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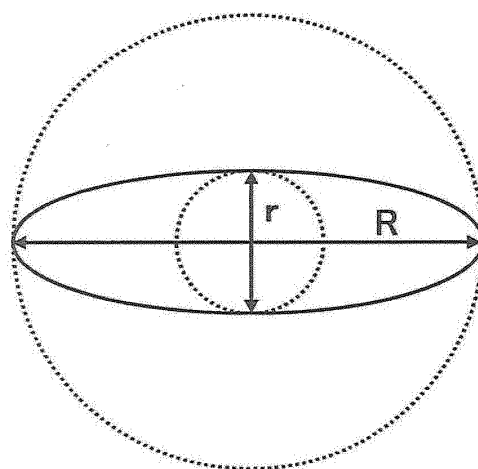
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(54) **MOISTURE ABSORBENT CORE SHEATH COMPOSITE YARN**

(57) A moisture absorbent core sheath composite yarn having a sheath portion polymer that is a polyamide and a core portion that is a thermoplastic polymer, and having a moisture absorbance/desorbance (ΔMR) of 5.0%, wherein the ΔMR maintenance rate after 20 washes is 90%-100%. A core sheath composite fiber having high moisture absorbance, being more comfortable than natural fibers, and having wash resistance with moisture absorbance that stands up to real use and color fastness is provided.

Figure 1



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a moisture absorbent core sheath composite yarn having excellent wash resistance.

BACKGROUND ART

10 **[0002]** Synthetic fibers made of thermoplastic resin such as polyamide or polyester is being widely used for clothing applications or industrial applications because of excellent strength, chemical resistance, heat resistance or the like.

[0003] In particular, polyamide fibers are being widely used for applications such as inner wear or sportswear because of their unique softness, high tensile strength, color development characteristic when dyed, high heat resistance and, in addition, excellent moisture absorbing properties. Polyamide fibers, however, have insufficient moisture absorbing properties as compared with natural fibers such as cotton, and also have a problem that a stuffy or sticky feeling is caused. Therefore, polyamide fibers are inferior to natural fibers in terms of comfortability.

15 **[0004]** In light of such background, there has been required a synthetic fiber that exhibits excellent moisture absorbing and desorbing properties to prevent a stuffy or sticky feeling and provides comfort like natural fibers, primarily in inner wear or sportswear applications.

20 **[0005]** Thus, generally, a method of adding a hydrophilic compound to polyamide fibers has most frequently been investigated. For example, Patent Document 1 proposes a method for improving moisture absorption performance by blending polyvinyl pyrrolidone as a hydrophilic polymer with polyamide and then spinning the blended mixture.

[0006] On the other hand, an intense and ongoing study has been mounted for both moisture absorption performance and mechanical properties by making a fiber structure into a core sheath structure which includes a highly moisture absorbent thermoplastic resin as a core portion and a thermoplastic resin having excellent mechanical properties as a sheath portion.

25 **[0007]** For example, Patent Document 2 discloses a core sheath composite fiber, including: a core portion; and a sheath portion, in which the core portion is not exposed through the surface of the core sheath composite fiber, the core portion is composed of a polyether block amide copolymer, the polyether block amide copolymer having a hard segment composed of nylon 6, the sheath portion is composed of a nylon-6 resin, and the area ratio of the core portion to the sheath portion in a cross section of the core sheath composite fiber is 3/1 to 1/5.

30 **[0008]** Patent Document 3 discloses sheath core type composite fibers excellent in moisture absorbing properties which are made up of a thermoplastic resin as core and fiber-forming polyamide resin as sheath, in which the thermoplastic resin consists mainly of polyether esteramide and the core accounts for 5 to 50% by weight of the whole weight of the final composite fibers.

35 **[0009]** Patent Document 4 discloses a moisture-breathing conjugated fiber in which polyamide or polyester is used as a sheath component and a moisture-absorbing thermoplastic resin constituted with a crosslinked polyethylene oxide is used as a core component.

40 **[0010]** Patent Document 5 discloses a core sheath composite cross-section fiber having excellent antistatic performance, moisture absorption, and cool feeling by contact, which is composed of a core made from a polyether block amide copolymer and a sheath portion made from a fiber-forming polymer such as polyamide or polyester at an exposure angle of the core to the surface of 5° to 90°.

45 **[0011]** Patent Document 6 discloses a flat core sheath composite fiber excellent in moisture absorbing properties, which includes a hydrophilic component such as a polyether ester amide-based compound and a polyether ester-based compound as core and a fiber forming polymer such as polyester as sheath portion, and has a flatness degree of 1.05 to 3.0.

50 **[0012]** As a technique for improving the moisture absorption performance of polyamide fibers, a method of adhering a hydrophilic compound to the surface of the fiber by post processing and impregnating the hydrophilic compound into the fiber is also proposed. The method for improving the moisture absorption performance by post processing, however, arises a problem such that the hydrophilic compound is fallen off by washing, resulting in deterioration of moisture absorption

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performance.

PRIOR ART DOCUMENTS

5 PATENT DOCUMENTS

[0013]

10 Patent Document 1: JP 9-188917 A
 Patent Document 2: WO 2014/10709
 Patent Document 3: JP 6-136618 A
 Patent Document 4: JP 8-209450 A
 Patent Document 5: WO 2008/123586
 Patent Document 6: JP 2000-239918 A

15 SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

20 **[0014]** The fiber disclosed in Patent Document 1, however, has moisture absorbing and desorbing properties that are nearly equal to those of natural fibers, but its performance is not fully satisfactory and higher moisture absorbing and desorbing properties need to be achieved.

25 **[0015]** The core sheath composite fiber disclosed in Patent Documents 2 to 6 has moisture absorbing and desorbing properties that are equal to or higher than those of natural fibers, but the core portion deteriorates in repeated use, which arises a problem such that the moisture absorption performance degrades due to the repeated use. Besides, the high moisture absorbing and desorbing polymer of the core portion has a polymer structure that allows a dye to easily enter and leave, so that its color fastness disadvantageously deteriorates.

30 **[0016]** The core sheath composite fiber disclosed in Patent Document 2 employs nylon 6 in the sheath portion for cool feeling by contact. Such nylon 6 is, however, the same as an ordinary one, and better cool feeling by contact needs to be achieved. The core sheath composite fiber disclosed in Patent Document 5 employs a water-insoluble polyethylene oxide modified product in the core portion for cool feeling by contact. Such modified product is, however, the same as an ordinary polyamide because the fiber has low cool feeling by contact caused by the moisture absorption performance of the core polymer and is covered with the sheath polyamide, so that further cool feeling by contact needs to be achieved. As for the cool feeling by contact, the core sheath composite fiber disclosed in Patent Document 6 provides novel dry texture by a synergetic effect between the increase of the skin contact area by flattening the cross-section fiber and the moisture absorption performance. However, the fiber is covered with sheath polyester, and as compared with general polyester, the fiber provides cool feeling by contact, but inferior to general polyamide. Even in the case where the sheath portion contains polyamide, novel dry texture is obtained by a synergetic effect between the increase of the skin contact area and the moisture absorption performance, but the performance of the fiber is not satisfactory and further cool feeling by contact needs to be achieved.

SOLUTIONS TO THE PROBLEMS

45 **[0017]** In view of overcoming the disadvantages of the conventional technology, an object of the present invention is to provide a core sheath composite yarn having high moisture absorption performance and cool feeling by contact, having a higher comfort than natural fibers, wash resistance with moisture absorption performance that is sufficient for practical use, and wash resistance with color fastness and cool feeling by contact.

[0018] In order to solve the aforementioned task, the present invention is composed of the following components.

- 50 (1) A core sheath composite yarn having a sheath polymer that is a polyamide and a core portion that is a thermoplastic polymer, having a moisture absorbance/desorbance (ΔMR) of 5.0% or more, in which the ΔMR maintenance rate after 20 washes is 90% or more and 100% or less.
- (2) The core sheath composite yarn described in (1) having a washing fastness of grade 3 or higher and grade 5 or lower.
- 55 (3) The core sheath composite yarn described in (1) or (2), wherein the sheath polymer has an α -crystal orientation parameter of polyamide of 1.9 or more and 2.7 or less, and the core thermoplastic polymer is a polyether ester amide copolymer.
- (4) The core sheath composite yarn described in any of (1) to (3), wherein the amount of amino terminal groups in

the sheath polymer of the core sheath composite yarn is 3.5×10^{-5} mol/g or more and 8.0×10^{-5} mol/g or less.

(5) The core sheath composite yarn described in any of (1) to (4), having a flatness degree of 1.5 or more and 5.0 or less.

(6) The core sheath composite yarn described in any of (1), (2) or (4), containing 0.1 to 5% by weight of inorganic particles in the whole fibers.

(7) The core sheath composite yarn described in (6), wherein the sheath polymer has an α -crystal orientation parameter of 1.7 or more and 2.6 or less.

(8) The core sheath composite yarn described in (6) or (7), in which the sheath polymer contains 0.2 to 6% by weight of inorganic particles.

(9) The core sheath composite yarn described in any of (6) to (8), wherein the inorganic particles are titanium oxide.

(10) A fabric having the core sheath composite yarn described in any of (1) to (9) in at least a portion thereof.

EFFECTS OF THE INVENTION

[0019] According to the present invention, a core sheath composite yarn having high moisture absorption performance and cool feeling by contact, having a higher comfort than natural fibers, wash resistance with moisture absorption performance that is sufficient for practical use, and having wash resistance with color fastness and cool feeling by contact can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a schematic view showing a core sheath composite yarn having an I-shaped cross section according to one preferred embodiment of the present invention.

Fig. 2 is a schematic view showing a core sheath composite yarn having a convex lens-shaped cross section according to one preferred embodiment of the present invention.

EMBODIMENTS OF THE INVENTION

[0021] The core sheath composite yarn of the present invention has a sheath polymer that is a polyamide and a core portion that is a thermoplastic polymer, having a moisture absorbance/desorbance (Δ MR) of 5.0% or more, in which the Δ MR maintenance rate after 20 washes is 90% or more and 100% or less.

[0022] The core sheath composite yarn of the present invention employs polyamide in the sheath portion and a thermoplastic polymer in the core portion.

[0023] As the thermoplastic polymer, a known polymer can be used, and in particular, a thermoplastic polymer having high moisture absorption performance is preferable. The thermoplastic polymer having high moisture absorption performance in the core portion refers to a polymer having a moisture absorbance/desorbance (Δ MR) of 10% or more when measured in pellet form, and includes a polyether ester amide copolymer, polyvinyl alcohol, cellulose-based thermoplastic resin, and the like. Among them, a polyether ester amide copolymer is preferable from the viewpoints of good thermal stability, good compatibility with the sheath polyamide, and excellent peeling resistance.

[0024] The polyether ester amide copolymer is a block copolymer having an ether bond, an ester bond, and an amide bond in the same molecular chain. Specifically, it is a block copolymer obtained by polycondensation reaction between one or more polyamide components (A) selected from lactam, amino carboxylic acid, and a diamine/dicarboxylic acid salt; and polyether ester component (B) made of dicarboxylic acid and poly(alkylene oxide) glycol.

[0025] Polyamide component (A) that may be used herein includes lactams such as ϵ -caprolactam, dodecanolactam, and undecanolactam; ω -aminocarboxylic acids such as aminocaproic acid, 11-aminoundecanoic acid, and 12-amino-dodecanoic acid; and nylon salts of diamine-dicarboxylic acid that are precursors of nylon 66, nylon 610, nylon 612 or the like. A preferred polyamide forming component is ϵ -caprolactam.

[0026] Polyether ester component (B) herein is composed of dicarboxylic acid having 4 to 20 carbon atoms and poly(alkylene oxide) glycol. The dicarboxylic acid having 4 to 20 carbon atoms that may be used includes an aliphatic dicarboxylic acid such as succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, sebacic acid, and dodecanoic diacid; an aromatic dicarboxylic acid such as terephthalic acid, isophthalic acid, and 2,6-naphthalenedicarboxylic acid; and an alicyclic dicarboxylic acid such as 1,4-cyclohexanedicarboxylic acid, and one or more kinds thereof may be used in combination. Preferred dicarboxylic acids are adipic acid, sebacic acid, dodecanoic diacid, terephthalic acid, and isophthalic acid. The poly(alkylene oxide) glycol that may be used includes polyethylene glycol, poly(1,2-and 1,3-propyleneoxide)glycol, poly(tetramethyleneoxide)glycol, and poly(hexamethyleneoxide)glycol. In particular, polyethylene glycol having good moisture absorption performance is preferable.

[0027] The poly(alkylene oxide) glycol preferably has a number average molecular weight of 300 to 10000, and more preferably 500 to 5000. When the number average molecular weight is 300 or more, fibers are less scattered away from the system during the polycondensation reaction and have stable moisture absorption performance, which is preferable. On the other hand, when the number average molecular weight is 10000 or less, a uniform block copolymer is obtained

to stabilize fiber forming property, which is preferable.

