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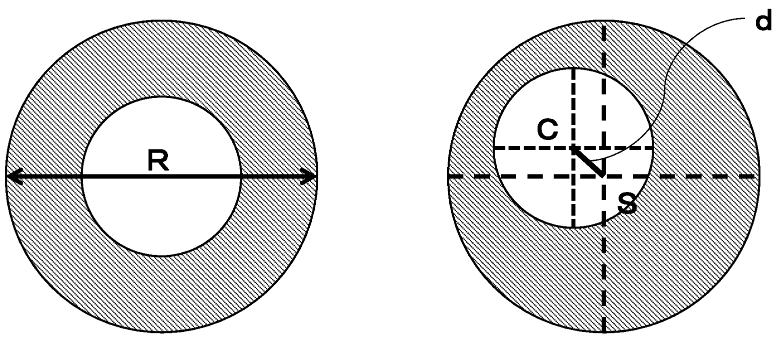
(54) POLYAMIDE CORE-SHEATH COMPOSITE FIBER AND FABRIC

(57) Provided is a polyamide core-sheath composite fiber comprising a sheath polymer formed from polyamide and a core polymer formed from polyether ester amide copolymer, wherein the core-sheath composite fiber has a strength of 3.6 cN/dtex or greater, a cross-sectional uniformity ratio d/R of the core-sheath component in the entire yarn of 0.072 or less, and an electrical specific resistance of 10^7 to 10^{10} $\Omega\cdot$cm. The provided polyamide core-sheath composite fiber has a humidity-absorbing property and an antistatic property, and while retaining strength, suppresses generation of fluff and has excellent high-order passability.

Figure 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a polyamide core-sheath composite fiber and a fabric. More specifically, the present invention relates to a polyamide core-sheath composite fiber and a fabric excellent in a humidity-absorbing property and an antistatic property.

BACKGROUND ART

[0002] Synthetic fibers made from thermoplastic resins such as polyamides and polyesters are widely used in clothing applications, industrial applications, and the like because they are excellent in strength, chemical resistance, heat resistance, and the like. In particular, polyamide fibers are excellent in characteristics such as distinctive softness, high tensile strength, the coloring property at dyeing, and high heat resistance and are widely used in general clothing applications such as underwear, outerwear, and sportswear.

[0003] In recent years, with the popularization of outdoor sports, the demand for sports and casual clothing applications is increasing year by year. In particular, woven fabrics used for down jacket base fabrics and windbreakers are required to be thin and lightweight, soft, and low in air permeability, and polyamide fibers are becoming finer in terms of the fineness and single yarn fineness. Polyamide fibers have a property of being easily charged and are easily charged with static electricity in a low-temperature and low-humidity winter environment. As thinning progresses, static electricity becomes more likely to be generated, and there is a demand for polyamide fibers having an excellent antistatic property.

[0004] Many polyamide fibers excellent in an antistatic property have been proposed, such as a method of applying an antistatic agent to a fiber or fabric by post-processing, a method of forming a composite fiber with a polymer having an antistatic property, and the like. Among them, core-sheath composite polyamide fibers using a humidity-absorbing component in a core have an excellent antistatic property and remove the drawback of polyamide fibers of having remarkable electrical resistance and being easily charged with static electricity. In particular, the core-sheath composite polyamide fibers are highly desired for applications such as outerwear used under low temperature and low humidity in winter, and research and proposals have been advanced.

[0005] For example, Patent Document 1 discloses a core-sheath composite fiber including a polyamide resin as a sheath and a polyether ester amide copolymer as a core and having a single yarn fineness of 3.5 dtex. Patent Document 2 discloses a composite fiber including a polyamide resin as a sheath and a polyether ester amide copolymer as a core and having an area ratio between the core and the sheath of 3/1 to 1/5 and a single yarn fineness of 3.25 dtex. Patent Document 3 discloses that a composite fiber including a polyamide as a core and a polyether ester amide copolymer as a core is excellent in an antistatic property.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0006]

Patent Document 1: Japanese Patent Laid-open Publication No. H6-136618
Patent Document 2: International Publication No. 2014/10709
Patent Document 3: Japanese Patent Laid-open Publication No. 2017-57513

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007] However, the core-sheath composite fibers disclosed in Patent Documents 1 and 2 are excellent in moisture-absorbing capability and antistatic capability, but the raw yarn strength decreases as the fibers become finer in terms of the fineness and single yarn fineness. When drawing is performed to ensure the raw yarn strength, much raw yarn fluff is generated, and not only the process passability through high-order processing steps is deteriorated but also the product quality is deteriorated. The core-sheath composite yarn disclosed in Patent Document 3 is excellent in antistatic capability but has a low core ratio of a polyether ester amide copolymer that ensures moisture-absorbing capability. When the core ratio is increased in order to ensure the moisture-absorbing capability, the raw yarn strength is reduced, much raw yarn fluff is generated, and high-order passability and product quality are deteriorated as in Patent Document 1 and Patent Document 2.

[0008] An object is to provide a polyamide core-sheath composite fiber that has a humidity-absorbing property and an antistatic property, suppresses generation of fluff while retaining strength, and has excellent high-order passability, because fibers are becoming finer in terms of the fineness and single yarn fineness with the demand for thin and lightweight, soft, and low-air-permeability woven fabrics.

SOLUTIONS TO THE PROBLEMS

[0009] In order to solve the above-mentioned problems, the present invention has the following constitution.

(1) A polyamide core-sheath composite fiber having a strength of 3.6 cN/dtex or greater, a cross-sectional uniformity ratio d/R of core and sheath components in a transverse cross-section of the fiber of 0.072 or less, and an electrical specific resistance of 10^7 to 10^{10} $\Omega\cdot$cm in a core-sheath composite multifilament including a sheath polymer formed from a polyamide and a core polymer formed from a polyether ester amide copolymer.

d: Distance between center of inscribed circle of core component and center of inscribed circle of sheath component
R: Diameter of inscribed circle of sheath component

(2) The polyamide core-sheath composite fiber according to (1), in which a single yarn fineness is 0.8 to 2.0 dtex, and an area ratio of a core in the transverse cross-section of the fiber is 20 to 40%.
(3) A fabric including the polyamide core-sheath composite fiber according to (1) or (2) in at least a part thereof.

EFFECTS OF THE INVENTION

[0010] According to the present invention, it is possible to provide a polyamide core-sheath composite fiber that has a humidity-absorbing property and an antistatic property, suppresses generation of fluff while retaining strength, and has excellent high-order passability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 schematically shows the shapes of transverse cross-sections of a fiber of the present invention.
Fig. 2 is a longitudinal sectional view of an example of a discharge hole of a spinneret for composite spinning used in the present invention.
Fig. 3 schematically shows a part of the arrangement of a core component introduction hole and a sheath component introduction holes of a lower introduction plate of the spinneret for composite spinning used in the present invention.
Fig. 4 shows an embodiment of a production device employing a direct spinning-drawing method preferably used in a method for producing a polyamide core-sheath composite fiber of the present invention.

EMBODIMENTS OF THE INVENTION

[0012] The polyamide core-sheath composite fiber of the present invention is a core-sheath composite fiber using a polyamide for the sheath and a polyether ester amide copolymer for the core.

[0013] As shown in Fig. 1, the polyamide core-sheath composite fiber of the present invention has a cross-sectional uniformity ratio (d/R) of 0.072 or less in a transverse cross-section. Here, the cross-sectional uniformity ratio is a value calculated by measuring the distance (d) between the center point (point C) of the inscribed circle of the core component and the center point (point S) of the inscribed circle of the sheath component, and the diameter (R) of the inscribed circle of the sheath component, and is an average value obtained by measuring the entire yarn. The closer the numerical value is to 0, the more concentric it is, and the larger the numerical value is, the more eccentric it is. By setting the cross-sectional uniformity ratio (d/R) within such a range, generation of single yarn fluff is suppressed, and high-order passability is excellent. The ratio is more preferably 0.050 or less. When the cross-sectional uniformity ratio (d/R) exceeds 0.072, the core polyether ester amide copolymer is eccentric, and the sheath thickness of the sheath polyamide is uneven. Therefore, when an external force is applied to a thin portion of the sheath, the single yarn is easily broken from the thin portion, and much single yarn fluff is generated, so that not only high-order passability is deteriorated but also product quality tends to deteriorate.

[0014] The polyamide core-sheath composite fiber of the present invention has a strength of 3.6 cN/dtex or more. Within such a range, yarn breakage in the high-order processing steps is reduced, and the high-order passability is improved. In addition, product durability is excellent. If the strength is less than 3.6 cN/dtex, yarn breakage in high-order processing steps tends to increase, leading to deterioration of high-order passability. In addition, in clothing applications mainly including outerwear clothing applications and sportswear clothing applications, there is a case where product durability is deteriorated due to a tendency that the product becomes undurable for actual use. The range is more preferably 4.0 cN/dtex or more.

