiber according to claim 1, which has a core-sheath structure in which the component A is a core component and the component B is a sheath component.
6. A method for producing a polyurethane elastomer fabric, comprising:
  - preparing a composite fiber as claimed in claim 1;
  - producing a fabric comprising the composite fiber by using the composite fiber; and
  - removing the component B from the fabric to produce a polyurethane elastomer fabric comprising a polyurethane elastomer monocomponent fiber.
7. A polyurethane elastomer fabric produced by a method as claimed in claim 6 comprising a polyurethane elastomer monocomponent fiber.
8. The polyurethane elastomer fabric according to claim 7, wherein the fabric comprises a polyurethane elastomer monocomponent fiber having a single fiber fineness of 0.3 to 50 dtex.
9. The polyurethane elastomer fabric according to claim 7, wherein the fabric has a peak value of mechanical dynamic loss tangent ( $\tan \theta$ ) of 0.2 to 1.0.
10. The polyurethane elastomer fabric according to claim 7, wherein the fabric comprises a polyurethane elastomer monocomponent fiber in a continuous fiber form.
11. The polyurethane elastomer fabric according to claim 7, wherein the fabric is a woven or knitted fabric.

\* \* \* \* \*