[0028] The constitutional ratio (molar ratio) of polyether ester component (B) in the polyether ester amide copolymer is preferably from 20 to 80% of all the copolymers. When the constitutional ratio is 20% or more, good moisture absorbing properties are obtained, which is preferable. On the other hand, when it is 80% or less, good color fastness or good wash resistance is obtained, which is preferable.

[0029] As the polyether ester amide copolymer, "MH1657" or "MV1074" manufactured by Arkema K. K. is commercially available.

[0030] As the sheath polyamide, nylon 6, nylon 66, nylon 46, nylon 9, nylon 610, nylon 11, nylon 12, and nylon 612; or a compound having such nylon and an amide-forming functional group, for example, a copolyamide containing a copolymer component such as laurolactam, sebacic acid, terephthalic acid, isophthalic acid, and 5-sodium sulfoisophthalic acid may be used. Among them, nylon 6, nylon 11, nylon 12, nylon 610, and nylon 612 are preferable from the viewpoints that the difference between the melting point of those nylons and the melting point of the polyether ester amide copolymer is small, and thermal deterioration of the polyether ester amide copolymer can be suppressed during melt spinning, and of fiber forming property. Among them, nylon 6 having excellent dyeability is preferable.

[0031] The sheath polyamide of the present invention further preferably contains a moisture absorbent in terms of enhancing moisture absorbing properties. Examples of the moisture absorbent include polyvinyl pyrrolidone, polyether amide, polyalkylene glycol, and polyether ester amide. Among them, polyvinyl pyrrolidone is particularly preferable. The degree of polymerization of the polyvinyl pyrrolidone, which is referred to as K value, is preferably in the range of 20 to 70. The term "K value" herein refers to a relative viscosity obtained by measurement with a capillary viscometer, using a relative viscosity of an aqueous polyvinyl pyrrolidone solution, that is a Fikentscher K value (DIN53726). This value is in correlation with the molecular weight of polyvinyl pyrrolidone and has been conventionally used for measurement of the molecular weight thereof. The K value is preferably 20 or more, because polyamide pyrrolidone is strongly entangled with the polyamide molecular chain to thereby obtain a fiber having stable moisture absorption/release performance. On the other hand, the K value is preferably 60 or less, from the viewpoint of suppressing thickening when polyvinyl pyrrolidone is incorporated in polyamide and of fiber forming property. The K value is more preferably in the range of 20 to 60.

[0032] The content of the polyvinyl pyrrolidone is preferably from 3 to 7% by weight relative to the sheath polyamide. When the content is 3% by weight or more, moisture quickly transfers from a skin to the fiber side during wearing, which can give a dry texture. When the content is 7% by weight or less, clothing having excellent washing fastness and strength sufficient to resist practical use can be provided.

[0033] Various additives such as a delustering agent, flame retardant, antioxidant, ultraviolet absorber, infrared absorber, crystal nucleating agent, fluorescent brightening agent, antistatic agent, and carbon may be copolymerized or mixed with the sheath polyamide of the present invention so that the total content of the additive is in the range of 0.001 to 10% by weight as required.

[0034] The core sheath composite yarn of the present invention has a function of controlling humidity in clothing in order to achieve good comfort in wearing. As an index of the humidity control, a moisture absorbance and desorbance (ΔMR) expressed by the moisture absorption difference between at the temperature and humidity in clothing represented by $30^{\circ}\text{C} \times 90\%\text{RH}$ when light to medium work or light to moderate exercise is performed and at the outside air temperature and humidity represented by $20^{\circ}\text{C} \times 65\%\text{RH}$ is used. The larger ΔMR , the better the moisture absorption performance, which corresponds to good comfort in wearing.

[0035] The core sheath composite yarn of the present invention preferably has a ΔMR of 5.0% or more, more preferably 7.0% or more, even more preferably 10.0% or more, and even more preferably 15.0% or more. When the ΔMR is within such range, clothing capable of suppressing sweating and stickiness in wearing and having excellent comfort can be provided. Note that the ΔMR level that can be achieved by the present invention is about 17.0%.

[0036] A moisture absorbance and desorbance (ΔMR) of 5.0% or more can be achieved by using a polymer having a ΔMR of 10% or more, which has been measured in pellet form.

[0037] As for the core sheath composite yarn of the present invention, the ΔMR maintenance rate after 20 washes is preferably 90% or more and 100% or less, and more preferably 95% or more and 100% or less. When the ΔMR maintenance rate is in such range, the wash resistance sufficient for practical use is obtained, so that clothing that maintains excellent comfort can be provided. Further, clothing having wash resistance sufficient for practical use and excellent comfort can be provided by satisfying the conditions such that ΔMR is 5.0% or more and the ΔMR maintenance rate after 20 washes is 90% or more.

[0038] It is possible for the core sheath composite yarn to have a ΔMR maintenance rate after 20 washes in the range of 90% or more and 100% or less by setting an α -crystal orientation parameter of the sheath polyamide to be described

later to an optimum value.

[0039] By having a ΔMR within such range, the core sheath composite yarn of the present invention can exhibit antistatic performance with less static cling or less dust adhesion in wearing due to static electricity. That is, since it is a yarn in which a thermoplastic polymer having high moisture absorption performance in the core portion is continuously arranged in a fiber axis direction, the yarn exhibits antistatic action that uses moisture in air, so that good antistatic performance is obtained even under a low temperature and low humidity (e.g., $20^{\circ}\text{C} \times 40\%\text{RH}$) environment.

[0040] The core sheath composite yarn of the present invention preferably has a frictional electrification voltage of 0 V or more and 1500 V or less, and more preferably 0 V or more and 1000 V or less, with a rubbing cloth of cotton under a $20^{\circ}\text{C} \times 40\%\text{RH}$ environment. The lower the frictional electrification voltage, the more excellent the antistatic performance. Common polyamide fibers, however, have a frictional electrification voltage of about 4500 to 5500 V, with a rubbing cloth of cotton under a $20^{\circ}\text{C} \times 40\%\text{RH}$ environment. When the frictional electrification voltage is within such range, clothing having excellent antistatic performance with less static cling or dust adhesion in wearing due to static electricity, that is, a clothing having excellent comfort can be provided.

[0041] The core sheath composite yarn of the present invention preferably has a washing fastness (discoloration, color fading) of grade 3 or higher and grade 5 or lower. When the washing fastness is within such range, wash resistance sufficient for practical use is obtained, which makes it possible to provide clothing having excellent color fastness.

[0042] It is possible for the core sheath composite yarn to have a washing fastness (discoloration, color fading) of grade 3 or higher and grade 5 or lower by setting an α -crystal orientation parameter of the sheath polyamide and an amount of amino terminal groups in the sheath polymer, both to be described later, to optimum values.

[0043] In the core sheath composite yarn of the present invention, it is preferable that the sheath polyamide has an α -crystal orientation parameter of 1.9 or more and 2.7 or less, and the core thermoplastic polymer is a polyether ester amide copolymer. The sheath polyamide is preferably an α -crystal in stable crystal form, and is formed when highly stressed. In order to set the parameter within such range, the core sheath composite yarn is spun under the specific conditions (core and sheath composition ratio, viscosity ratio, etc.) as described later, and drawing at the time of taking up after spinning and drawing of the sheath portion between take-up rollers are preferentially applied to the sheath polyamide, thereby allowing the α -crystal in stable crystal form to be present in the sheath portion. As a result of this, the dyeing strength after dyeing of the core sheath composite yarn is increased, and color fastness becomes better. Besides, the drawn force during spinning is concentrated on the sheath polyamide, and crystallization of the thermoplastic polymer having high moisture absorption performance in the core portion is suppressed, so that the moisture absorption performance of the core sheath composite yarn can be enhanced, which is preferable.

[0044] When the core thermoplastic polymer is a polyether ester amide copolymer, the polyether ester component easily forms a localized structure due to crystallization and the localized portion has poor durability against an alkaline liquid. Therefore, when the α -crystal orientation parameter of the sheath polyamide is in such range and the crystallization of the polyether ester amide copolymer in the core portion is suppressed, wash resistance with moisture absorption performance that is sufficient for practical use can be exhibited.

[0045] When the α -crystal orientation parameter is 1.9 or more, crystallization of the sheath polyamide proceeds to achieve good color fastness as a composite yarn, and crystallization of the core thermoplastic polymer having high moisture absorption performance does not proceed to achieve good moisture absorption performance. Further, in the case of a polyether ester amide copolymer, crystallization does not proceed, so that wash resistance with moisture absorption performance that is sufficient for practical use becomes good. On the other hand, when the α -crystal orientation parameter is 2.7 or less, crystallization of the sheath polyamide does not proceed, which can prevent the occurrence of yarn breakage or fluffing during spinning, so that productivity improves. The α -crystal orientation parameter is more preferably 2.00 or more and 2.60 or less, and even more preferably 2.05 or more and 2.60 or less.

[0046] In the core sheath composite yarn of the present invention, the amount of amino terminal groups in the sheath polymer is preferably 3.5×10^{-5} mol/g or more and 8.0×10^{-5} mol/g or less. It is preferable that when the amount of amino terminal groups rich in hydrophilicity is 3.5×10^{-5} mol/g or more, the moisture absorption performance is enhanced. Further, since the amino terminal group serves as a dyeing seat, color development characteristic or color fastness suitable for use in clothing is obtained. On the other hand, the amount of amino terminal groups is preferably 8.0×10^{-5} mol/g or less, because the fiber is less likely to have dyeing specks during dyeing. The amount of amino terminal groups is more preferably 4.2×10^{-5} mol/g or more and 8.0×10^{-5} mol/g or less, and even more preferably 4.5×10^{-5} mol/g or more and 8.0×10^{-5} mol/g or less.

[0047] Since the core sheath composite yarn of the present invention employs a thermoplastic polymer having high moisture absorption performance in the core portion, thermal conductivity can be enhanced, which makes it easier for the core sheath composite yarn to exhibit cool feeling by contact than polyamide yarns alone. The cool feeling by contact depends on the heat transfer rate per unit area obtained when the amount of heat stored on the skin side immediately after the fiber contacts a skin is transferred to the fiber on the lower temperature side. Polyamide is an organic matter with relatively low thermal conductivity and does not impart cool feeling by contact even when worn directly to the skin as clothing. In order to enhance actual cool feeling by contact, the cross section having a larger contact area is formed,

and an additive having high thermal conductivity is contained, so that clothing excellent in cool feeling by contact as well as moisture absorption performance and maintaining better comfort can be provided.

[0048] The core sheath composite yarn of the present invention preferably has a flat cross sectional shape and a flatness degree of 1.5 or more and 5.0 or less.

[0049] Since the cool feeling by contact depends on the heat transfer rate per unit area, the amount of heat to be transferred depends on the contact area. Therefore, the flatness degree of an I shape (Fig. 1), a convex cross sectional shape (Fig. 2), or a similar cross sectional shape, which is a cross sectional shape having a large contact area, is preferably 1.5 or more. The term "flatness degree" used herein means a ratio of the circumscribed circle diameter (R in Fig. 1, Fig. 2) to the inscribed circle diameter (r in Fig. 1, Fig. 2). The higher the flatness degree, the more effective the cool feeling by contact. The flatness degree is more preferably 2.0 or more. On the other hand, as the flatness degree becomes high, the thread strength tends to lower, so that the flatness degree needs to be 5.0 or less.

[0050] The core sheath composite yarn of the present invention preferably contains 0.1 to 5% by weight of inorganic particles in the whole fibers. Since the cool feeling by contact is obtained when the amount of heat stored on the skin side immediately after the fiber contacts a skin is transferred to the fiber on the lower temperature side, an inorganic compound having higher thermal conductivity and lower thermal capacity than polyamide is preferably contained in an amount of 0.1 to 5% by weight in the whole fibers.

[0051] In the present invention, reasons for selecting the inorganic compound include to prevent adverse influence during production or dyeing of the core sheath composite yarn, to maintain yarn properties, and to avoid coloring or the like due to the polymer when used, which is light fastness. The inorganic compound is not particularly limited as long as such adverse influences are not exerted on the core sheath composite yarn. Examples of the inorganic compound having higher thermal conductivity and lower thermal capacity than polyamide include barium sulfate, titanium oxide, aluminum oxide, zirconium oxide, calcium oxide, magnesium oxide, aluminum nitride, boron nitride, zirconium nitride, aluminum silicate, and zirconium carbide. Among these, barium sulfate, titanium oxide, magnesium oxide, and aluminum oxide are preferable, in consideration of fiber properties, color development characteristic, easy handling of inorganic particles, and high degree of processability.

[0052] The content of the inorganic compound is preferably 0.1% by weight or more in the whole fibers because few inorganic compound cannot increase the thermal conductivity, which makes it difficult to enhance the cool feeling by contact. Besides, the larger amount of inorganic compound, the more the cool feeling by contact was enhanced, but the tensile strength of the yarn properties lowers, and the high degree of processability deteriorates. Therefore, the inorganic compound is preferably contained in an amount of 5% by weight or less, more preferably 0.3 to 3% by weight, and even more preferably 0.3 to 2.0% by weight.