[0015] The polyamide core-sheath composite fiber of the present invention preferably has an area ratio of the core in a transverse cross-section of the fiber of 20% or more and 40% or less. The ratio is more preferably 20% or more and 30% or less, still more preferably 25% or more and 30% or less. Within this range, the sheath easily absorbs more moisture present in the air in a limited amount, and the ratio of transmission of the absorbed moisture to the core increases. In addition, since the area ratio of the core is small, the charged static electricity is quickly transmitted through the core that has absorbed moisture, so that an excellent humidity-absorbing property and antistatic property are exhibited.

[0016] The polyamide core-sheath composite fiber of the present invention has an electrical specific resistance of 10^7 to 10^{10} $\Omega\cdot$cm under conditions of a temperature of 20°C and a humidity of 40% RH. With such a range, an antistatic property is provided. A general polyamide fiber has an electrical specific resistance of the order of 10^{14} $\Omega\cdot$cm. Then, static electricity depends on the amount of moisture in the air, and static electricity is less likely to be generated in a humid environment and is likely to be generated in a dry environment. In order to exhibit a sufficient antistatic property, sufficient antistatic capability can be exhibited when the specific resistance is 10^{10} $\Omega\cdot$cm or less under the conditions of a temperature of 20°C and a humidity of 40% RH. The lower limit of the electrical specific resistance that can be achieved in the present invention is of the order of about 10^7 $\Omega\cdot$cm.

[0017] In the polyamide core-sheath composite fiber of the present invention, ΔMR is preferably 5.0% or more. With such a range, a humidity-absorbing property is provided. In order to give high wearing comfort, a function of adjusting the humidity inside the clothes is required. As an indicator of this humidity adjustment, ΔMR is used. The ΔMR is represented by the difference in moisture absorptivity between that at the temperature and humidity inside the clothes typified by 30°C × 90% RH in work on light to medium duty or light to medium exercise, and that at the outside temperature and humidity typified by 20°C × 65% RH. The larger the ΔMR is, the higher the moisture-absorbing capability is, and a larger ΔMR indicates higher wearing comfort. A ΔMR of 5.0% or more makes it possible to suppress stuffy and sticky feeling during wearing and to provide clothing excellent in comfort. The upper limit value of the ΔMR is about 17.0%.

[0018] The polyamide core-sheath composite fiber of the present invention can be arbitrarily set as long as it has a total fineness suitable for clothing, preferably 8 to 155 dtex. In addition, the single yarn fineness can also be arbitrarily set according to product requirements but is preferably 0.8 to 2.0 dtex because fibers are becoming finer in terms of the fineness and the single yarn fineness with the demand for thin and lightweight, soft, and low-air-permeability woven fabrics.

[0019] The polyamide core-sheath composite fiber of the present invention preferably has an elongation of 40% or more. The elongation is more preferably 42 to 65%. Within such a range, yarn breakage in the high-order processing steps is reduced, and the high-order passability is improved.

[0020] The polyamide core-sheath composite fiber of the present invention employs a polyamide for the sheath and a polyether ester amide copolymer for the core.

[0021] The polyether ester amide copolymer used for the core of the present invention is a block copolymer having an ether bond, an ester bond, and an amide bond in one molecular chain. More specifically, the polyether ester amide copolymer is a block copolymer obtained by the polycondensation reaction of at least one polyamide component (A) selected from lactams, aminocarboxylic acids, and salts of diamines and dicarboxylic acids, with a polyether ester component (B) formed of a dicarboxylic acid and a poly(alkylene oxide) glycol.

[0022] Examples of the polyamide component (A) include lactams such as ε-caprolactam, dodecanolactam, and undecanolactam, ω-aminocarboxylic acids such as aminocaproic acid, 11-aminoundecanoic acid, and 12-aminododecanoic acid, and nylon salts of diamines and dicarboxylic acids, which are precursors of nylon 66, nylon 610, nylon 612, and the like. A preferable polyamide-forming component is ε-caprolactam.

[0023] The polyether ester component (B) is formed of a dicarboxylic acid having 4 to 20 carbon atoms and a poly(alkylene oxide) glycol. Examples of the dicarboxylic acid having 4 to 20 carbon atoms include aliphatic dicarboxylic acids such as succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, sebacic acid, and dodecadi acid, aromatic dicarboxylic acids such as terephthalic acid, isophthalic acid, and 2,6-naphthalenedicarboxylic acid, and alicyclic dicarboxylic acids such as 1,4-cyclohexanedicarboxylic acid. One of them or a mixture of two or more of them can be used. Preferable dicarboxylic acids are adipic acid, sebacic acid, dodecadi acid, terephthalic acid, and isophthalic acid. Examples of the poly(alkylene oxide) glycol include polyethylene glycol, poly(1,2- and 1,3-propylene oxide) glycol, poly(tetramethylene oxide) glycol, and poly(hexamethylene oxide) glycol. Polyethylene glycol having particularly high moisture-absorbing capability is preferable.

[0024] The number average molecular weight of the poly(alkylene oxide) glycol is preferably 300 to 5,000, more preferably 500 to 4,000. A molecular weight of 300 or more is preferable because the poly(alkylene oxide) glycol hardly scatters to the outside of the system during the polycondensation reaction, and a fiber having stable humidity-absorbing and antistatic properties is obtained. A molecular weight of 5,000 or less is preferable because the poly(alkylene oxide) glycol is uniformly dispersed in the polymer, and good humidity-absorbing and antistatic properties can be obtained.

[0025] The constituent ratio of the polyether ester component (B) in the entire polyether ester amide copolymer is preferably 20 to 80% in terms of molar ratio. A constituent ratio of 20% or more is preferable because high humidity-absorbing and antistatic properties can be obtained. A constituent ratio of 80% or less is preferable because high color fastness and washing durability of humidity-absorbing and antistatic properties can be obtained.

[0026] The constituent ratio between the polyamide and the poly(alkylene oxide) glycol is preferably 20%/80% to 80%/20% in terms of molar ratio. A constituent ratio of the poly(alkylene oxide) glycol of 20% or more is preferable because good humidity-absorbing and antistatic properties can be obtained. A constituent ratio of the poly(alkylene oxide) glycol of 80% or less is preferable because high color fastness and washing durability of humidity-absorbing and antistatic properties can be obtained.

[0027] As such a polyether ester amide copolymer, "MH 1657" and "MV 1074" manufactured by ARKEMA K.K. and the like are commercially available.

[0028] The chips of the polyether ester amide copolymer used for the core 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, optimum stress is applied to the sheath during spinning, crystallization of the polyamide in the sheath proceeds, and the strength is increased.

[0029] As for the poly(alkylene oxide) glycol, a chain reaction in which radicals are generated from the inside of the molecule by heat application and attack adjacent atoms to generate radicals proceeds, and a high temperature exceeding 200°C is caused by heat of reaction. In addition, as the molecular weight of the poly(alkylene oxide) glycol is smaller, heat is easily applied to the molecular chain, so that radicals tend to be generated more easily, and heat of reaction tends to be generated more easily.

[0030] Since the number average molecular weight of the poly(alkylene oxide) glycol contained in the polyether ester amide copolymer used in the present invention is as relatively small as 300 to 5,000, from the above mechanism, thermal degradation of the polyether ester amide copolymer is likely to proceed, and hardening or embrittlement of a raw yarn, deterioration of the humidity-absorbing property and the antistatic property, and the like are very likely to occur.

[0031] Therefore, it is preferable to add a hindered phenolic antioxidant that supplements radicals to the polyether ester amide copolymer in the core. A half-hindered phenolic antioxidant is more preferable. The amount of the hindered phenolic antioxidant to be added is preferably 1.0 wt% or more and 5.0 wt% or less with respect to the weight of the polyether ester amide copolymer in the core. The amount is more preferably 2.0 wt% or more.

[0032] Examples of a both-hindered phenolic antioxidant include pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate] (IR 1010), tris(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanuric acid (IR 1790), (1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenyl)benzene (AO-330), 1,3,5-tris[[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]methyl]-1,3,5-triazine-2,4,6(1H,3H,5H)-trione (IR 3114), and N,N'-hexamethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propanamide] (IR 1098).