[0053] As described above, the cool feeling by contact depends on the heat transfer rate per unit area obtained when the amount of heat stored on the skin side immediately after the fiber contacts a skin is transferred to the fiber on the lower temperature side. In the case of the core sheath composite yarn of the present invention, it is preferable that immediately after the core sheath composite yarn contacts a skin, the amount of heat stored on the skin side transfers to the sheath portion thereof on the lower temperature side and subsequently transfers to the sheath portion thereof on the lower temperature side. Since the sheath polyamide has low thermal conductivity, it does not impart cool feeling by contact even when worn directly to the skin as clothing, and heat transfer is not performed smoothly to the polyether ester amide copolymer of the core portion.

[0054] Thus, the sheath polyamide preferably contains 0.2 to 6% by weight of an inorganic compound having higher thermal conductivity and lower thermal capacity than polyamide. By such constitution, heat from a skin is quickly transferred to the core sheath composite yarn side in wearing, and further, heat transfer from the sheath polyamide of the core sheath composite yarn to the polyether ester amide copolymer of the core portion is smoothly performed, to thereby obtain cool feeling by contact. The more the content of the inorganic compound, the higher the cool feeling by contact can be enhanced. However, in consideration of the effectiveness of cool feeling by contact, fiber forming property, yarn properties or the like, the sheath polyamide more preferably contains 0.2 to 3% by weight of the inorganic compound.

[0055] In the core sheath composite yarn of the present invention which contains 0.1 to 5% by weight of inorganic particles in the whole fibers, the sheath polyamide preferably has an α -crystal orientation parameter in the range of 1.7 to 2.6. The α -crystal in the sheath polyamide is in stable crystal form, being formed when highly stressed during production of the core sheath composite yarn. In order to set the parameter within such range, the core sheath composite yarn is spun under the specific conditions (core and sheath composition ratio, viscosity ratio, etc.) as described later, and drawing at the time of taking up after spinning and drawing of the sheath portion between take-up rollers are preferentially applied to the sheath polyamide, thereby allowing the α -crystal in stable crystal form to be present in the sheath portion.

[0056] By setting the α -crystal orientation parameter of the sheath polyamide in such range, the dyeing strength after dyeing of the core sheath composite yarn is increased, and color fastness becomes better, as well as the drawing force during spinning is concentrated on the sheath polyamide, and the crystallization of the polyether ester amide copolymer in the core portion is suppressed, so that a core sheath composite yarn having excellent moisture absorption performance and excellent cool feeling by contact is obtained. Further, it is possible to suppress crystallization of the polyether ester

amide copolymer in the core portion, which can prevent a localized structure from generating due to the crystallization of the polyether ester component of the core portion, so that the durability against alkaline liquid can be maintained, and moisture absorption performance or cool feeling by contact can be kept even after washing.

[0057] When the sheath polyamide has an α -crystal orientation parameter of 1.7 or more, crystallization of the sheath polyamide proceeds to achieve good color fastness of the core sheath composite yarn, and crystallization of the polyether ester amide copolymer in the core portion does not proceed to achieve good moisture absorption performance and good cool feeling by contact. Further, since the crystallization of the polyether ester amide copolymer of the core portion does not proceed, moisture absorption performance or cool feeling by contact can be kept even after washing. On the other hand, when the sheath polyamide has an α -crystal orientation parameter of 2.6 or less, crystallization of the sheath polyamide does not proceed, which can prevent the occurrence of yarn breakage or fluffing during a high degree of processing, so that productivity improves. The α -crystal orientation parameter is more preferably 1.8 to 2.5, and even more preferably 1.85 to 2.5.

[0058] The core sheath composite yarn of the present invention preferably has a tensile strength of 2.5 cN/dtex or more, and more preferably 3.0 cN/dtex or more. When the tensile strength is within such range, clothing excellent in strength sufficient for practical use can be provided mainly for use in clothing including inner wear and sportswear.

[0059] The core sheath composite yarn of the present invention preferably has an elongation percentage of 35% or more, and more preferably from 40 to 65%. When the elongation percentage is within such range, the process passability in a high-degree process such as weaving, knitting, and false twist becomes good.

[0060] The total fineness and the number of filaments of the core sheath composite yarn of the present invention are not particularly limited, and it is preferable that the total fineness of the yarn as a multifilament is 5 dtex or more and 235 dtex or less, and the number of filaments is 1 or more and 144 or less, in view of that the yarn is used as long fiber material for clothing.

[0061] The core sheath composite yarn of the present invention can be obtained by a known method of melt spinning or composite spinning and the method is exemplified as follows.

[0062] For example, polyamide (sheath) and a thermoplastic polymer (core) having high moisture absorption performance are separately melted, and the melted components are weighed and transferred with a gear pump. Then, a combined flow is formed so as to have a core sheath structure directly by a usual method and a thread is discharged from a spinneret. With a thread cooling device such as a chimney, the thread is cooled to room temperature by blowing out cool air, and is oiled with an oiling device and also bound. Thereafter, the bound thread is interlaced with a first fluid interlacing nozzle device, and passes through a take-up roller and a drawing roller. At this time, the thread is drawn at a peripheral speed rate of the take-up roller to the drawing roller. Further, the thread is thermoset with the drawing roller, and then wound up with a winder (a take-up device).

[0063] It is possible to set the α -crystal orientation parameter of the sheath portion of the core sheath composite yarn according to the present invention within such range by controlling the core sheath composite rate during spinning, core sheath polymer viscosity, drawing process, or the like, in addition to polymer selection.

[0064] The core portion needs to account for 20 to 80 parts by weight of 100 parts by weight of the core sheath composite yarn of the present invention. The core portion more preferably accounts for 30 to 70 parts by weight. When the proportion is within such range, drawing can be suitably applied to the sheath polyamide. Besides, good color fastness and good moisture absorption performance are obtained. When the proportion is less than 20 parts by weight, sufficient moisture absorption performance cannot be obtained. On the other hand, when the proportion exceeds 80 parts by weight, not only a split is likely to occur in the surface of the fiber due to swelling in a hot water atmosphere such as dyeing, but also excessive drawing is applied to the sheath polyamide, so that a desired α -crystal orientation parameter cannot be obtained. Besides, spinning and drawing that generate excessive tension lead to occurrence of yarn breakage or fluffing, which is not preferable to stably produce desired fibers.

[0065] A polyamide chip to be used in the sheath portion of the present invention needs to have a sulfuric acid relative viscosity of 2.3 or more and 3.3 or less. The sulfuric acid relative viscosity is preferably 2.6 or more and 3.3 or less. When it is within such range, drawing can be suitably applied to the sheath polyamide. When the sulfuric acid relative viscosity is 2.3 or more, not only practical strength of the raw yarn is obtained, but also suitable drawing is applied to proceed crystallization of the sheath polyamide, so that a proper α -crystal orientation parameter is obtained, and color fastness is improved, which is preferable. On the other hand, when the sulfuric acid relative viscosity is 3.3 or less, which is a melt viscosity suitable for spinning, the yarn can be produced at a spinning temperature suitable for the core thermoplastic polymer having high moisture absorption performance, which is preferable.

[0066] A chip of the thermoplastic polymer having high moisture absorption performance to be used in the core portion of the present invention preferably has an ortho-chlorophenol relative viscosity of 1.2 or more and 2.0 or less. When the ortho-chlorophenol relative viscosity is 1.2 or more, suitable drawing is applied to the sheath portion to proceed crystallization of the sheath polyamide, so that a proper α -crystal orientation parameter is obtained, and yarn breakage or fluffing less occurs, which is preferable. On the other hand, when the ortho-chlorophenol relative viscosity is 2.0 or less, excessive drawing is not applied to the core portion, to thereby proceed the crystallization of the sheath polyamide, so

that a proper α -crystal orientation parameter is obtained, and color fastness is improved, which is preferable.

[0067] In the drawing process, the spinning conditions are preferably set so that the product of the drawing ratio, which is a value of the peripheral speed rate of the take-up roller and the drawing roller, and the speed (spinning speed) of the thread taken up with the take-up roller is 3300 m/min or more and 4500 m/min or less. The product is more preferably 3500 m/min or more and 4500 m/min or less, and even more preferably 4000 m/min or more and 4500 m/min or less. Such numerical values refer to the total drawn amount in which the polymer discharged from the spinneret is drawn from the spinneret linear discharge rate to the peripheral speed of the take-up roller and further from the peripheral speed of the take-up roller to the peripheral speed of the drawing roller. When it is within such range, drawing can be suitably applied to the sheath polyamide. When it is 3300 m/min or more, not only crystallization of the sheath polyamide proceeds to improve color fastness, but also crystallization of the core thermoplastic polymer having high moisture absorption performance does not proceed to easily improve the moisture absorption performance. On the other hand, when it is 4500 m/min or less, not only crystallization of the sheath polyamide moderately proceeds to achieve a specific degree of crystallization, but also yarn breakage or fluffing during spinning less occurs, which is preferable.

[0068] In the oiling process, the spinning lubricant applied with the oiling device is preferably an anhydrous lubricant. The core thermoplastic polymer having high moisture absorption performance is a polymer having a ΔMR of 10% or more and excellent in moisture absorption performance. In the case where an anhydrous lubricant is applied thereto, the polymer gradually absorbs moisture in the air, so that swelling is less prone to occur and stable winding is achieved, which is preferable.

[0069] In the core sheath composite yarn of the present invention, the content of inorganic particles is preferably from 0.1 to 5% by weight in the whole fibers. In order to control inorganic particles within such range, inorganic particles are contained in either or both of the sheath polyamide and the core polyether ester amide copolymer, so that the control is achieved.

[0070] In order to enhance the cool feeling by contact, it is preferable that immediately after the core sheath composite yarn contacts a skin, the amount of heat stored on the skin side transfers to the sheath portion of the core sheath composite yarn on the lower temperature side and subsequently transfers to the core portion thereof on the lower temperature side, so that the cool feeling by contact is further enhanced. That is, it is preferable that inorganic particles are contained in the sheath polyamide. In this case, it is preferable that the sheath polyamide contains 0.2 to 6% by weight of inorganic particles. Within such range, heat from a skin is quickly transferred to the core sheath composite yarn side in wearing, and further, heat transfer from the sheath polyamide of the core sheath composite yarn to the polyether ester amide copolymer of the core portion is smoothly performed, so that cool feeling by contact can be maintained even after washing. The more the content of inorganic particles in the core portion, the higher the cool feeling by contact can be enhanced. However, in terms of the effectiveness of cool feeling by contact, high degree of processability, yarn properties or the like, the core portion more preferably contains 0.2 to 3% by weight of inorganic particles.

[0071] As a method of uniformly containing inorganic particles in a polyamide (sheath) and a thermoplastic polymer (core) such as a polyether ester amide copolymer or the like at a high concentration, a method of blending inorganic particles with pellets and melting the blended mixture; a method of blending master pellets containing inorganic particles at a high concentration with pellets and melting the blended mixture; a method of adding inorganic particles to a polymer in molten state and then kneading the added mixture; or a method of adding inorganic particles to raw materials or a reaction system before or during polymerization of a polymer may be used. In order to uniformly disperse inorganic particles while a secondary aggregation of inorganic particles added at a high concentration is suppressed, a method of adding inorganic particles during polymerization of a polymer is particularly preferable.

[0072] The core sheath composite yarn of the present invention is excellent in moisture absorption performance and cool feeling by contact, and can be preferably used in clothing. The fabric form can be selected according to the purpose such as woven fabric, knitted fabric, and non-woven fabric. As described above, the larger ΔMR , the better the moisture absorption performance, which corresponds to good comfort in wearing. Therefore, fabric having the core sheath composite yarn of the present invention in at least a portion thereof can provide clothing having excellent comfort by adjusting the mixing ratio of the core sheath composite yarn of the present invention so as to have a ΔMR of 5.0% or more. Also, as described above, cool feeling by contact corresponds to smooth heat transfer that is performed immediately after the fiber contacts a skin. Accordingly, by designing fabric which allows the core sheath composite yarn of the present invention to contact a skin, clothing having excellent comfort can be provided. As the clothing, various clothing products such as inner wear, sportswear, and the like can be provided.

EXAMPLES

[0073] Hereinafter, the present invention will be further described in detail with reference to examples. The measurement methods for the characteristic values in examples are as follows.

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(1) Sulfuric Acid Relative Viscosity

[0074] A test sample in an amount of 0.25 g was dissolved in a 98 wt% concentrated sulfuric acid so as to achieve 1 g/100 ml, and a time (T1) taken for the solution to flow through at 25°C was measured using an Ostwald viscometer. Subsequently, a time (T2) taken for the 98 wt% concentrated sulfuric acid alone to flow through was measured. A rate of T1 to T2, that is T1/T2, was determined as a sulfuric acid relative viscosity.

(2) Ortho-Chlorophenol Relative Viscosity

[0075] A test sample in an amount of 0.5 g was dissolved in ortho-chlorophenol so as to achieve 1 g/100 ml, and a time (T1) taken for the solution to flow through at 25°C was measured using an Ostwald viscometer. Subsequently, a time (T2) taken for the ortho-chlorophenol alone to flow through was measured. A rate of T1 to T2, that is T1/T2, was determined as a sulfuric acid relative viscosity.