[0033] In the case of the both-hindered phenolic antioxidant, thermal degradation of the polyether ester amide copolymer proceeds due to thermal hysteresis during a spinning step (a high temperature applied during polymer melting or heat setting after drawing) and thermal hysteresis during a high-order processing step (dyeing or heat setting of the fabric or the like), and the amount of active ingredient of the antioxidants that supplement radicals remaining at the stage of the fabric and the article of clothing is significantly reduced. Therefore, by using a hindered amine light stabilizer (HALS) in combination in order not to reduce the amount of active ingredient of the antioxidants that supplement radicals remaining in the fabric and the clothing, thermal degradation of the hindered phenolic antioxidants can be suppressed, heat of reaction/thermal degradation can be suppressed, and hardening or embrittlement of the raw yarn and deterioration of humidity-absorbing and antistatic properties can be suppressed. Examples of the HALS include a polycondensate of dibutylamine-1,3,5-triazine·N,N-bis(2,2,6,6-tetramethyl-4-piperidyl-1,6-hexamethylenediamine·N-(2,2,6,6-tetramethyl-4-piperidyl)butylamine (CHIMASSORB 2020 FDL), 4,7,N,N'-tetrakis[4,6-bis[butyl(1,2,2,6,6-pentamethyl-4-piperidinyl)amino]-1,3,5-triazin-2-yl]-4,7-diazadecane-1,10-diamine (CHIMASSORB 119), poly[{6-(1,1,3.3-tetramethylbutyl)amino-1,3,5-triazine-2,4-diyl)((2,2,6,6-tetramethyl-4-piperidyl)imino)hexamethylene((2,2,6,6-tetramethyl-4-piperidyl)imino] (CHIMASSORB 944).

[0034] Examples of the half-hindered phenolic antioxidant include 2,2'-dimethyl-2,2'-(2,4,8,10-tetraoxaspiro[5.5]undecane-3,9-diyl)dipropane-1,1'-diyl=bis[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propanoate] ("Sumilizer" (registered trademark) AG-80 manufactured by Sumitomo Chemical Co., Ltd. and "ADK STAB" (registered trademark) AO-80 manufactured by ADEKA Corporation) and 1,3,5-tris[[4-(1,1-dimethylethyl)-3-hydroxy-2,6-dimethylphenyl]methyl]-1,3,4-triazine-2,4,6(1H,3H,5H)-trione (Cyanox 1790 manufactured by Solvay S.A.).

[0035] As for the half-hindered phenolic antioxidant, the decrease in the amount of the active ingredient of the antioxidant in the thermal hysteresis during the spinning step and the thermal hysteresis during the high-order processing step is very small as compared with the both-hindered phenolic antioxidant. Therefore, the heat of reaction/thermal degradation can be suppressed by using the half-hindered phenolic antioxidant alone without using the HALS in combination unlike the both-hindered phenolic antioxidant, and hardening or embrittlement of the raw yarn and deterioration of humidity-absorbing and antistatic properties can be suppressed. In addition, since the decomposition product of the half-hindered phenol is less colored, yellowing can also be suppressed.

[0036] It is also possible to use other phosphorus stabilizers in combination with the polyether ester amide copolymer in the core. Various other additives, such as a matting agent, a flame retardant, an ultraviolet absorber, an infrared absorber, a crystal nucleating agent, a fluorescent whitening agent, an antistatic agent, a hygroscopic polymer, and carbon may be contained in the form of a copolymer or a mixture as needed at a total additive content of 5 wt% or less with respect to the polyether ester amide copolymer.

[0037] The ratio of the core is preferably 20 wt% to 40 wt% with respect to the entire composite fiber. The ratio is more preferably 20 wt% to 30 wt%, more preferably 25 wt% to 30 wt%. As the ratio of the core increases, the humidity-absorbing and antistatic properties are improved, but the strength decreases. On the other hand, as the ratio of the core decreases, the strength increases, but the humidity-absorbing and antistatic properties are deteriorated. Within such a range, the humidity-absorbing property and the antistatic property are exhibited, and it becomes possible to appropriately draw the polyamide in the sheath, so that the strength is enhanced.

[0038] Examples of the polyamide used in the sheath of the present invention include nylon 6, nylon 66, nylon 46, nylon 9, nylon 610, nylon 11, nylon 12, and nylon 612, or copolymerized polyamides containing these nylons and a copolymerization component such as a compound having an amide-forming functional group, such as laurolactam, sebacic acid, terephthalic acid, isophthalic acid, and sodium 5-sulfoisophthalate. Among them, nylon 6, nylon 11, nylon 12, nylon 610, and nylon 612 have a small difference in melting point from the polyether ester amide copolymer and can suppress thermal degradation of the polyether ester amide copolymer during melt spinning, which is preferable from the viewpoint of the yarn-making property. Nylon 6 having excellent dyeability is particularly preferable.

[0039] The polyamide in the sheath may contain various other additives, such as a matting agent, a flame retardant, an antioxidant, an ultraviolet absorber, an infrared absorber, a crystal nucleating agent, a fluorescent whitening agent, an antistatic agent, a hygroscopic polymer, and carbon in the form of a copolymer or a mixture as needed at a total additive content of 5 wt% or less with respect to the polyether ester amide copolymer.

[0040] The polyamide chips used in the sheath of the present invention preferably has a sulfuric acid relative viscosity of 2.3 or more and 3.3 or less. Within such a range, it becomes possible to appropriately draw the polyamide in the sheath, so that the strength is enhanced.

[0041] The polyether ester amide copolymer used in the present invention has a melt viscosity of 400 to 600 poise, which is lower than the melt viscosity of 900 to 1,500 poise of the polyamide used in the present invention, and has a large difference in melt viscosity. Therefore, it is preferable to select a combination of a polyether ester amide copolymer and a polyamide having a melt viscosity ratio at a spinning temperature of 3.0 or less. Within such a range, the stress applied in the longitudinal direction of the yarn at the time of thinning and drawing after the yarn is discharged from the spinneret at the time of spinning is not biased to the sheath component, and there is a tendency that the cross-sectional uniformity ratio (d/R) can be reduced. When the ratio is more than 3.0, the stress applied in the longitudinal direction of the yarn at the time of thinning and drawing is biased to the sheath component, and the cross-sectional uniformity ratio increases. The term "melt viscosity" as used herein refers to a melt viscosity that can be measured with a capillary rheometer using a chip-shaped polymer caused to have a moisture content of 200 ppm or less by a vacuum dryer, and means a melt viscosity at the same shear rate at a spinning temperature.

[0042] Since the melting point of the polyether ester amide copolymer is lower than the melting point of the polyamide, it is preferable to select a polyether ester amide copolymer and a polyamide having a melting point difference of 30°C or less from the viewpoint of suppressing thermal degradation of the polyether ester amide copolymer during melt spinning and yarn-making properties.

[0043] In the spinning step, the temperature of the melted portion of the core polymer is preferably 235°C or higher and 260°C or lower. When the temperature of the melted portion of the core polymer is 235°C or higher, the polyether ester amide copolymer in the core has a melt viscosity suitable for melt spinning, which is preferable. When the temperature of the melted portion is 260°C or lower, thermal decomposition of the polyther ester amide copolymer in the core due to temperature rise can be suppressed, which is preferable.

[0044] The temperature of the melted portion of the sheath polymer is preferably 240°C or higher and 285°C or lower. When the temperature of the melted portion of the sheath polymer is 240°C or higher, the polyamide in the sheath has a melt viscosity suitable for melt spinning, which is preferable. When the temperature is 285°C or lower, thermal decomposition of the polyther ester amide copolymer in the core due to temperature rise can be suppressed, which is preferable.

[0045] The temperature of the melted portion of the joining portion is preferably 235°C or higher and 270°C or lower. When the temperature is 235°C or higher, the polyamide and the polyether ester amide copolymer have melt viscosities suitable for melt spinning, which is preferable. When the temperature is 270°C or lower, decomposition by thermal decomposition of the polyther ester amide copolymer can be suppressed, which is preferable.

[0046] In order to control the cross-sectional uniformity ratio (d/R) of the core-sheath composite fiber of the present invention within such a range, it is necessary to optimize the spinneret design until the core and sheath components are joined to each other depending on the melt viscosities of the core-component and sheath-component polymers.

[0047] Fig. 2 is a longitudinal sectional view of an example of a discharge hole of a spinneret for composite spinning used for the core-sheath composite fiber of the present invention. In Fig. 2, members are laminated in the order of an upper introduction plate 1, a lower introduction plate 2, and a spinneret plate 3 from the top to form a composite spinneret. Hereinafter, in the composite spinneret illustrated in Figs. 2 and 3, a description will be given along a flow of the polymer from upstream to downstream of the composite spinneret.

[0048] The core component polymer flows into a core component introduction hole 1-1 of the upper introduction plate, is metered by a core component narrowing part 1-2 drilled at the lower end, and is then discharged into a core component introduction hole 2-1 of the lower introduction plate. Likewise, the core component polymer that has flowed into the core component introduction hole 2-1 of the lower introduction plate is metered by a core component narrowing part 2-2 drilled at the lower end and then flows into a joining pool 3-1 of the spinneret plate 3.

[0049] The sheath component polymer flows into a sheath component introduction hole 1-3 of the upper introduction plate and is discharged into a sheath component pool 2-3 of the lower introduction plate. On the lower surface of the sheath component pool 2-3 of the lower introduction plate that stores the polymer flowing in from each sheath component introduction hole of the upper introduction plate, a sheath component introduction hole 2-4 for allowing the polymer to flow downstream is drilled. The sheath component polymer that has flowed into the sheath component pool 2-3 is metered by a sheath component narrowing part 2-5 drilled at the lower end and then flows into the joining pool 3-1 of the spinneret plate 3.

[0050] The core polymer and the sheath polymer each flow into the joining pool 3-1 of the spinneret plate 3, flow into a discharge hole 3-3 in a core-sheath composite form, are metered by a discharge hole narrowing part 3-2 drilled at the lower end, and are then discharged.

[0051] In order to maintain the metering property of the core component polymer, it is necessary to perform metering once in the upper introduction plate 1, further perform metering in the lower introduction plate 2, which means twice in total. Since the core component polymer has a low viscosity, by metering the polymer amount twice, the polymer flow can be controlled, and the core component can be located at the true center. In addition, by performing metering in the upper introduction plate 1, it is also intended to increase the pressure of the core component polymer, improve the sealing property between the upper introduction plate 1 and the lower introduction plate 2, and prevent polymer leakage.

[0052] In order to maintain the metering property of the sheath component polymer, it is necessary to set the relationship L/D between the hole length (L) and the hole diameter (D) of the sheath component narrowing part 2-5 of the lower introduction plate 2 to 1.0 to 2.5. By setting L/D to 1.0 or more, the metering property is stabilized, and the cross-sectional uniformity ratio can be set in such a range. When the hole diameter is large and the hole length is small, the metering property is deteriorated, and eccentricity is likely to occur, and when L/D is less than 1.0, the cross-sectional uniformity ratio (d/R) may exceed 7.2. When the hole diameter (D) is excessively reduced in order to enhance the metering property, the polymer foreign matter easily causes clogging, and the cross section tends to be poor. In addition, if the hole length (L) is too large, the back surface pressure of the spinneret increases, the distortion of the spinneret increases, and the pump cannot withstand the polymer pressure, which tends to cause polymer leakage. By setting L/D to 2.5 or less, a uniform cross section can be obtained, and stable yarn making can be performed. L/D is more preferably 1.5 to 2.5.

[0053] As shown in Fig. 3, in the lower introduction plate 2, it is necessary to drill the core component introduction hole 2-1 and three sheath component introduction holes 2-4 around the core component introduction hole 2-1. By setting the number of drilled holes to three, it becomes possible to uniformly fill the joining pool 3-1 of the spinneret plate 3 with the sheath polymer, and the cross-sectional uniformity ratio can be set to such a range. When the number of drilled holes is two or less, the filling of the joining pool 3-1 with the polymer tends to be biased, and the cross-sectional uniformity ratio (d/R) may exceed 7.2. When the number of drilled holes is four or more, it is necessary to design the hole diameter (D) to be small or the hole length (L) to be large in order to maintain the metering property, clogging and leakage are likely to occur, the yarn-making stability is likely to decrease, and the cross section tends to be poor.

[0054] In addition, it is preferable that the discharge rate per hole of the three drilled sheath component introduction holes 2-4 is set to be the same in order to further reduce the cross-sectional uniformity ratio (d/R), and for this reason, it is preferable that the holes are drilled at point-symmetric points, that is, on the same orbit.

[0055] Fig. 4 shows an embodiment of a production device employing a direct spinning-drawing method preferably used in a method for producing the polyamide core-sheath composite fiber of the present invention.

[0056] The polyamide (sheath) and the polyether ester amide copolymer (core) are separately melted, metered and transported by a gear pump, and discharged from a composite spinneret 4 to form each filament. Each filament discharged from the composite spinneret 4 in this manner is cooled and solidified to room temperature by blowing cooling air to the filament with a yarn cooling device 5 such as a chimney. Thereafter, an oil is applied with an oiling device 6, and the filaments are converged to form multifilaments, the multifilaments are entangled with a fluid entangling nozzle device 7 and pass through a take-up roller 8 and a drawing roller 9, and at that time, the multifilaments are drawn according to the ratio of the circumferential velocities of the take-up roller 8 and the drawing roller 9. Furthermore, the yarn is heat-treated by heating the drawing roller 9 and wound with a winding device.

[0057] The production of the polyamide core-sheath composite fiber of the present invention can be achieved by any method using a cooling device that blows cooling/rectifying air from a certain direction, an annular cooling device that blows cooling/rectifying air from the outer peripheral side toward the central side, or an annular cooling device that blows cooling/rectifying air from the central side toward the outer periphery as the cooling device 5. A vertical distance Ls (hereinafter referred to as a cooling start distance) from the lower surface of the spinneret to the upper end of the cooling air blowing part of the cooling device 5 is preferably in the range of 159 to 219 mm from the viewpoint of suppressing yarn swinging and fiber unevenness, more preferably 169 to 189 mm. The cooling air velocity blown out from the cooling air blowing surface is preferably in the range of 20.0 to 40.0 (m/min) on average in the section from the upper end surface to the lower end surface of the cooling air blowing part from the viewpoint of fineness unevenness and strength.

[0058] In the production of the polyamide core-sheath composite fiber of the present invention, the polymer discharged from the spinneret is blown with cooling air from the cooling device to be solidified into yarns, and the yarns are drawn in the section from the solidification position to the oiling position by spinning tension with accompanying flow and then mechanically drawn between the take-up roller and the drawing roller. As for the core-sheath composite fiber of the present invention, it is important to perform mechanical drawing in order to promote the orientation crystallization of the sheath polymer to increase the strength, and to decrease the spinning tension in order to suppress the orientation crystallization of the core polymer to improve the moisture-absorbing capability. Therefore, the position of the oiling device 6, that is, a vertical distance Lg (hereinafter referred to as an oiling position Lg) from the lower surface of the spinneret to the oiling nozzle position of the oiling device 6 in Fig. 4 is preferably 800 to 1,500 mm, more preferably 1,000 to 1,300 mm, although it depends on the single yarn fineness and the cooling efficiency of the filament from the cooling device. When the oiling position is less than 800 mm, the filament is not sufficiently cooled and is damaged due to contact with an oiling guide while having an unstable structure, so that not only the single yarn strength of the filament decreases, but also fluff tends to increase. In particular, as the sheath thickness is thinner, which means a smaller single yarn fineness, a higher core ratio, a higher cross-sectional uniformity ratio, and the like, damage is more likely to occur, and the above phenomenon may be remarkably produced. On the other hand, if the oiling position is more than 1500 mm, not only the orientation crystallization of the core polymer proceeds due to the high spinning tension to decrease the moisture-absorbing capability, but also the mechanical draw ratio is reduced, which may cause decrease in the strength and generation of fluff.

[0059] In the drawing step in the production of the polyamide core-sheath composite fiber of the present invention, the spinning conditions are preferably set so that the product of the velocity (spinning velocity) of the yarn taken up by the take-up roller and the draw ratio, which is the value of the circumferential velocity ratio between the take-up roller and the drawing roller, is 3,300 or more and 4,500 or less. The product is more preferably 4,000 or less. This numerical value represents the total amount of drawing of the polymer discharged from the spinneret from the spinneret discharge linear velocity to the circumferential velocity of the take-up roller, and further from the circumferential velocity of the take-up roller to the circumferential velocity of the drawing roller. Setting the value within this range makes it possible to appropriately draw the polyamide in the sheath. When the value is 3,300 or more, crystallization of the polyamide in the sheath proceeds, so that the raw yarn strength is improved, which is preferable. When the value is 4,500 or less, crystallization of the polyamide in the sheath proceeds appropriately, and yarn breakage and fluff generation during yarn making are small, which is preferable.

[0060] As fabrics are required to be thin, lightweight, and soft and to have a low air permeability, fibers become finer in terms of the fineness and single yarn fineness, and the single yarn strength of the polyamide core-sheath composite fiber composed of a polyamide in the sheath and a polyether ester amide copolymer in the core is decreased. Further, as the area ratio of the core increases, and as the single yarn fineness decreases, the sheath thickness of the polyamide in the sheath responsible for the single yarn strength decreases, and the single yarn strength decreases.

[0061] On the other hand, in the case of a polyamide single-component fiber, it is commonly carried out to appropriately adjust the draw ratio within a range in which the elongation required for high-order processing can be maintained in order to secure the single-yarn strength, but in the polyamide core-sheath composite fiber of the present invention, as the sheath thickness decreases, the sheath tends to burst as the draw ratio increases, so that much single-yarn fluff is generated, the high-order passability deteriorates, and the product quality deteriorates. Therefore, in the polyamide core-sheath composite fiber of the present invention, it is necessary to set the strength and the cross-sectional uniformity ratio within the above ranges. For this purpose, it is necessary to set production conditions for making the sheath thickness uniform while securing the strength of the polyamide in the sheath.

[0062] Depending on the core-sheath composite ratio, the single yarn fineness, and the cooling efficiency of the filament from the cooling device, when the oiling position is set to 800 to 1,500 mm from the spinneret surface, and the product of the spinning velocity and the draw ratio is set to 3,300 or more and 4,500 or less, optimum stress is applied to the polyamide in the sheath during spinning, and appropriate drawing can be applied, so that crystallization of the polyamide in the sheath proceeds, and the strength can be controlled within the above range.