(3) K Value

[0076] An aqueous solution of polyvinyl pyrrolidone having a concentration of 1% was made, the relative viscosity of the solution was measured, and a K value was determined by the Fikentscher's equation.

$$\log Z = C[75k^2/(1 + 1.5kC) + k]$$

wherein Z represents a relative viscosity of the aqueous solution having a concentration of C; k represents K value $\times 10^{-3}$; and C represents a concentration of the aqueous solution (%).

(4) Degree of Fineness

[0077] A fiber sample was placed on a measuring device having 1.125 m/turn and was rotated 200 turns to produce a looped hank. After the looped hank was dried with a hot air dryer ($105 \pm 2^\circ\text{C} \times 60 \text{ min}$), the mass of the hank was weighed with a balance and multiplied by the official moisture percentage to obtain the degree of fineness. Note that the official moisture percentage of the core sheath composite yarn was 4.5%.

(5) Strength and Elongation Percentage

[0078] The fiber sample was measured under the constant-speed elongation conditions specified in JIS L1013 (Testing methods for man-made filament yarns, 2010) with "TENSILON" (registered trademark) UCT-100 manufactured by Orientec (KK) company. The elongation percentage was determined from the elongation at a point indicating the maximum strength in the tensile strength-elongation curve. The strength was determined as a value obtained by dividing the maximum strength by the degree of fineness. The measurement was done 10 times and the average value was determined as strength and elongation percentage.

(6) Cross Sectional Shape

[0079] An embedding agent composed of paraffin, stearic acid, and ethyl cellulose was dissolved, and the core sheath composite yarn was introduced therein. Thereafter, the dissolved mixture was left alone at room temperature to be solidified. The undrawn yarn in the embedding agent was cut in a direction of the cross section, the cross section of the cut yarn was photographed with a CCD camera (CS5270) manufactured by Tokyo Electronic Co., Ltd. Then, as for 10 core sheath composite yarns arbitrarily selected from the single yarns (all of the single yarns when the number thereof was 10 or less), the flatness degrees of all the single yarns from the sectional pictures printed out at a magnification of 400 times with a color video processor (SCT-CP710) manufactured by Mitsubishi Electric Corporation were calculated according to the following method, and an average value thereof was determined as a flatness degree of the yarn thread.

$$\text{Flatness degree} = \frac{\text{circumscribed circle diameter}}{\text{inscribed circle diameter (r)}}$$

(7) α -Crystal Orientation Parameter

[0080] A fiber sample was measured by a laser Raman spectroscopy, and a ratio of the Raman band intensity in parallel polarization ((I1120) parallel) to the Raman band intensity in orthogonal polarization ((I1120) orthogonal), the Raman band being derived from α -crystal of nylon found near 1120 cm^{-1} , was obtained. The obtained value was used as a parameter for evaluation of orientation degree. Based on the Raman band intensity of the CH bending band (near 1440 cm^{-1}) with a small anisotropy of orientation, a scattering intensity for every polarization condition (parallel/orthogonal) is normalized.

$$\alpha\text{-crystal orientation parameter} = (I_{1120}/I_{1440})_{\text{parallel}} / (I_{1120}/I_{1440})_{\text{orthogonal}}$$

[0081] The test sample for orientation measurement was embedded in a resin (a bisphenol epoxy resin, cured for 24 hours) and then sectioned with a microtome. The sectioned sample had a thickness of $2.0\text{ }\mu\text{m}$. The sectioned sample was then cut slightly at an angle from the fiber axis so that the cut surface had an elliptical shape, and a portion where the short axis of the ellipse had a constant thickness was selected and then measured. The measurement was conducted in microscope mode, and the laser spot diameter at the position of the sample was $1\text{ }\mu\text{m}$. An orientation analysis was conducted at the core, the center portion of the sheath layer, and the orientation was measured under the polarization conditions. The polarization conditions are determined as parallel conditions when the polarizing direction agrees with the fiber axis, and vertical conditions when it is orthogonal to the fiber axis. Then, the extent of the orientation was evaluated by the Raman band intensity ratio obtained from those conditions. Note that measurement was done by $n=3$ at each of the measurement points. The detailed conditions are listed below.

Laser Raman spectroscopy

[0082]

Apparatus: T-64000 (Jobin Yvon/Atago Bussan K. K.)
 Conditions: Measurement mode; Microscopic Raman
 Objective lens; $\times 100$
 Beam diameter; $1\text{ }\mu\text{m}$
 Light source; Ar + laser/ 514.5 nm
 Laser power; 50 mW
 Diffraction grating; Single 600 gr/mm
 Slit; $100\text{ }\mu\text{m}$
 Detector; CCD/Jobin Yvon 1024×256

(8) Amount of Amino Terminal Groups in Sheath Polymer Chip

[0083] One gram of a test sample was dissolved in 50 ml of a phenol/ethanol mixing solution (phenol/ethanol = 80/20) by shaking at 30°C to give a solution. This solution was subjected to neutralization titration with 0.02 N hydrochloric acid, and the amount of 0.02 N hydrochloric acid used was determined. Besides, the above mentioned phenol/ethanol mixing solvent (in the same amount as above) alone was subjected to neutralization titration with 0.02 N hydrochloric acid, and the amount of 0.02 N hydrochloric acid used was determined. Then, the amount of amino terminal groups per 1 g of the test sample was determined from the difference between those hydrochloric acid amounts.

[0084] (9) Amount of Amino Terminal Groups in Sheath Polymer of Core Sheath Composite Yarn

A. Measurement of Weight Ratio of Sheath Portion

[0085] An embedding agent composed of paraffin, stearic acid, and ethyl cellulose was dissolved, and the core sheath composite yarn was introduced therein. Thereafter, the dissolved mixture was left alone at room temperature to be solidified. The undrawn yarn in the embedding agent was cut in a direction of the cross section, the cross section of the cut yarn was photographed with a CCD camera (CS5270) manufactured by Tokyo Electronic Co., Ltd. Then, as for 10 core sheath composite yarns arbitrarily selected from the single yarns (all of the single yarns when the number thereof was 10 or less), the sectional pictures printed out at a magnification of 1500 times with a color video processor (SCT-CP710) manufactured by Mitsubishi Electric Corporation were cut out to give a sheath portion and a core portion. The

weights of these portions were measured and the weight ratio of the sheath portion was calculated by the following equation.

$$\begin{aligned} \text{Weight ratio of sheath portion} &= (\text{weight of sheath} \\ &\text{portion} / (\text{weight of sheath portion} + \text{weight of core portion})) \\ &\times 100 \end{aligned}$$

B. Amount of Amino Terminal Groups in Core Sheath Composite Yarn

[0086] The amount of amino terminal groups was determined by the method described in (8) above.

C. Amount of Amino Terminal Groups in Sheath Polymer

[0087] The amount of amino terminal groups in the sheath polymer was calculated by multiplying the amount of amino terminal groups obtained in the above B by the weight ratio of the sheath portion obtained in the above A.

$$\begin{aligned} \text{Concentration of Amino Terminal Groups in Sheath Polymer} \\ &= \text{Amount of amino terminal groups in core sheath composite yarn} \\ &\times \text{weight ratio of sheath portion} / 100 \end{aligned}$$

(10) Production of Circular Knitted Fabric

A. Production of Circular Knitted Fabric

[0088] Circular knitted fabric was produced by adjusting the density to 50 with a circular knitting machine. When the degree of fineness based on corrected mass of the fiber is low, doubling was appropriately performed so that the yarn fed to the circular knitting machine had a total fineness in the range of 50 to 100 dtex. When the total fineness exceeded 100 dtex, a single yarn was fed to the circular knitting machine and circular knitted fabric was produced by adjusting the density to 50 as described above.

B. Refining of Circular Knitted Fabric

[0089] An aqueous solution containing 2 g/l of a nonionic surfactant (manufactured by DKS Co., Ltd., NOIGEN SS) was prepared in an amount of 100 ml relative to 1 g of knitted fabric, and the circular knitted fabric obtained in A above was washed at 60°C for 30 minutes. Thereafter, the washed fabric was washed with running water for 20 minutes, dewatered with a dewaterer, and air-dried.

C. Dyeing of Circular Knitted Fabric

[0090] The circular knitted fabrics obtained in A and B above were dyed using the following dye and dyeing assistant auxiliaries.

Acid dye: Erionyl Blue A-R 2.0% by mass

Dyeing assistant auxiliaries: Acetic acid 1.5%

[0091] The knitted fabric was dyed in a dye bath containing acid dye and dyeing assistant auxiliaries set at 98°C under normal pressure for 45 minutes. Thereafter, the dyed fabric was washed with running water for 20 minutes, dewatered with a dewaterer, and air-dried.

(11) Color Development Characteristic

[0092] The color development characteristic of the dyed circular knitted fabric obtained in (10) C was evaluated by the following four grades.

S: Uniformly colored in dark as a whole.

[0093]

A: Uniformly colored in medium (light to dark) to dark as a whole.

B: Uniformly colored in light to medium (light to dark) as a whole.

C: Uniformly colored in light as a whole.

(12) Moisture Absorbance and Desorbance (ΔMR)

[0094] About 1 to 2 g of circular knitted fabric (10) A was weighed in a weighing tube, the weighed fabric was kept at 110°C for two hours to be dried, and the weight of the dried fabric was measured (W_0). Next, the object substance was kept at a temperature of 20°C and a relative humidity of 65% for 24 hours, and the weight thereof was then measured (W_{65}). The measured substance was kept at a temperature of 30°C and a relative humidity of 90% for 24 hours, and the weight thereof was then measured (W_{90}). Calculation was made by the following equation.

$$MR1 = [(W_{65} - W_0) / W_0] \times 100\% \dots\dots (1)$$

$$MR2 = [(W_{90} - W_0) / W_0] \times 100\% \dots\dots (2)$$

$$\Delta MR = MR2 - MR1 \dots\dots (3)$$

(13) ΔMR After Washing

[0095] After circular knitted fabric (10) A was repeatedly washed 20 times by the method described in No. 103 specified in Appendix 1 of JIS L0217 (1995), the moisture absorbance and desorbance described above was measured and calculated.

In the case where ΔMR was 5.0% or more, it was judged that good wearing comfort was obtained.

(14) ΔMR Maintenance(Retention:in Tables 1-10) Rate After Washing

[0096] As an index showing change in ΔMR before and after washing, the ΔMR maintenance rate after washing was calculated by the following expression.

$$\Delta MR \text{ after washing treatment} / \Delta MR \text{ before washing treatment} \\ \times 100$$

In the case where the ΔMR maintenance rate was 90% or more, the wash resistance was judged as good.

(15) Washing Fastness

[0097] Dyed circular knitted fabric (10) C was measured under the A-2 condition in Table 7 in accordance with A method specified in JIS L0844 (2011) 7.1. Judgement was made about discoloration and color fading in a grade evaluation in accordance with 10 (a) visual method specified in JIS L0801 (2011). When both of discoloration and color fading were judged as grade 3 or higher, the washing fastness was determined as pass, and when at least one of discoloration and color fading was judged as grade 2-3 or lower, the washing fastness was determined as failure.

(16) Overall Evaluation

[0098] The washing fastness, Δ MR after washing, and Δ MR maintenance rate after washing were evaluated in the following three levels.

S: All of three criteria such that washing fastness discoloration and contamination are both evaluated as grade 4 or higher, Δ MR after washing is 7.0% or higher, and Δ MR maintenance rate after washing is 95% or higher apply.

A: All of three criteria apply such that washing fastness discoloration and contamination are both evaluated as grade 3 or higher, Δ MR after washing is 5.0%, and Δ MR maintenance rate after washing is 90% or higher.

C: One or more criteria of three criteria such that washing fastness discoloration and contamination are both evaluated as grade 2-3 or lower, Δ MR after washing is less than 5.0%, and Δ MR maintenance rate after washing is less than 90% apply. S and A were determined as "pass" because of a higher comfort than natural fibers and excellent wash resistance sufficient for practical use

(17) Cool Feeling by Contact (q-max)

[0099] The cool feeling by contact was evaluated by an evaluated coldness/warmth feeling value (q-max) obtained by measuring coldness/warmth feeling using Thermolabo IIB type precise rapid thermal properties measurement apparatus KES-F7 (manufactured by Kato Tech Co., Ltd.) . The q-max value refers to a measured value (unit: W/cm²) of a peak heat flux, in which heat is stored in a pure copper plate, and immediately after the plate contacts a surface of a test sample, the amount of heat stored transfers to the sample body on the lower temperature side.

[0100] Circular knitted fabric (10) A and the apparatus (KES-F7 THERMO LABO IIB TYPE (manufactured by Kato Tech Co., Ltd.)) were left alone overnight in a room adjusted to a room temperature of 20°C and a relative humidity of 60%. In order to set the temperature of T-BOX (temperature detection and heat retaining plate) which measured the amount of heat transfer by contacting the circular knitted fabric, to 10°C higher than room temperature, a hot plate, BT-plate, for warmth storage was set to 30°C. A hot plate G-BT that kept temperature around BT to warm the BT-plate was set to 20.3°C to be stabilized. Circular knitted fabric was located with the back (on the skin side during wearing) of the cloth upward, T-BOX was quickly placed on the circular knitted fabric, and q-max was measured. Note that the measuring portion of the circular knitted fabric was cut into a 10 cm square piece, and the weight of the piece was measured to thereby calculate the basis weight (g/cm²) of the circular knitted fabric.