[0063] By adopting a composite spinneret suitable for the flow balance, the flow balance (melt viscosity ratio) of a polyamide having a melt viscosity of 900 to 1,500 poise and a polyether ester amide copolymer having a melt viscosity of 400 to 600 poise, discharge stability can be secured, and the cross-sectional uniformity ratio can be controlled within the above range.

[0064] By adopting such a composite spinneret and yarn-making conditions, a core-sheath composite fiber excellent in the humidity-absorbing property and the antistatic property having a strength of 3.6 cN/dtex or more and a cross-sectional uniformity ratio d/R of the core and sheath components of the entire filament of 0.072 or less can be obtained. In particular, this effect is remarkably exhibited in the case where the sheath thickness is relatively small, the single yarn fineness is 2.0 dtex or less, and the area ratio of the core is 20% or more.

[0065] The core-sheath composite fiber of the present invention is excellent in the humidity-absorbing property and the antistatic property and thus can be preferably used for clothing. The fabric form can be selected according to a purpose such as a woven fabric and a knitted fabric. The clothing items may be various clothing products such as underwear and sportswear.

EXAMPLES

[0066] Hereinafter, the present invention will be described more specifically with reference to examples. A method of measuring characteristic values in the examples is as follows.

(1) Sulfuric acid relative viscosity

[0067] After dissolving 0.25 g of a chip sample so as to be 1 g with respect to 100 ml of 98 wt% sulfuric acid, a flow time (T1) at 25°C was measured using an Ostwald viscometer. Subsequently, a flow time (T2) of 98 wt% sulfuric acid was measured. The ratio of T1 to T2, that is, T1/T2 was defined as the sulfuric acid relative viscosity.

(2) Ortho-chlorophenol relative viscosity (OCP relative viscosity)

[0068] After dissolving 0.5 g of a chip sample so as to be 1 g with respect to 100 ml of ortho-chlorophenol, the flow time (T1) at 25°C was measured using an Ostwald viscometer. Then, the flow time (T2) of ortho-chlorophenol was measured. The ratio of T1 to T2, that is, T1/T2 was defined as the sulfuric acid relative viscosity.

(3) Melt viscosity

[0069] A chip sample was caused to have a moisture content of 200 ppm or less with a vacuum dryer, and the melt viscosity was measured with Capilograph 1B manufactured by Toyo Seiki Seisaku-sho, Ltd. while changing the strain rate stepwise. The measurement temperature was set to a spinning temperature, and the measurement was performed in a nitrogen atmosphere with the period of time from when the sample was put into a heating furnace to the start of the measurement being set to 5 minutes.

(4) Fineness and single yarn fineness

[0070] A fiber sample was set on a sizing reel having a perimeter of 1.125 m and rotated 200 times to make a looped skein. The skein was dried (105 ± 2°C × 60 minutes) with a hot air dryer, and the skein mass was measured with a balance. The fineness was calculated from the value obtained by multiplying the skein mass by the official regain. The official regain of the core-sheath composite fiber was set to 4.5%.

(5) Strength and elongation

[0071] A fiber sample was measured with "TENSILON" (registered trademark) UCT-100 manufactured by Orientec Co., Ltd. under the constant rate extension conditions shown in JIS L 1013 (Testing methods for man-made filament yarns, 2010). The elongation was calculated from the elongation at the point showing maximum strength in the tensile strength-elongation curve. In addition, for the strength, the value obtained by dividing the maximum strength by the fineness was defined as strength. The measurement was performed 10 times, and the average values therefor were defined as the strength and the elongation.

(6) Cross-sectional uniformity ratio and cross-sectional uniformity

A. Photographing of transverse cross-section

[0072] An embedding agent composed of paraffin, stearic acid, and ethyl cellulose was dissolved, fibers were introduced and then solidified by being left standing at room temperature, and a raw yarn in the embedding agent was cut in a transverse cross-sectional direction. The transverse cross section of the fiber was photographed with a CCD camera (CS 5270) manufactured by Tokyo Electronics Co., Ltd., and the image was printed out at a magnification of 1,500 times with a color video processor (SCT-CP 710) manufactured by Mitsubishi Electric Corporation.

B. Measurement of cross-sectional uniformity ratio

[0073] As illustrated in Fig. 1, the distance (d) between the center point (point C) of the inscribed circle of the core component and the center point (point S) of the inscribed circle of the sheath component and the diameter (R) of the inscribed circle of the sheath component are measured, and calculation is performed. The cross sections of all the filaments of the core-sheath composite yarn were each measured, and the average value therefor was taken as the cross-sectional uniformity ratio.

C. Cross-Sectional Uniformity

[0074] Cross-sections of all the filaments of the core-sheath composite yarn were visually observed and evaluated according to the following criteria.

A: A uniform cross section without variations in circular shape and size of the sheath component and the core component is observed.
C: A poor cross section showing variations in circular shape and size of the sheath component and the core component is observed.

(7) Amount of fluff

[0075] A fiber sample was rewound at a velocity of 500 m/min, a laser-type fluff detector was installed at a position 2 mm away from the yarn during rewinding, and the total number of detected defects was converted into the number per 100,000 m and displayed. A value of 2 pieces/100,000 m or less was regarded as acceptable.

(8) Specific resistance

[0076] A fiber sample is sufficiently scoured in a 0.2-wt% weak alkaline aqueous solution of an anionic surfactant to remove oil and the like and then sufficiently rinsed and dried. Next, the sample is aligned to form a fiber bundle having a length (L) of 5 cm and a total fineness (D) of 2,200 dtex (2,000 denier), subjected to humidity conditioning by being left standing for 2 days under the conditions of a temperature of 20°C and a humidity of 40% RH, and then measured for the resistance of the sample at an applied voltage of 500 V with a vibrating reed minute-potential electrometer, and calculation is performed by the following formula.

$\rho = (R \times 0.9D)/(9 \times 10^5 \times L \times d \times 10^4)$
ρ: Volume resistivity ($\Omega \cdot$cm), R: resistance (Ω), D: fineness (dtex), L: sample length (cm), d: sample density (g/m2).

(9) ΔMR

[0077] About 1 to 2 g of a fiber sample (or woven fabric) was weighed in a weighing bottle and held at 110°C for 2 hours to be dried, and the weight (W0) was measured. Then, a target substance was held at 20°C and a relative humidity of 65% for 24 hours, and then the weight (W65) was measured. Then, the target substance was held at 30°C and a relative humidity of 90% for 24 hours, and then the weight (W90) was measured. Then, the ΔMR was calculated according to the following formulae.

$$MR65 = [(W65 - W0)/W0] \times 100\% \cdots\cdots (1)$$

$$MR90 = [(W90 - W0)/W0] \times 100\% \cdots\cdots (2)$$

$$\Delta MR = MR90 - MR65 \qquad \cdots\cdots\cdots\cdots (3)$$

(10) High-order passability

[0078] Using a water jet loom, the number of times the loom stops due to yarn breakage when 10 rolls (1,000 m/roll) plain-weave fabrics were woven at a loom rotation speed of 750 rpm and a weft length of 1,620 mm was evaluated according to the following criteria.

> S: Less than twice, A: twice or more and less than four times, B: four times or more and less than six times, C: six times or more
> S, A, and B were defined as acceptable process passability.

[Example 1]

(Production of polyamide core-sheath composite fiber)

[0079] As the polyether ester amide copolymer, polyether ester amide copolymer (MH 1657 manufactured by ARKEMA K.K., ortho-chlorophenol relative viscosity: 1.69, melting point: 200°C, melt viscosity: 450 poise (260°C)) chips containing nylon 6 as the polyamide component and polyethylene glycol having a molecular weight of 1,500 as the polyether component and having a molar ratio between nylon 6 and polyethylene glycol of 24% : 76% was used for the core. Master chips caused to contain a half-hindered phenolic antioxidant: 2,2'-dimethyl-2,2'-(2,4,8,10-tetraoxaspiro[5.5]undecane-3,9-diyl)dipropane-1,1'-diyl=bis[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propanoate] (ADK STAB AO-80 manufactured by ADEKA Corporation) in the polyether ester amide copolymer at a high concentration using a twin screw extruder in advance were blended with polyether ester amide copolymer chips to adjust the content to 3.0 wt% with respect to the weight of the core.

[0080] As the polyamide, nylon 6 chips that did not contain titanium oxide and had a sulfuric acid relative viscosity of 2.73, a melting point of 215°C, and a melt viscosity of 1,250 poise were used for the sheath.

[0081] The polyether ester amide copolymer as the core and nylon 6 as the sheath were melted at 240°C as the temperature of the melted portion of the core and 270°C as the temperature of the melted portion of the sheath and discharged from a concentric core-sheath composite spinneret of a 3-plate structure illustrated in Figs. 2 and 3 employing a number of times of core metering of 2, a number of drilled sheath component introduction holes 2-4 of 3, a hole length (L) of the sheath component narrowing part 2-5 of the lower introduction plate 2 for metering the sheath component of 0.3 mm, a hole diameter (D) of 0.2 mm, and a number of discharge holes of the spinneret plate 3 of 24 at a spinning temperature of 265°C such that the core/sheath ratio (wt%) was 30/70.

[0082] Using the composite spinning machine illustrated in Fig. 4, the yarn is passed through a yarn cooling device with a cooling start distance Ls of 100 mm with cold air having an air temperature of 18°C and an air velocity of 30 m/min to cool and solidify the yarn to room temperature. Thereafter, a non-hydrous oil was applied at an oiling position Lg from the spinneret surface of 1,300 mm, and the filaments were bundled to form multifilaments. After the non-hydrous oil was supplied using an oiling device, entanglement was applied with a first fluid entangling nozzle device. The multifilaments were drawn at a circumferential velocity of a take-up roller as a first roll of 3,255 m/min and a circumferential velocity of a drawing roller as a second roll of 4,167 m/min, heat-set at a draw ratio of 1.28 times with the drawing roller at 150°C, and wound at a relaxation rate of 4.0% and a winding velocity of 4,000 m/min to provide two core-sheath composite yarns of 22 dtex and 12 filaments. The physical properties of the raw yarns are as shown in Table 1.

(Production of woven fabric)

[0083] The core-sheath composite fibers were used as a warp and a weft, and a plain weave structure was woven at a warp density of 188 yarns/2.54 cm and a weft density of 155 yarns/2.54 cm.

[0084] The obtained gray fabric was scoured with an open soaper in a solution containing 2 g of caustic soda (NaOH) per liter by a conventional method, dried at 120°C with a cylinder dryer, then pre-set at 170°C, subjected to a dyeing treatment at 98°C for 60 minutes using an acidic dye (Nylosan Blue-GFL 167% (manufactured by Sandoz Ltd.) 1.0% owf and a fixing treatment at 80°C for 20 minutes using 3 g/l of synthetic tannin (NYLONFIX 501 manufactured by Senka Corporation) with a jet dyeing machine, then dried (120°C), and finish-set (175°C). Thereafter, calendering (processing conditions: cylinder processing, heating roll surface temperature: 180°C, heating roll load: 147 kN, cloth running velocity: 20 m/min) was performed once on both surfaces of the woven fabric to provide a woven fabric having a warp density of 210/2.54 cm and a weft density of 160/2.54 cm. The results of evaluation of the resulting woven fabric are shown in Table 1.

[Examples 2 and 3 and Comparative Examples 1 and 2]

[0085] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that a spinneret having L/D changed as shown in Table 1 in the sheath component narrowing part 2-5 of the lower introduction plate 2 for metering the sheath component was used, and woven fabrics were produced. The results are shown in Table 1.

[Comparative Examples 3 and 4]

[0086] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that a spinneret having the core component introduction hole 2-1 and the number of drilled sheath component introduction holes 2-4 around the core component introduction hole 2-1 changed as shown in Table 1 in the lower introduction plate 2 was used, and woven fabrics were produced. The results are shown in Table 1.

[Comparative Example 5]

[0087] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that a spinneret (not shown) employing a two-plate structure, a number of times of core metering of one, a number of drilled holes of three, and L/D of the sheath component narrowing part for metering the sheath component changed as shown in Table 1 was used, and a woven fabric was produced. The results are shown in Table 1.

[Table 1-1]

		Example 1	Example 2	Example 3	Comparative Example 1
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	**2.73**	**2.73**	**2.73**	**2.73**
Spinneret	Drawing	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3
	Configuration	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice
	Sheath component introduction hole: number of drilled holes	**3**	**3**	**3**	**3**
	Sheath component narrowing part: L/D	**1.5**	**2.0**	**2.5**	**1.0**
Yarn making conditions	Spinning velocity (m/min)	**3255**	**3255**	**3255**	**3255**
	Draw ratio	**1.28**	**1.28**	**1.28**	**1.28**
	Product	**4166**	**4166**	**4166**	**4166**
	Oiling position (mm)	**1300**	**1300**	**1300**	**1300**
Yarn characteristics	Fineness (dtex)	**22**	**22**	**22**	**22**
	Number of filaments	**12**	**12**	**12**	**12**
	Single yarn fineness	**1.8**	**1.8**	**1.8**	**1.8**
	Core ratio (%)	**30**	**30**	**30**	**30**
	Cross-sectional uniformity	**A**	**A**	**A**	**A**
	Cross-sectional uniformity ratio d/R	**0.045**	**0.030**	**0.020**	**0.075**
	Strength (cN/dtex)	**4.2**	**4.2**	**4.2**	**4.2**
	Elongation (%)	**44**	**44**	**44**	**44**
	ΔMR (%)	**10.0**	**10.0**	**10.0**	**10.0**
	Specific resistance (log Ω·cm)	**8.8**	**8.8**	**8.8**	**8.8**
	Amount of fluff (pieces/100,000 m)	**1.0**	**0.5**	**0.0**	**5.0**
High-order passability		**A**	**S**	**S**	**C**

[Table 1-2]

		Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
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	2.73	2.73	2.73	2.73
Spinneret	Drawing	Figs. 2 and 3	Fig. 2	Fig. 2	Not shown
	Configuration	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Two-plate structure, core metered once
	Sheath component introduction hole: number of drilled holes	3	2	4	3
	Sheath component narrowing part: L/D	3.0	1.5	1.5	1.5
Yarn making conditions	Spinning velocity (m/min)	3255	3255	3255	3255
	Draw ratio	1.28	1.28	1.28	1.28
	Product	4166	4166	4166	4166
	Oiling position (mm)	1300	1300	1300	1300
Yarn characteristics	Fineness (dtex)	22	22	22	22
	Number of filaments	12	12	12	12
	Single yarn fineness	1.8	1.8	1.8	1.8
	Core ratio (%)	30	30	30	30
	Cross-sectional uniformity	C	A	C	A
	Cross-sectional uniformity ratio d/R	-	0.090	-	0.095
	Strength (cN/dtex)	4.2	4.2	4.2	4.2
	Elongation (%)	44	44	44	44
	ΔMR (%)	10.0	10.0	10.0	10.0
	Specific resistance (log Ω·cm)	8.8	8.8	8.8	8.8
	Amount of fluff (pieces/100,000 m)	-	7.0	-	9.0
High-order passability		-	C	-	C

[0088] In Examples 1 to 3 of the present invention, generation of fluff was suppressed, and high-order passability was excellent.

In Comparative Example 1 in which L/D of the sheath component narrowing part of the lower introduction plate for measuring the sheath component was small, Comparative Example 3 in which the number of drilled holes was small, and Comparative Example 5 in which the core metering was performed once, the metering property of the polyether ester amide copolymer polymer was poor, the cross-sectional uniformity ratio was high, which indicated that bias was observed, and fluff and high-order passability were poor. In Comparative Example 2 having a large L/D and Comparative

Example 4 having a large number of drilled holes, the cross-section was not uniform, and the yarn-making stability was poor.

[Examples 4 and 5 and Comparative Examples 6 and 7]

[0089] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that the oiling position Lg was changed as shown in Table 2 and the spinning velocity and the draw ratio were adjusted as shown in Table 2, and woven fabrics were produced. The results are shown in Table 2.

[Examples 6 to 8]

[0090] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that the core ratio (wt%) was changed as shown in Table 2 and the spinning velocity and the draw ratio were adjusted as shown in Table 2, and woven fabrics were produced. The results are shown in Table 2.