[0101] In this measurement method, in the case where the q-max was 0.175 (W/cm²) or more, it was judged that good wearing comfort was obtained.

(18) Maintenance Rate of Cool Feeling by Contact (q-max) After Washing

[0102] After circular knitted fabric (10) A was repeatedly washed 20 times by the method described in No. 103 specified in Appendix 1 of JIS L0217 (1995), the cool feeling by contact described above was measured. As an index showing change in the cool feeling by contact before and after washing, the q-max maintenance rate after washing was calculated by the following expression.

$$(\text{q-max after washing}) / (\text{q-max before washing treatment}) \times 100$$

In the case where the q-max maintenance rate was 90% or more, the wash resistance was judged as good.

(19) Antistatic property

[0103] Circular knitted fabric (10) A was measured in accordance with A method (Half life measurement method) and B method (Frictional electrification voltage measurement method) specified in JIS L1094 (Testing methods for electrostatic propensity of woven and knitted fabric, 2014). The fabric was measured with a rubbing cloth of cotton (shirting No. 3) in a longitudinal direction under environmental conditions of 20°C × 40%RH.

[0104] In the case where the frictional withstanding voltage was 1500 V or less, it was judged that good antistatic performance was obtained in wearing.

(20) Antistatic Property After Washing

[0105] After circular knitted fabric (10) A was repeatedly washed 20 times by the method described in No. 103 specified

in Appendix 1 of JIS L0217 (1995), the antistatic property described above was measured.

[Example 1]

[0106] The polyamide component was nylon 6, the polyether component (poly(alkylene oxide) glycol) was polyethylene glycol having a molecular weight of 1500, the core portion was made of polyether ester amide copolymer (manufactured by Arkema K. K., MH1657, ortho-chlorophenol relative viscosity: 1.69) having a constitutional ratio (molar ratio) of the polyether component of about 76%, and the sheath portion was made of nylon 6 having a sulfuric acid relative viscosity of 2.71 and an amino terminal group amount of 5.95×10^{-5} mol/g. These portions were melted at 270°C and spun from a concentric core sheath composite spinneret (24 holes) so as to have a core/sheath ratio (part by weight) of 50/50. Note that the amount of amino terminal groups was adjusted with hexamethylenediamine and acetic acid during the polymerization.

[0107] At this time, the number of rotations of a gear pump was selected so that the total fineness of the core sheath composite yarn thus obtained was 56 dtex, and the amount of discharge of the gear pump was set to 22 g/min. Then, with a thread cooling device, the thread was cooled to be solidified, and an anhydrous lubricant was applied thereto with an oiling device. Thereafter, the thread was interlaced with a first fluid interlacing nozzle device, and drawn with a take-up roller (first roll) having a peripheral speed of 3368 m/min and a drawing roller (second roll) having a peripheral speed of 4210 m/min. With the drawing roller, the thread was thermoset at 150°C and wound up at a winding speed of 4000 m/min, to thereby obtain a core sheath composite yarn having 56 dtex/24 filaments. The properties of the fiber thus obtained were shown in Table 1.

[0108] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.4%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 12.4%, and Δ MR maintenance rate after washing was 100%, which were very good. That is, fabric and clothing including the obtained core sheath composite yarn provided comfortable clothing excellent in wash resistance sufficient for practical use.

[0109] Further, it also had excellent cool feeling by contact such that q-max was 0.170 W/cm², q-max after washing was 0.170 W/cm², and the q-max maintenance rate after washing was 100%.

[0110] Besides, the core sheath composite yarn had excellent antistatic performance having a frictional electrification voltage of 800 V under a 20°C × 40%RH environment and a frictional electrification voltage after washing of 800 V, so that comfortable clothing having wash resistance sufficient for practical use and excellent antistatic performance were obtained.

[Example 2]

[0111] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2381 m/min, a peripheral speed of the drawing roller (second roll) of 3571 m/min, and a winding speed of 3500 m/min. The properties of the fiber thus obtained were shown in Table 1.

[0112] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 11.6%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 11.1%, and Δ MR maintenance rate after washing was 95.7%, which were good.

[Example 3]

[0113] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2245 m/min, a peripheral speed of the drawing roller (second roll) of 3367 m/min, and a winding speed of 3300 m/min. The properties of the fiber thus obtained were shown in Table 1.

[0114] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 10.8%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 9.9%, and Δ MR maintenance rate after washing was 91.7%, which were good.

[Example 4]

[0115] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 4474 m/min, a peripheral speed of the drawing roller (second roll) of 4474 m/min, and a winding speed of 4250 m/min. The properties of the fiber thus obtained were shown in Table 1.

[0116] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.1%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 13.1%, and Δ MR maintenance rate after washing was 100%, which were very good.

[Example 5]

[0117] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 30/70. The properties of the fiber thus obtained were shown in Table 1.

[0118] The core sheath composite yarn thus obtained had high moisture absorption performance with a Δ MR of 7.5%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 7.2%, and Δ MR maintenance rate after washing was 96.0%, which were good.

[0119] Besides, the core sheath composite yarn had excellent antistatic performance having a frictional electrification voltage of 850 V under a 20°C $\times$ 40%RH environment and a frictional electrification voltage after washing of 850 V, so that comfortable clothing having wash resistance sufficient for practical use and excellent antistatic performance were obtained.

[Example 6]

[0120] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 20/80. The properties of the fiber thus obtained were shown in Table 2.

[0121] The core sheath composite yarn thus obtained had sufficient moisture absorption performance with a Δ MR of 5.9%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 5.5%, and Δ MR maintenance rate after washing was 93.2%, which were good.

[Example 7]

[0122] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 70/30. The properties of the fiber thus obtained were shown in Table 2.

[0123] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 15.1%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 15.0%, and Δ MR maintenance rate after washing was 99.3%, which were good.

[Example 8]

[0124] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 80/20.

[0125] The properties of the fiber thus obtained were shown in Table 2.

[0126] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 16.9%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 16.7%, and Δ MR maintenance rate after washing was 99.4%, which were good.

[Example 9]

[0127] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 2.40 and an amino terminal group amount of 3.95×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 2.

[0128] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 11.1%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 10.1%, and Δ MR maintenance rate after washing was 90.1%, which were good.

[Example 10]

[0129] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 2.63 and an amino terminal group amount of $5.20 \times$

10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 2.

[0130] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.0%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 11.6%, and Δ MR maintenance rate after washing was 96.7%, which were very good.

[Example 11]

[0131] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 3.30 and an amino terminal group amount of 4.78×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 3.

[0132] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.1%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 13.1%, and Δ MR maintenance rate after washing was 100%, which were very good.

[Example 12]

[0133] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 2.63 and an amino terminal group amount of 7.40×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 3.

[0134] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.7%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 12.2%, and Δ MR maintenance rate after washing was 96.1%, which were very good.

[Example 13]

[0135] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 2.63 and an amino terminal group amount of 4.15×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 3.

[0136] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 11.5%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 10.5%, and Δ MR maintenance rate after washing was 91.3%, which were good.

[Example 14]

[0137] A core sheath composite yarn having 56 dtex/68 filaments was obtained in the same manner as in Example 1, except that the concentric core sheath composite spinneret had 68 holes and the peripheral speed of the take-up roller (first roll) was 3508 m/min. The properties of the fiber thus obtained were shown in Table 3.

[0138] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.6%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 13.6%, and Δ MR maintenance rate after washing was 100%, which were good.

[Example 15]

[0139] A core sheath composite yarn having 56 dtex/68 filaments was obtained in the same manner as in Example 5, except that the concentric core sheath composite spinneret had 68 holes and the peripheral speed of the take-up roller (first roll) was 3508 m/min. The properties of the fiber thus obtained were shown in Table 3.

[0140] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 8.3%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 7.9%, and Δ MR maintenance rate after washing was 95.2%, which were good.

[Example 16]

[0141] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that a nylon 6 blended polymer in which a nylon 6 having a relative viscosity of 2.71 without containing any

additives and a nylon 6 having a relative viscosity of 2.71 with 20% by weight of polyvinyl pyrrolidone (Luviskol K30SP manufactured by BASF, K value=30) being added were chip-blended at a ratio of 1:5 so that the addition rate of polyvinyl pyrrolidone was 3.3% by weight was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 4.

[0142] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.3%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 13.3%, and Δ MR maintenance rate after washing was 100%, which were very good. That is, fabric and clothing including the obtained core sheath composite yarn provide comfortable clothing excellent in wash resistance sufficient for practical use. Besides, due to the containing of polyvinyl pyrrolidone in the sheath portion as a moisture absorbent, not only moisture absorbing properties were enhanced but also moisture was quickly transferred from the skin to the fiber side at the time of wearing, thereby giving a dry texture as compared with Example 1.

[Example 17]

[0143] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that a nylon 6 having a relative viscosity of 2.71 without containing any additives and a nylon 6 having a relative viscosity of 2.71 with 20% by weight of polyvinyl pyrrolidone (Luviskol K30SP manufactured by BASF, K value=30) being added were chip-blended at a ratio of 1:2 so that the addition rate of polyvinyl pyrrolidone was 6.7% by weight. The properties of the fiber thus obtained were shown in Table 4.

[0144] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.6%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 13.6%, and Δ MR maintenance rate after washing was 100%, which were very good.

[Comparative Example 1]

[0145] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that nylon 6 having a sulfuric acid relative viscosity of 2.15 and an amino terminal group amount of 4.70×10^{-5} mol/g was used as the sheath component and spinning was performed. The properties of the fiber thus obtained were shown in Table 5.

[0146] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 10.5%, but did not have wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 73.3%. The washing fastness discoloration and the color fading were both evaluated as grades 2-3, resulting in inferior color fastness. That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn do not have wash resistance (moisture absorption performance, dyeability) sufficient for practical use. Besides, the core sheath composite yarn had a frictional electrification voltage of 1000 V under a $20^{\circ}\text{C} \times 40\%\text{RH}$ environment, but a frictional electrification voltage after washing of 1700 V, resulting in inferior antistatic performance. That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn was likely to have static cling or dust adhesion in wearing under a low temperature and low humidity environment, thereby providing inferior comfort.

[Comparative Example 2]

[0147] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 10/90. The properties of the fiber thus obtained were shown in Table 5.

[0148] The washing fastness discoloration and the color fading of the obtained core sheath composite yarn were both evaluated as grades 3-4, resulting in good color fastness. Besides, the obtained core sheath composite yarn did not have sufficient moisture absorption performance with a Δ MR of 4.2%. Also, it did not have wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 84.4%. That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn do not achieve a higher comfort than natural fibers.

[Comparative Example 3]

[0149] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 90/10. The properties of the fiber thus obtained were shown in Table 5.

[0150] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a

Δ MR of 17.8%, and had wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 92.7%. However, the washing fastness discoloration and the color fading were both evaluated as grades 2-3, resulting in inferior color fastness. That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn do not have wash resistance (dyeability) sufficient for practical use.

[0151] Further, while raw yarns were collected, yarn breakage frequently occurred and stable spinning was difficult. Besides, when the wound fiber package was observed, occurrence of fluffing was found, causing many defective products, resulting in inferior productivity.

[Comparative Example 4]

[0152] A core sheath composite yarn having 56 dtex/24 filaments was obtained in the same manner as in Example 1, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2020 m/min, a peripheral speed of the drawing roller (second roll) of 3030 m/min, and a winding speed of 3000 m/min. The properties of the fiber thus obtained were shown in Table 5.

[0153] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 10.0%, but did not have wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 88.0%. The washing fastness discoloration and the color fading were both evaluated as grades 2, resulting in inferior color fastness. That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn do not have wash resistance (moisture absorption performance, dyeability) sufficient for practical use.

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.71	2.71	2.71	2.71	2.71
Core/sheath ratio		50/50	50/50	50/50	50/50	30/70
Spinning conditions	Take-up speed(m/min)	3368	2381	2245	4474	3368
	Drawing ratio	1.25	1.5	1.5	1.0	1.25
	Product	4210	3571	3367	4474	4210
Yarn properties	α -crystal orientation parameter	2.15	2.05	2.00	2.19	2.08
	Amino terminal group amount of sheath polymer	6.08	6.08	6.08	6.08	6.08
	Degree of fineness (dtex)	56	56	56	56	56
	Strength (cN/dtex)	3.4	3.1	3.0	3.3	3.7
	Elongation percentage (%)	42	46	50	40	44

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(continued)

		Example 1	Example 2	Example 3	Example 4	Example 5
Moisture absorption performance	ΔMR (%)	12.4	11.6	10.8	13.1	7.5
	ΔMR after washing (%)	12.4	11.1	9.9	13.1	7.2
	Retention rate (%)	100	95.7	91.7	100	96.0
Color development characteristic		S	S	S	S	S
Washing fastness	Discoloration (grade)	4	3-4	3	4-5	3-4
	Color fading (grade)	4	3-4	3	4-5	3-4
Overall evaluation		S	A	A	S	A

[Table 2]

		Example 6	Example 7	Example 8	Example 9	Example 10
25	Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
		OCP relative viscosity	1.69	1.69	1.69	1.69
30	Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6
		Sulfuric acid relative viscosity	2.71	2.71	2.71	2.40
35	Core/sheath ratio		20/80	70/30	80/20	50/50
40	Spinning conditions	Take-up speed(m/min)	3368	3368	3368	3368
		Drawing ratio	1.25	1.25	1.25	1.25
		Product	4210	4210	4210	4210
45	Yarn properties	α -crystal orientation parameter	2.03	2.20	2.35	1.94
		Amino terminal group amount of sheath polymer	6.08	6.08	6.08	4.10
		Degree of fineness (dtex)	56	56	56	56
		Strength (cN/dtex)	3.9	3.6	3.7	3.2
		Elongation percentage (%)	44	43	36	40

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(continued)

		Example 6	Example 7	Example 8	Example 9	Example 10
Moisture absorption performance	ΔMR (%)	5.9	15.1	16.9	11.1	12.0
	ΔMR after washing (%)	5.5	15.0	16.7	10.1	11.6
	Retention rate (%)	93.2	99.3	99.4	90.1	96.7
Color development characteristic		S	A	A	B	A
Washing fastness	Discoloration (grade)	3-4	3-4	3	3	4
	Color fading (grade)	3-4	3-4	3	3	4
Overall evaluation		A	A	A	A	S

[Table 3]

		Example 11	Example 12	Example 13	Example 14	Example 15
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	3.30	2.63	2.63	2.71	2.71
Core/sheath ratio		50/50	50/50	50/50	50/50	30/70
Spinning conditions	Take-up speed(m/min)	3368	3368	3368	3508	3508
	Drawing ratio	1.25	1.25	1.25	1.20	1.20
	Product	4210	4210	4210	4210	4210
Yarn properties	α -crystal orientation parameter	2.52	2.09	2.09	2.15	2.07
	Amino terminal group amount of sheath polymer	4.85	7.65	4.30	6.08	6.08
	Degree of fineness (dtex)	56	56	56	56	56
	Strength (cN/dtex)	3.7	3.1	3.0	3.2	3.4
	Elongation percentage (%)	44	42	42	41	42

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(continued)

		Example 11	Example 12	Example 13	Example 14	Example 15
Moisture absorption performance	Δ MR (%)	13.1	12.7	11.5	13.6	8.3
	Δ MR after washing (%)	13.1	12.2	10.5	13.6	7.9
	Retention rate (%)	100	96.1	91.3	100	95.2
Color development characteristic		A	S	B	S	S
Washing fastness	Discoloration (grade)	4-5	4-5	3	4	3-4
	Color fading (grade)	4-5	4-5	3	4	3-4
Overall evaluation		S	S	A	S	A

[Table 4]

		Example 16	Example 17
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.71	2.71
	Moisture absorbent	Polyvinyl pyrrolidone	Polyvinyl pyrrolidone
	Content (wt%)	3.3	6.7
Core/sheath ratio		50/50	50/50
Spinning conditions	Take-up speed(m/min)	3368	3368
	Drawing ratio	1.25	1.25
	Product	4210	4210
Yarn properties	α -crystal orientation parameter	2.15	2.15
	Amino terminal group amount of sheath polymer	6.08	6.08
	Degree of fineness (dtex)	56	56
	Strength (cN/dtex)	2.9	2.6
	Elongation percentage (%)	42	42
Moisture absorption performance	Δ MR (%)	13.3	13.6
	Δ MR after washing (%)	13.3	13.6
	Retention rate (%)	100	100
Color development characteristic		S	S
Washing fastness	Discoloration (grade)	4	4
	Color fading (grade)	4	4
Overall evaluation		S	S

[Table 5]

		Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.15	2.71	2.71	2.71
Core/sheath ratio		50/50	10/90	90/10	50/50
Spinning conditions	Take-up speed(m/min)	3368	3368	3368	2020
	Drawing ratio	1.25	1.25	1.25	1.50
	Product	4210	4210	4210	3030
Yarn properties	α -crystal orientation parameter	1.80	1.87	2.75	1.85
	Amount of aminoterminal groups	4.80	6.08	6.08	6.08
	Degree of fineness (dtex)	56	56	56	56
	Strength (cN/dtex)	2.7	4.1	3.3	2.7
	Elongation percentage (%)	38	46	33	55
Moisture absorption performance	Δ MR (%)	10.5	4.2	17.8	10.0
	Δ MR after washing (%)	7.7	3.5	16.5	8.8
	Retention rate (%)	73.3	84.4	92.7	88.0
Color development characteristic		A	S	C	A
Washing fastness	Discoloration (grade)	2-3	3-4	2-3	2
	Color fading (grade)	2-3	3-4	2-3	2
Overall evaluation		C	C	C	C

[Example 18]

[0154] The polyamide component was nylon 6, the polyether component (poly(alkylene oxide) glycol) was polyethylene glycol having a molecular weight of 1500, the core portion was made of polyether ester amide copolymer (manufactured by Arkema K. K., MH1657, ortho-chlorophenol relative viscosity: 1.69) having a constitutional ratio (molar ratio) of

polyether component of about 76%, and the sheath portion was made of nylon 6 having a sulfuric acid relative viscosity of 2.71 and an amino terminal group amount of 5.95×10^{-5} mol/g. These portions were melted at 270°C and then spun from a core sheath composite spinneret having a dumbbell-shaped discharging hole so as to have a core/sheath ratio (part by weight) of 50/50.

[0155] At this time, the number of rotations of a gear pump was selected so that the total fineness of the core sheath composite yarn thus obtained was 56 dtex, and the amount of discharge of the gear pump was set to 22 g/min. Then, with a thread cooling device, the thread was cooled to be solidified, and an anhydrous lubricant was applied thereto with an oiling device. Thereafter, the thread was interlaced with a first fluid interlacing nozzle device, and drawn with a take-up roller (first roll) having a peripheral speed of 3368 m/min and a drawing roller (second roll) having a peripheral speed of 4210 m/min. With the drawing roller, the thread was thermoset at 150°C and wound up at a winding speed of 4000 m/min, to thereby obtain a core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments and an I-shaped cross section. The properties of the fiber thus obtained were shown in Table 6.

[0156] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.4%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 12.4%, and Δ MR maintenance rate after washing was 100%, which were very good. Further, q-max was 0.183 W/cm², q-max after washing was 0.183 W/cm², the q-max maintenance rate after washing was 100%, which were very good. That is, fabric and clothing including the obtained core sheath composite yarn are excellent in moisture absorption performance and cool feeling by contact, and provides comfortable clothing excellent in wash resistance sufficient for practical use.

[Example 19]

[0157] A core sheath composite yarn having a flatness degree of 2.5, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that the core and sheath portions were melted at 275°C and then spun, the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2381 m/min, a peripheral speed of the drawing roller (second roll) of 3571 m/min, and a winding speed of 3500 m/min. The properties of the fiber thus obtained were shown in Table 6.

[0158] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 11.9%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 11.5%, and Δ MR maintenance rate after washing was 97%, which were good. Further, q-max was 0.178 W/cm², q-max after washing was 0.178 W/cm², and the q-max maintenance rate after washing was 100%, which were very good.

[Example 20]

[0159] A core sheath composite yarn having a flatness degree of 4.8, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that the core and sheath portions were melted at 265°C and then spun. The properties of the fiber thus obtained were shown in Table 6.

[0160] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.8%. The washing fastness discoloration and the color fading were both evaluated as grade 4, Δ MR after washing was 12.8%, and Δ MR maintenance rate after washing was 100%, which were very good. Further, q-max was 0.186 W/cm², q-max after washing was 0.186 W/cm², and the q-max maintenance rate after washing was 100%, which were very good.

[Example 21]

[0161] A core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments, and a convex lens-shaped cross section was obtained in the same manner as in Example 18, except that a core sheath composite spinneret having a convex lens-shaped discharging hole was used, and spinning was performed so as to have a core/sheath ratio (part by weight) of 30/70. The properties of the fiber thus obtained were shown in Table 6.

[0162] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 7.5%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 7.2%, and Δ MR maintenance rate after washing was 96%, which were very good. Further, q-max was 0.177 W/cm², q-max after washing was 0.177 W/cm², and the q-max maintenance rate after washing was 100%, which were very good.

[Example 22]

[0163] A core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 20/80. The properties of the fiber thus obtained were shown in Table 6.

[0164] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 5.9%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 5.5%, and Δ MR maintenance rate after washing was 93%, which were good. Further, q-max was 0.175 W/cm², q-max after washing was 0.175 W/cm², and the q-max maintenance rate after washing was 100%, which were very good.

[Example 23]

[0165] A core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments, and a convex lens-shaped cross section was obtained in the same manner as in Example 18, except that a core sheath composite spinneret having a convex lens-shaped discharging hole was used, and spinning was performed so as to have a core/sheath ratio (part by weight) of 70/30. The properties of the fiber thus obtained were shown in Table 7.

[0166] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 15.2%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 15.0%, and Δ MR maintenance rate after washing was 99%, which were good. Further, q-max was 0.186 W/cm², q-max after washing was 0.185 W/cm², the q-max maintenance rate after washing was 99%, which were very good.

[Example 24]

[0167] A core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 80/20. The properties of the fiber thus obtained were shown in Table 7.

[0168] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 17.0%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 16.9%, and Δ MR maintenance rate after washing was 99%, which were good. Further, q-max was 0.188 W/cm², q-max after washing was 0.186 W/cm², the q-max maintenance rate after washing was 99%, which were very good.

[Example 25]

[0169] A core sheath composite yarn having a flatness degree of 2.0, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 2.40 and an amino terminal group amount of 3.95×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 7.

[0170] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 11.1%. The washing fastness discoloration and the color fading were both evaluated as grade 3, Δ MR after washing was 10.2%, and Δ MR maintenance rate after washing was 92%, which were good. Further, q-max was 0.178 W/cm², q-max after washing was 0.166 W/cm², the q-max maintenance rate after washing was 93%, which were very good.

[Example 26]

[0171] A core sheath composite yarn having a flatness degree of 3.0, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 2.63 and an amino terminal group amount of 7.40×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 7.

[0172] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 12.1%. The washing fastness discoloration and the color fading were both evaluated as grades 3-4, Δ MR after washing was 11.5%, and Δ MR maintenance rate after washing was 95%, which were good.

[0173] Further, q-max was 0.180 W/cm², q-max after washing was 0.171 W/cm², the q-max maintenance rate after washing was 95%, which were very good.

[Example 27]

[0174] A core sheath composite yarn having a flatness degree of 4.5, 56 dtex/24 filaments, and a convex lens-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 3.30 and an amino terminal group amount of 4.78×10^{-5} mol/g was used as the sheath portion and spinning was performed, and a core sheath composite spinneret having convex lens-shaped discharging hole was used. The properties of the fiber thus obtained were shown in Table 7.

[0175] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.0%. The washing fastness discoloration and the color fading were both evaluated as grades 4-5, Δ MR after washing was 13.0%, and Δ MR maintenance rate after washing was 100%, which were very good. Further, q-max was 0.183 W/cm², q-max after washing was 0.183 W/cm², the q-max maintenance rate after washing was 100%, which were very good.

[Comparative Example 5]

[0176] A core sheath composite yarn having a flatness degree of 1.3, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 2.15 and an amino terminal group amount of 4.70×10^{-5} mol/g was used as the sheath portion and spinning was performed. The properties of the fiber thus obtained were shown in Table 8.

[0177] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 10.6%, but did not have wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 76%. The washing fastness discoloration and the color fading were both evaluated as grades 2-3, resulting in inferior color fastness.

[0178] Further, q-max was 0.165 W/cm², q-max after washing was 0.139 W/cm², the q-max maintenance rate after washing was 84%, so that the core sheath composite yarn did not have wash resistance with cool feeling by contact that was sufficient for practical use.

[0179] That is, it can be seen that the fabric and clothing including the obtained core sheath composite yarn do not have wash resistance (moisture absorption performance, dyeability, cool feeling by contact) sufficient for practical use.

[Comparative Example 6]

[0180] A core sheath composite yarn having a flatness degree of 5.5, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 3.45 and an amino terminal group amount of 4.50×10^{-5} mol/g was used as the sheath portion and the core and sheath portions were melted at 280°C and then spun. The properties of the fiber thus obtained were shown in Table 8.

[0181] The core sheath composite yarn thus obtained had extremely high moisture absorption performance with a Δ MR of 13.1%, but did not have wash resistance with moisture absorption performance that was sufficient for practical use with a Δ MR maintenance rate after washing of 80%. The washing fastness discoloration and the color fading were evaluated as grades 3-4 and 2-3, resulting in inferior washing fastness.

[0182] Further, q-max was 0.188 W/cm², q-max after washing was 0.147 W/cm², and the q-max maintenance rate after washing was 78%, so that the core sheath composite yarn did not have wash resistance with cool feeling by contact that was sufficient for practical use.