[Table 2-1]

		Example 4	Example 5	Comparative Example 6	Comparative Example 7
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	**2.73**	**2.73**	**2.73**	**2.73**
Spinneret	Drawing	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3
	Configuration	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice
	Sheath component introduction hole: number of drilled holes	**3**	**3**	**3**	**3**
	Sheath component narrowing part: L/D	**1.5**	**1.5**	**1.5**	**1.5**
Yarn making conditions	Spinning velocity (m/min)	**3086**	**3472**	**2976**	**3623**
	Draw ratio	**1.35**	**1.2**	**1.4**	**1.15**
	Product	**4166**	**4166**	**4166**	**4166**
	Oiling position (mm)	**1500**	**1000**	**1800**	**600**
Yarn characteristics	Fineness (dtex)	**22**	**22**	**22**	**22**
	Number of filaments	**12**	**12**	**12**	**12**
	Single yarn fineness	**1.8**	**1.8**	**1.8**	**1.8**
	Core ratio (%)	**30**	**30**	**30**	**30**
	Cross-sectional uniformity	**A**	**A**	**A**	**A**
	Cross-sectional uniformity ratio d/R	**0.045**	**0.045**	**0.045**	**0.045**
	Strength (cN/dtex)	**4.4**	**4.0**	**3.4**	**3.5**
	Elongation (%)	**44**	**42**	**44**	**42**
	ΔMR (%)	**10.0**	**10.0**	**10.0**	**9.5**
	Specific resistance (log Ω·cm)	**8.8**	**8.8**	**8.8**	**8.8**
	Amount of fluff (pieces/100,000 m)	**1.5**	**0.8**	**2.5**	**2.5**
High-order passability		**A**	**A**	**C**	**C**

[Table 2-2]

		Example 6	Example 7	Example 8
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	**1.69**	**1.69**	**1.69**
Sheath component	Polymer	**Nylon 6**	**Nylon 6**	**Nylon 6**
	Sulfuric acid relative viscosity	**2.73**	**2.73**	**2.73**
Spinneret	Drawing	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3
	Configuration	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice
	Sheath component introduction hole: number of drilled holes	**3**	**3**	**3**
	Sheath component narrowing part: L/D	**1.5**	**1.5**	**1.5**
Yarn making conditions	Spinning velocity (m/min)	**2750**	**3000**	**3700**
	Draw ratio	**1.5**	**1.4**	**1.15**
	Product	**4125**	**4200**	**4255**
	Oiling position (mm)	**1300**	**1300**	**1300**
Yarn characteristics	Fineness (dtex)	**22**	**22**	**22**
	Number of filaments	**12**	**12**	**12**
	Single yarn fineness	**1.8**	**1.8**	**1.8**
	Core ratio (%)	**20**	**25**	**40**
	Cross-sectional uniformity	**A**	**A**	**A**
	Cross-sectional uniformity ratio d/R	**0.045**	**0.045**	**0.055**
	Strength (cN/dtex)	**4.9**	**4.5**	**3.7**
	Elongation (%)	**44**	**44**	**44**
	ΔMR (%)	**6.7**	**8.3**	**13.3**
	Specific resistance (log Ω·cm)	**9.8**	**9.3**	**8.3**
	Amount of fluff (pieces/100,000 m)	**1.0**	**1.0**	**1.5**
High-order passability		**A**	**A**	**B**

[0091] In Examples 4 to 8 of the present invention, the humidity-absorbing property and the antistatic property were exhibited, generation of fluff was suppressed while the strength was maintained, and the high-order passability was excellent.

[0092] In Comparative Example 6 in which the oiling position Lg was long from the bottom of the spinneret, appropriate drawing could not be applied to the polyamide in the sheath, the strength was reduced, the fluff was increased, and the high-order passability was poor. In Comparative Example 7 in which the oiling position Lg was short from the bottom of the spinneret, the filament was not sufficiently cooled and was damaged due to contact with the oiling guide while having an unstable structure, so that the strength slightly decreased, the fluff increased, and the high-order passability was poor. In Example 8 having a high core ratio, the sheath was thinner, the strength was slightly lower, and the amount of fluff was slightly greater than in Example 1, but the high-order passability was at an acceptable level.

[Examples 9 and 10]

[0093] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that the number of discharge holes was changed, the number of filaments was changed as shown in Table 3, and the spinning velocity, the draw ratio, and the oiling position were adjusted as shown in Table 3, and woven fabrics were produced. The results are shown in Table 3.

[Example 11]

[0094] Core-sheath composite yarns were provided by spinning in the same manner as in Example 1 except that nylon 6 chips having a sulfuric acid relative viscosity of 2.63, a melting point of 215°C, and a melt viscosity of 1,000 poise and containing 1.8% of titanium oxide were used as the polyamide in the sheath, and the spinning velocity and the draw ratio were adjusted as shown in Table 3, and a woven fabric was produced. The results are shown in Table 3.

[Table 3]

		Example 9	Example 10	Example 11
Core component	Polymer	Polyether ester amide copolymer	Polyether ester amide copolymer	Polyether ester amide copolymer
	OCP relative viscosity	1.69	1.69	1.69
Sheath component	Polymer	Nylon 6	Nylon 6	Nylon 6
	Sulfuric acid relative viscosity	2.73	2.73	2.63
Spinneret	Drawing	Figs. 2 and 3	Figs. 2 and 3	Figs. 2 and 3
	Configuration	Three-plate structure, core metered twice	Three-plate structure, core metered twice	Three-plate structure, core metered twice
	Sheath component introduction hole: number of drilled holes	3	3	3
	Sheath component narrowing part: L/D	1.5	1.5	1.5
Yarn making conditions	Spinning velocity (m/min)	2800	3350	3500
	Draw ratio	1.5	1.25	1.2
	Product	4200	4188	4200
	Oiling position (mm)	1300	1000	1300
Yarn characteristics	Fineness (dtex)	22	22	22
	Number of filaments	7	22	12
	Single yarn fineness	3.1	1.0	1.8
	Core ratio (%)	30	30	30
	Cross-sectional uniformity	A	A	A
	Cross-sectional uniformity ratio d/R	0.045	0.055	0.055
	Strength (cN/dtex)	4.4	3.9	3.8
	Elongation (%)	44	44	42
	ΔMR (%)	9.5	10.5	9.5
	Specific resistance (log Ω·cm)	8.5	9.5	8.5
	Amount of fluff (pieces/100,000 m)	0.7	1.5	1.5
High-order passability		A	B	B

DESCRIPTION OF REFERENCE SIGNS

[0095]

1: Upper introduction plate
1-1: Core component introduction hole
1-2: Core component narrowing part
1-3: Sheath component introduction hole
2: Lower introduction plate
2-1: Core component introduction hole
2-2: Core component narrowing part

2-3: Sheath component pool
2-4: Sheath component introduction hole
2-5: Sheath component narrowing part
3: Spinneret plate
3-1: Joining pool
3-2: Discharge hole narrowing part
3-3: Discharge hole
4: Spinneret
5: Cooling device
6: Oiling device
7: Fluid entangling nozzle device
8: Take-up roller
9: Drawing roller
10: Winding device
Lg: Oiling position
Ls: Cooling start distance

Claims

1. A polyamide core-sheath composite fiber having a strength of 3.6 cN/dtex or greater, a cross-sectional uniformity ratio d/R of core and sheath components in a transverse cross-section of the fiber of 0.072 or less, and an electrical specific resistance of 10^7 to 10^{10} $\Omega\cdot$cm in a core-sheath composite multifilament including a sheath polymer formed from a polyamide and a core polymer formed from a polyether ester amide copolymer,

   wherein d is a distance between a center of an inscribed circle of the core component and a center of an inscribed circle of the sheath component, and
   R is a diameter of the inscribed circle of the sheath component.

2. The polyamide core-sheath composite fiber according to claim 1, wherein a single yarn fineness is 0.8 to 2.0 dtex, and an area ratio of a core in the transverse cross-section of the fiber is 20 to 40%.