[Comparative Example 7]

[0183] A core sheath composite yarn having a flatness degree of 4.0, 56 dtex/24 filaments, and an I-shaped cross section was obtained in the same manner as in Example 18, except that nylon 6 having a sulfuric acid relative viscosity of 2.71 and an amino terminal group amount of 5.95×10^{-5} mol/g was used as the core portion to be a single component yarn. The properties of the fiber thus obtained were shown in Table 8.

[0184] The single component yarn thus obtained did not have excellent moisture absorption performance with a Δ MR of 2.4%. The washing fastness discoloration and the color fading were both evaluated as grade 5, Δ MR after washing was 2.4%, and Δ MR maintenance rate after washing was 100%, which were good.

[0185] However, q-max was 0.157 W/cm², q-max after washing was 0.157 W/cm², and the q-max maintenance rate after washing was 100%, but the core sheath composite yarn did not have excellent cool feeling by contact.

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[Table 6]

		Example 18	Example 19	Example 20	Example 21	Example 22
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.71	2.71	2.71	2.71	2.71
Core/sheath ratio	Core/Sheath	50/50	50/50	50/50	30/70	20/80
Cross sectional shape		I-shape (Fig. 1)	I-shape (Fig. 1)	I-shape (Fig. 1)	Convex-shape (Fig. 2)	I-shape (Fig. 1)
Flatness degree		4.0	2.5	4.8	4.0	4.0
Spinning conditions	Take-up speed(m/min)	3368	2381	3368	3368	3368
	Drawing ratio	1.25	1.5	1.25	1.25	1.25
	Product	4210	3571	4210	4210	4210
Yarn properties	α -crystal orientation parameter	2.15	2.05	2.18	2.08	2.01
	Amino terminal group amount of sheath polymer	6.08	6.09	6.07	6.08	6.08
	Degree of fineness (dtex)	56	56	56	56	56
	Strength (cN/dtex)	3.3	3.5	3.0	3.5	3.8
	Elongation percentage (%)	42	44	41	44	44
Moisture absorption performance	Δ MR (%)	12.4	11.9	12.8	7.5	5.9
	Δ MR after washing (%)	12.4	11.5	12.8	7.2	5.5
	Δ MR retention rate (%)	100	97	100	96	93
Color development characteristic		S	S	S	S	S
Washing fastness	Discoloration (grade)	4	3	4	4-5	4-5
	Color fading (grade)	4	3	4	4-5	4-5

(continued)

		Example 18	Example 19	Example 20	Example 21	Example 22
Overall evaluation		S	A	S	S	A
Cool feeling by contact	q-max (W/cm ²)	0.183	0.178	0.186	0.177	0.175
	q-max after washing (W/cm ²)	0.183	0.178	0.186	0.177	0.175
	ΔMR maintenance rate (%)	100	100	100	100	100

[Table 7]

		Example 23	Example 24	Example 25	Example 26	Example 27
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.71	2.71	2.40	2.63	3.30
Core/sheath ratio	Core/Sheath	70/30	80/20	50/50	50/50	50/50
Cross sectional shape		Convex-shape (Fig. 2)	I-shape (Fig. 1)	I-shape (Fig. 1)	I-shape (Fig. 1)	Convex-shape (Fig. 2)
Flatness degree		4.0	4.0	2.0	3.0	4.5
Spinning conditions	Take-up speed(m/min)	3368	3368	3368	3368	3368
	Drawing ratio	1.25	1.25	1.25	1.25	1.25
	Product	4210	4210	4210	4210	4210
Yarn properties	α-crystal orientation parameter	2.19	2.36	1.95	2.08	2.51
	Amino terminal group amount of sheath polymer	6.08	6.08	4.10	7.65	4.85
	Degree of fineness (dtex)	56	56	56	56	56
	Strength (cN/dtex)	3.4	3.5	3.1	3.1	3.6
	Elongation percentage (%)	42	40	40	42	44

(continued)

		Example 23	Example 24	Example 25	Example 26	Example 27
Moisture absorption performance	ΔMR (%)	15.2	17.0	11.1	12.1	13.0
	ΔMR after washing (%)	15.0	16.9	10.2	11.5	13.0
	ΔMR retention rate (%)	99	99	92	95	100
Color development characteristic		A	A	△	A	A
Washing fastness	Discoloration (grade)	3-4	3	3	3-4	4-5
	Color fading (grade)	3-4	3	3	3-4	4-5
Overall evaluation		A	A	A	A	S
Cool feeling by contact	q-max (W/cm ²)	0.186	0.188	0.178	0.180	0.183
	q-max after washing (W/cm ²)	0.185	0.186	0.166	0.171	0.183
	ΔMR maintenance rate (%)	99	99	93	95	100

[Table 8]

		Comparative Example 5	Comparative Example 6	Comparative Example 7
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Nylon 6
	OCP (sulfuric acid) relative viscosity	1.69	1.69	2.71
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.15	3.45	2.71
Core/sheath ratio	Core/Sheath	50/50	50/50	-
Cross sectional shape		I-shape (Fig. 1)	I-shape (Fig. 1)	I-shape (Fig. 1)
Flatness degree		1.3	5.5	4.0
Spinning conditions	Take-up speed(m/min)	3368	3368	3368
	Drawing ratio	1.25	1.25	1.25
	Product	4210	4210	4210

(continued)

		Comparative Example 5	Comparative Example 6	Comparative Example 7
Yarn properties	α -crystal orientation parameter	1.81	2.79	-
	Amino terminal group amount of sheath polymer	4.80	5.33	-
	Degree of fineness (dtex)	56	56	56
	Strength (cN/dtex)	2.3	2.4	4.5
	Elongation percentage (%)	39	39	56
Moisture absorption performance	Δ MR (%)	10.6	13.1	2.4
	Δ MR after washing (%)	8.0	10.5	2.4
	Δ MR retention rate (%)	76	80	100
Color development characteristic		A	A	S
Washing fastness	Discoloration (grade)	2-3	3-4	5
	Color fading (grade)	2-3	2-3	5
Overall evaluation		C	C	C
Cool feeling by contact	q-max (W/cm ²)	0.165	0.188	0.157
	q-max after washing (W/cm ²)	0.139	0.147	0.157
	Δ MR maintenance rate (%)	84	78	100

[Example 28]

[0186] As a polyether ester amide copolymer, the polyamide component was nylon 6, and the polyether component (poly(alkylene oxide) glycol) was polyethylene glycol having a molecular weight of 1500, both components not containing titanium oxide. A chip of the polyether ester amide copolymer (manufactured by Arkema K. K., MH1657, ortho-chlorophenol relative viscosity: 1.69) having a constitutional ratio (molar ratio) of the polyether component of about 76% was used in the core portion.

[0187] As the polyamide, a nylon 6 chip containing 0.3% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.63, and an amino terminal group amount of 5.10×10^{-5} mol/g was used in the sheath portion. Note that the titanium oxide was added in polymerization, and the amount of amino terminal groups was adjusted with hexamethylenediamine and acetic acid in polymerization.

[0188] The polyether ester amide copolymer (manufactured by Arkema K. K., MH1657) that was dried until the chip moisture percentage became 0.03% by weight or less was used as the core portion, and the nylon 6 that was dried until the chip moisture percentage became 0.03% by weight or less was used as the sheath portion. The core portion and the sheath portion were melted separately at 260°C, using a concentric spinneret for spinning core sheath composite fibers, and those melted portions were melt discharged so as to have a core/sheath ratio (part by weight) of 50/50. The core/sheath ratio was adjusted by the number of rotations of the gear pump with which the melted polymer was weighed.

[0189] Then, with a thread cooling device, the thread was cooled to be solidified, and an anhydrous lubricant was applied thereto with an oiling device. Thereafter, the thread was interlaced with a first fluid interlacing nozzle device, and drawn with a take-up roller (first roll) having a peripheral speed of 3368 m/min and a drawing roller (second roll) having a peripheral speed of 4210 m/min. With the drawing roller, the thread was thermoset at 150°C and wound up at a winding speed of 4000 m/min, to thereby obtain a core sheath composite fiber having 56 dtex/24 filaments.

[0190] The amount of titanium oxide in the core sheath composite fiber thus obtained was 0.15% by weight. The properties of the fiber were shown in Table 9.

[0191] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness.

[Example 29]

[0192] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip containing 1.8% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.63, and an amino terminal group amount of 5.10×10^{-5} mol/g was used in the sheath portion.

[0193] The amount of titanium oxide in the core sheath composite fiber thus obtained was 0.9% by weight. The properties of the fiber were shown in Table 9.

[0194] It can be seen that the core sheath composite fiber that is excellent in moisture absorption performance and cool feeling by contact is obtained. Further, the α -crystal orientation parameter in the sheath portion is controlled by suitably applying drawing to the sheath polyamide and setting the core/sheath ratio to a proper value, so that the core sheath composite fiber that maintains moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing is found to be obtained.

[Example 30]

[0195] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip containing 5.0% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.40, and an amino terminal group amount of 5.90×10^{-5} mol/g was used in the sheath portion.

[0196] The amount of titanium oxide in the core sheath composite fiber thus obtained was 2.5% by weight. The properties of the fiber were shown in Table 9.

[0197] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness.

[Example 31]

[0198] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip containing 5.0% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.40, and an amino terminal group amount of 5.90×10^{-5} mol/g was used in the sheath portion to set the core/sheath ratio (part by weight) to 30/70.

[0199] The amount of titanium oxide in the core sheath composite fiber thus obtained was 3.5% by weight. The properties of the fiber were shown in Table 9.

[0200] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness.

[Example 32]

[0201] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip not containing titanium oxide but 1.0% by weight of barium sulfate, having a sulfuric acid relative viscosity of 2.60, and an amino terminal group amount of 5.98×10^{-5} mol/g was used in the sheath portion.

[0202] The amount of barium sulfate in the core sheath composite fiber thus obtained was 0.5% by weight. The properties of the fiber were shown in Table 9.

[0203] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness.

[Example 33]

[0204] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip not containing titanium oxide but 1.0% by weight of magnesium oxide, having a sulfuric acid relative viscosity of 2.60, and an amino terminal group amount of 5.98×10^{-5} mol/g was used in the sheath portion.

[0205] The amount of magnesium oxide in the core sheath composite fiber thus obtained was 0.5% by weight. The properties of the fiber were shown in Table 9.

[0206] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness.

[Comparative Example 8]

[0207] A nylon 6 fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip not containing titanium oxide, having a sulfuric acid relative viscosity of 2.71, and an amino terminal group amount of 5.95×10^{-5} mol/g was used, melted at 260°C, and the melted chip was melt discharged using a round hole spinneret. The properties of the fiber were shown in Table 9. Since the nylon 6 fiber in Comparative Example 8 was commonly available, the fiber was found to have poor moisture absorption performance and cool feeling by contact.

[Example 34]

[0208] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip containing 0.1% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.63, and an amino terminal group amount of 5.10×10^{-5} mol/g was used in the sheath portion. The properties of the fiber were shown in Table 9.

[Example 35]

[0209] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 28, except that as the polyamide, a nylon 6 chip containing 20% by weight of titanium oxide, having a sulfuric acid relative viscosity of 2.30, and an amino terminal group amount of 5.21×10^{-5} mol/g was used in the sheath portion.

[0210] Fiber breakage frequently occurred during spinning. The properties of the fiber were shown in Table 10.

[0211] It can be seen that the core sheath composite fiber is excellent in moisture absorption performance and cool feeling by contact, and even after washing, it maintains such properties as well as having excellence in color fastness. Due to excessive amount of titanium oxide, spinning yarn breakage frequently occurred, and the yarn had a low tensile strength of 1.7 cN/dtex. Such insufficient strength led to poor productivity, inferior higher-degree process passability, and poor product durability, so that the core sheath composite fiber was not practical.

[Example 36]

[0212] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2381 m/min, a peripheral speed of the drawing roller (second roll) of 3571 m/min, and a winding speed of 3500 m/min. The properties of the fiber were shown in Table 10.

[0213] The α -crystal orientation parameter in the sheath portion was controlled by suitably applying drawing to the sheath polyamide, so that the core sheath composite fiber that maintained good moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 37]

[0214] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 2245 m/min, a peripheral speed of the drawing roller (second roll) of 3367 m/min, and a winding speed of 3300 m/min. The properties of the fiber were shown in Table 10.

[0215] The α -crystal orientation parameter in the sheath portion was controlled by suitably applying drawing to the sheath polyamide, and the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 38]

[0216] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that the thread was wound up at a peripheral speed of the take-up roller (first roll) of 4474 m/min, a peripheral speed of the drawing roller (second roll) of 4474 m/min, and a winding speed of 4250 m/min. The properties of the fiber were shown in Table 10.

[0217] The α -crystal orientation parameter in the sheath portion was controlled by suitably applying drawing to the sheath polyamide, so that the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 39]

[0218] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 30/70. The properties of the fiber thus obtained were shown in Table 10.

[0219] The α -crystal orientation parameter in the sheath portion was controlled by setting the core/sheath ratio to a proper value, so that the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 40]

[0220] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 20/80. The properties of the fiber thus obtained were shown in Table 10.

[0221] The α -crystal orientation parameter in the sheath portion was controlled by setting the core/sheath ratio to a proper value, so that the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 41]

[0222] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 70/30. The properties of the fiber thus obtained were shown in Table 10.

[0223] The α -crystal orientation parameter in the sheath portion was controlled by setting the core/sheath ratio to a proper value, so that the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Example 42]

[0224] A core sheath composite fiber having 56 dtex/24 filaments was obtained in the same manner as in Example 29, except that spinning was performed so as to have a core/sheath ratio (part by weight) of 80/20.

[0225] The properties of the fiber thus obtained were shown in Table 10.

[0226] The α -crystal orientation parameter in the sheath portion was controlled by setting the core/sheath ratio to a proper value, so that the core sheath composite fiber that maintained moisture absorption performance and cool feeling by contact as well as having excellence in color fastness even after washing was obtained.

[Table 9]

Core component	Polymer type	Example 28	Example 29	Example 30	Example 31	Example 32	Example 33	Comparative Example 8	Example 34
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69	1.69	-	1.69
Sheath component	Polymer type	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Amount of amino terminal groups (C10 ⁻⁵ mol/g)	5.10	5.10	5.90	5.90	5.98	5.98	5.95	5.10
	Sulfuric acid relative viscosity	2.63	2.63	2.40	2.40	2.60	2.60	2.71	2.63
	Inorganic particles	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide	Barium sulfate	Magnesium oxide	-	Titanium oxide
	Content (wt%)	0.3	1.8	5.0	5.0	1.0	1.0	0	0.1
Core/sheath ratio	Core/Sheath	50/50	50/50	50/50	30/70	50/50	50/50	-	50/50
Cross sectional shape of fiber	Concentric core sheath								
	Take-up speed (m/min)	3368	3368	3368	3368	3368	3368	3368	3368
	Drawing ratio	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Product (m/min)		4210	4210	4210	4210	4210	4210	4210	4210

(continued)

	Example 28	Example 29	Example 30	Example 31	Example 32	Example 33	Comparative Example 8	Example 34
Sheath ratio (wt%)	50	50	50	70	50	50	-	50
Content of inorganic particles in whole fibers (wt%)	0.15	0.9	2.5	3.5	0.5	0.5	0	0.05
Content of inorganic particles in sheath polymer (wt%)	0.3	1.8	5	5	1.0	1.0	-	0.1
α -crystal orientation parameter	2.05	1.98	1.90	1.85	2.02	2.02	-	2.09
Amino terminal group amount of sheath polymer (C10 ⁻⁵ mol/g)	5.25	5.25	6.05	6.05	6.10	6.10	-	5.25
Degree of fineness (dtex)	56	56	56	56	56	56	56	56
Strength (cN/dtex)	3.2	3.0	2.8	2.7	3.0	3.0	4.5	3.4
Elongation percentage (%)	42	42	42	42	42	42	56	42
Δ MR (%)	12.4	12.4	12.4	7.5	12.4	12.4	2.4	12.4
Δ MR after washing (%)	12.4	12.4	12.4	7.5	12.4	12.4	2.4	12.4
Maintenance rate (%)	100	100	100	100	100	100	100	100
Moisture absorption performance								
Yarn properties								

(continued)

		Example 28	Example 29	Example 30	Example 31	Example 32	Example 33	Comparative Example 8	Example 34
Washing fastness	Discoloration (grade)	4	4	4	4	4	4	5	4
	Color fading (grade)	4	4	4	4	4	4	5	4
Overall evaluation		S	S	S	S	S	S	C	S
Cool feeling by contact	q-max (W/cm ²)	0.190	0.195	0.200	0.200	0.210	0.198	0.157	0.171
	q-max after washing (w/cm ²)	0.190	0.195	0.200	0.200	0.198	0.193	0.157	0.171
	Retention rate (%)	100	100	100	100	100	100	100	100

[Table 10]

Core component	Polymer type	Example 35	Example 36	Example 37	Example 38	Example 39	Example 40	Example 41	Example 42
	OCP relative viscosity	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69
Sheath component	Polymer type	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6	Nylon 6
	Amount of amino terminal groups (C10 ⁻⁵ mol/g)	5.21	5.10	5.10	5.10	5.10	5.10	5.10	5.10
	Sulfuric acid relative viscosity	2.30	2.63	2.63	2.63	2.63	2.63	2.63	2.63
	Inorganic particles	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide	Titanium oxide
	Content	20	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Core/sheath ratio	Core/Sheath	50/50	50/50	50/50	50/50	30/70	20/80	70/30	80/20
Cross sectional shape of fiber	Concentric core sheath		Concentric core sheath	Concentric core sheath	Concentric core sheath	Concentric core sheath	Concentric core sheath	Concentric core sheath	Concentric core
	Take-up speed (m/min)	3368	2381	2245	4474	3368	3368	3368	3368
	Drawing ratio	1.25	1.5	1.5	1.0	1.25	1.25	1.25	1.25
	Product (m/min)	4210	3571	3367	4474	4210	4210	4210	4210

(continued)

	Example 35	Example 36	Example 37	Example 38	Example 39	Example 40	Example 41	Example 42
Sheath ratio (wt%)	50	50	50	50	70	80	30	20
Content of inorganic particles in whole fibers (wt%)	10	0.9	0.9	0.9	1.26	1.44	0.54	0.36
Content of inorganic particles in sheath polymer (wt%)	20	1.8	1.8	1.8	1.8	1.8	1.8	1.8
α -crystal orientation parameter	1.85	1.88	1.83	2.02	1.91	1.86	2.03	2.18
Amino terminal group amount of sheath of sheath polymer (C10 ⁻⁵ mol/g)	5.35	5.25	5.25	5.25	5.25	5.25	5.25	5.25
Degree of fineness (dtex)	56	56	56	56	56	56	56	56
Strength (cN/dtex)	1.7	3.0	2.8	3.1	3.5	3.7	3.4	3.5
Elongation percentage (%)	42	46	50	40	44	44	43	36
Yarn properties								

(continued)

	Example 35	Example 36	Example 37	Example 38	Example 39	Example 40	Example 41	Example 42
Moisture absorption performance	Δ MR (%)	12.4	11.6	10.8	13.1	7.5	15.1	16.9
	Δ MR after washing (%)	12.4	11.1	9.9	13.1	7.2	15.0	16.7
	Maintenance rate (%)	100	95.7	91.7	100	96.0	99.3	99.4
Washing fastness	Discoloration (grade)	4	3-4	3	4-5	3-4	3-4	3
	Color fading (grade)	4	3-4	3	4-5	3-4	3-4	3
Overall evaluation		S	A	A	S	A	A	A
	q-max (W/cm ²)	0.210	0.195	0.195	0.195	0.196	0.195	0.194
Cool feeling by contact	q-max after washing (w/cm ²)	0.210	0.192	0.185	0.195	0.192	0.193	0.193
	Retention rate (%)	100	98.5	94.8	100	98.0	99.0	99.5

INDUSTRIAL APPLICABILITY

[0227] The core sheath composite yarn of the present invention can provide a core sheath composite yarn having high moisture absorption performance, a higher comfort than natural fibers, wash resistance with moisture absorption performance that is sufficient for practical use, and color fastness.

Claims

1. A core sheath composite yarn having a sheath polymer that is a polyamide and a core portion that is a thermoplastic polymer, having a moisture absorbance/desorbance (ΔMR) of 5.0% or more, wherein the ΔMR maintenance rate after 20 washes is 90% or more and 100% or less.
2. The core sheath composite yarn according to claim 1, having a washing fastness of grade 3 or higher and grade 5 or lower.
3. The core sheath composite yarn according to claim 1 or 2, wherein the sheath polymer has an α -crystal orientation parameter of 1.9 or more and 2.7 or less, and the core thermoplastic polymer is a polyether ester amide copolymer.
4. The core sheath composite yarn according to any of claims 1 to 3, wherein the amount of amino terminal groups in the sheath polymer of the core sheath composite yarn is 3.5×10^{-5} mol/g or more and 8.0×10^{-5} mol/g or less.
5. The core sheath composite yarn according to any of claims 1 to 4, having a flatness degree of 1.5 or more and 5.0 or less.
6. The core sheath composite yarn according to any of claim 1, 2 or 4, containing 0.1 to 5% by weight of inorganic particles in the whole fibers.
7. The core sheath composite yarn according to claim 6, wherein the sheath polymer has an α -crystal orientation parameter of 1.7 or more and 2.6 or less.
8. The core sheath composite yarn according to claim 6 or 7, wherein the sheath polymer contains 0.2 to 6% by weight of inorganic particles.
9. The core sheath composite yarn according to any of claims 6 to 8, wherein the inorganic particles are titanium oxide.
10. A fabric having the core sheath composite yarn defined in any of claims 1 to 9 in at least a portion thereof.

Figure 2

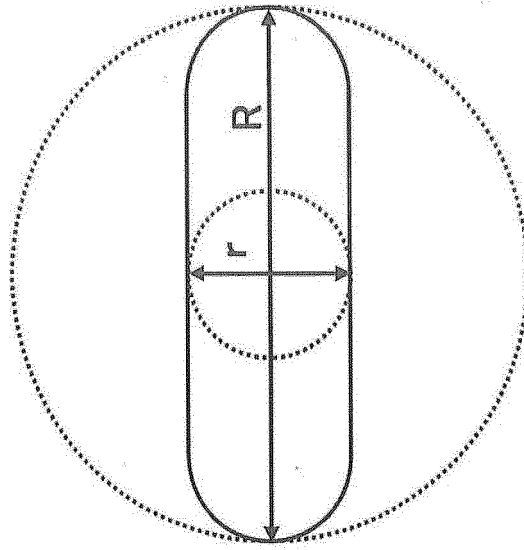
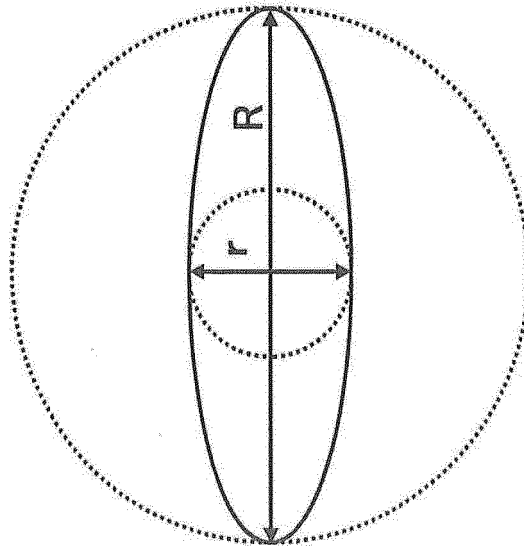


Figure 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/084892

A. CLASSIFICATION OF SUBJECT MATTER

D01F8/12(2006.01)i, D03D15/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D01F8/12, D03D15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 09-041221 A (Toray Industries, Inc.), 10 February 1997 (10.02.1997), claims; examples 3, 4 (Family: none)	1-3, 10 4-10
X Y	JP 06-306709 A (Asahi Chemical Industry Co., Ltd.), 01 November 1994 (01.11.1994), claims; examples (Family: none)	1-3, 10 4-10
X Y	JP 11-158728 A (Unitika Ltd.), 15 June 1999 (15.06.1999), claims; examples 1 to 5 (Family: none)	1, 2, 6-8, 10 4-10

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

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Date of the actual completion of the international search
12 February 2016 (12.02.16)Date of mailing of the international search report
01 March 2016 (01.03.16)
 Name and mailing address of the ISA/
 Japan Patent Office
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/084892

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2001-055633 A (Unitika Ltd.), 27 February 2001 (27.02.2001), claims; examples 1 to 3 (Family: none)	1, 2, 6-8, 10 4-10
X Y	WO 99/049111 A1 (Unitika Ltd.), 30 September 1999 (30.09.1999), claims; examples 1 to 3, 6, 7, 9, 14 to 16, 18, 19, 21 to 23, 25, 26; comparative examples 4, 15, 16, 20, 21 & US 6756329 B1 claims; examples 1 to 3, 6, 7, 9, 14 to 16, 18, 19, 21 to 23, 25, 26; comparative examples 4, 15, 16, 20, 21 & EP 1087043 A1 & CN 1294643 A	1, 2, 10 4-10
X Y	JP 11-001825 A (Unitika Ltd.), 06 January 1999 (06.01.1999), claims; paragraph [0022]; examples 1 to 7 (Family: none)	1, 2, 10 4-10
Y A	JP 2004-107809 A (Toray Industries, Inc.), 08 April 2004 (08.04.2004), claims; paragraphs [0014] to [0027] (Family: none)	4-10 1-3
A	JP 11-021724 A (Kuraray Co., Ltd.), 26 January 1999 (26.01.1999), entire text (Family: none)	1-10

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REFERENCES CITED IN THE DESCRIPTION

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- JP 8209450 A [0013]
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