3. A fabric comprising the polyamide core-sheath composite fiber according to claim 1 or 2 in at least a part thereof.

Figure 1

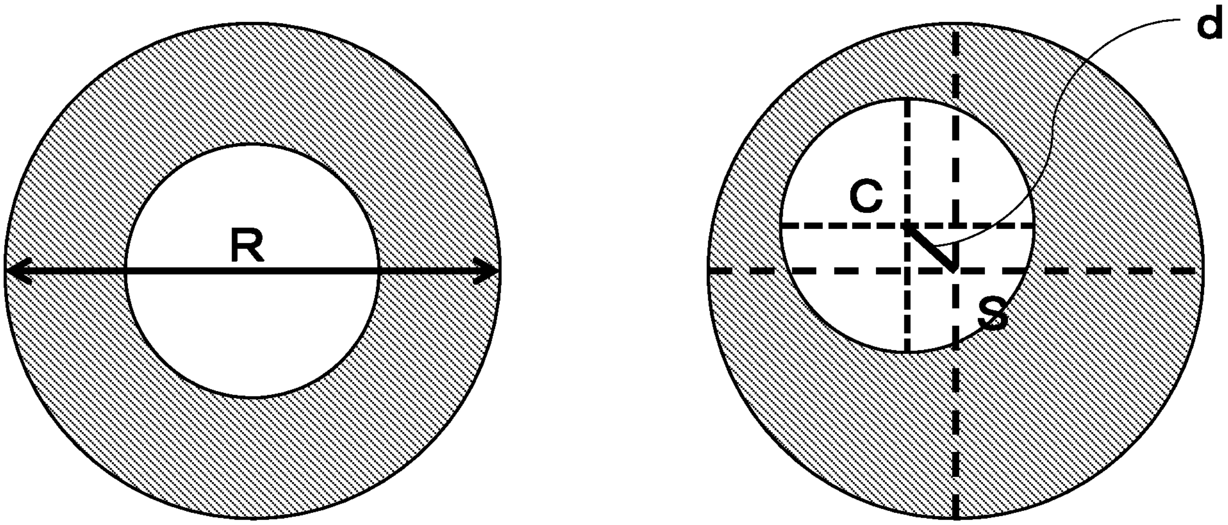


Figure 2

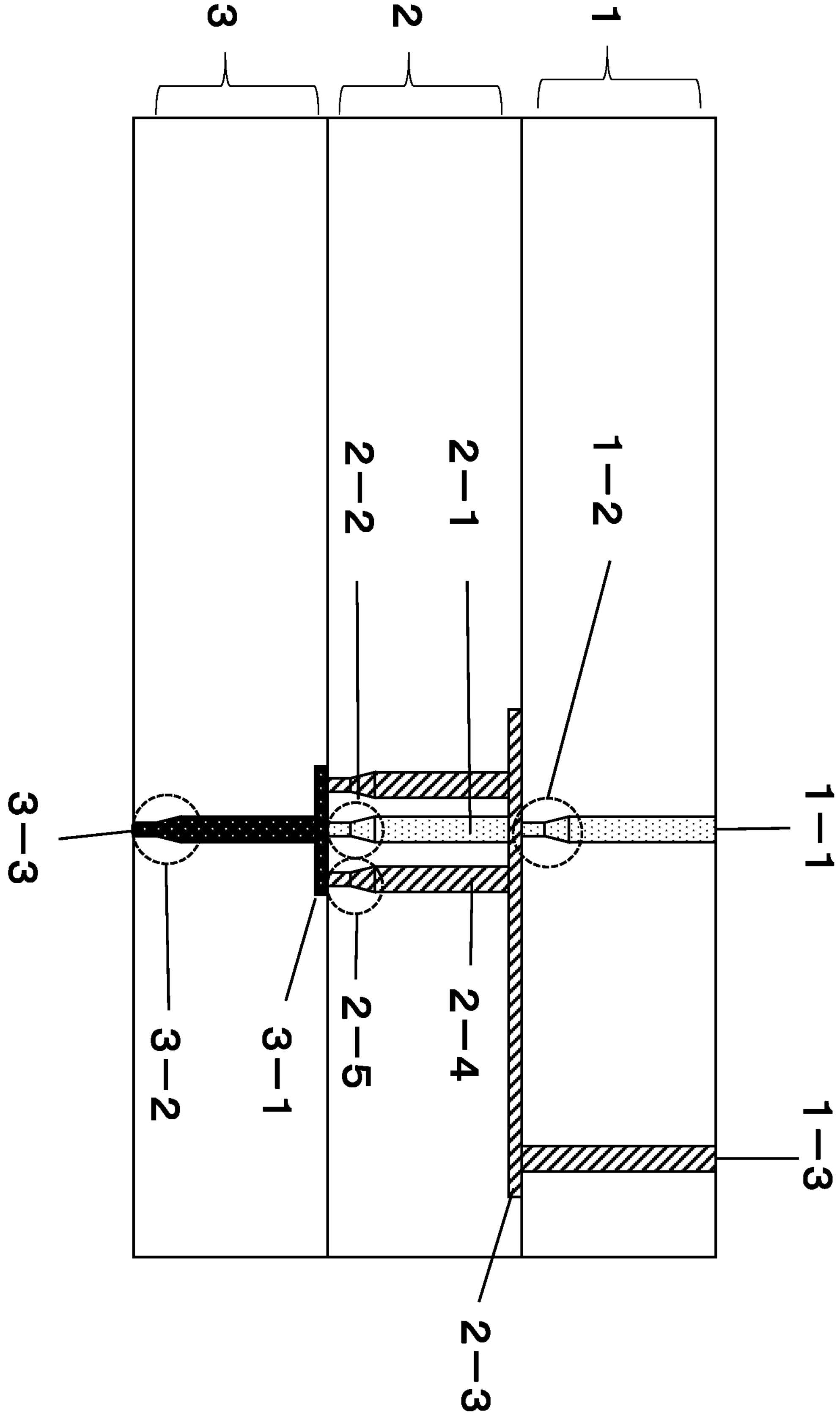


Figure 3

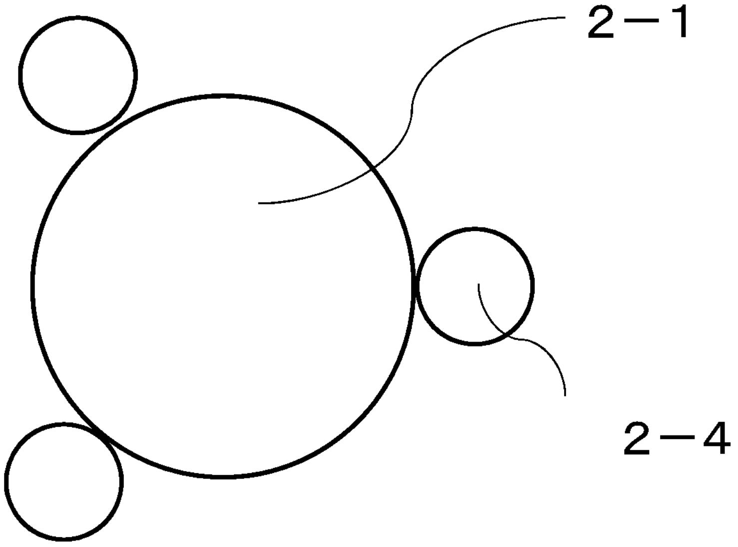
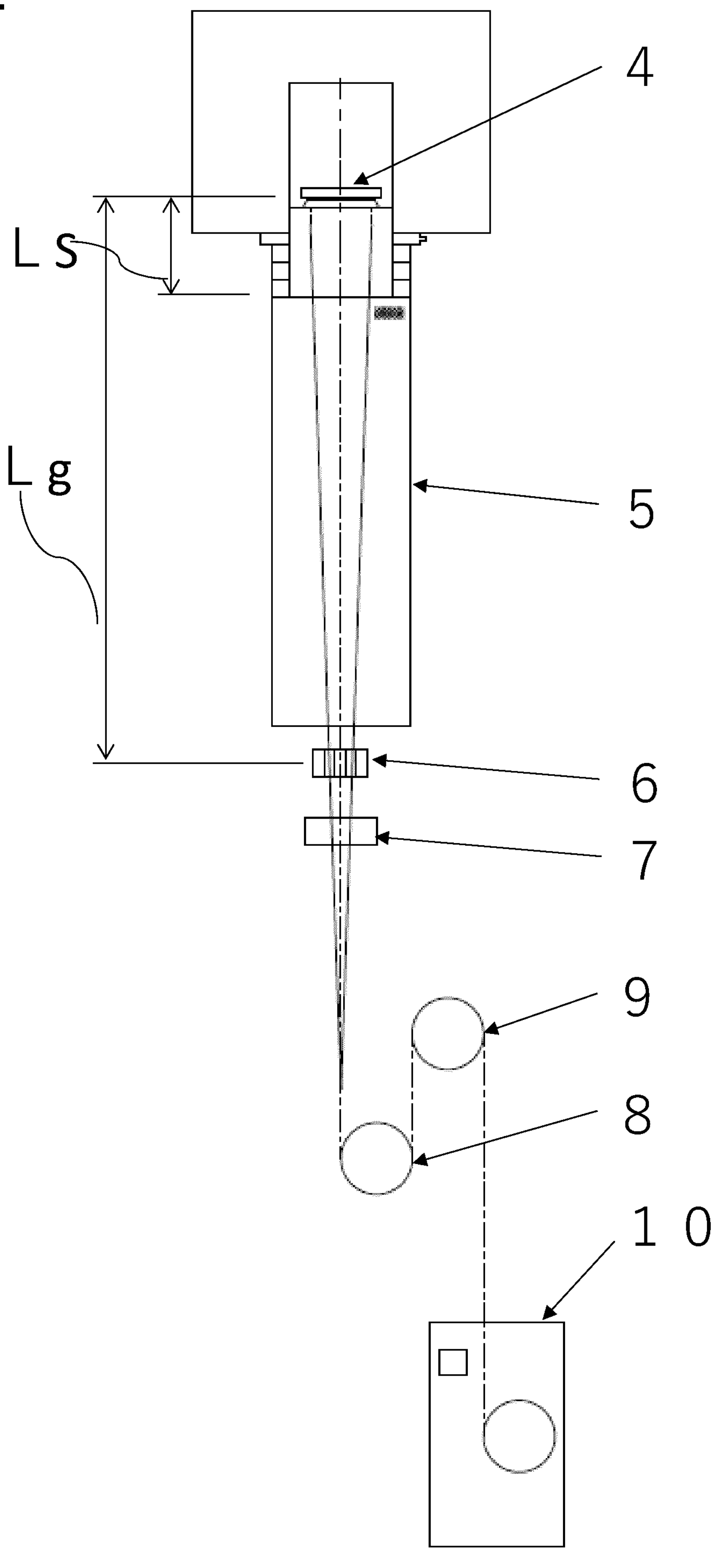


Figure 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/033633

A. CLASSIFICATION OF SUBJECT MATTER

D01F 8/12(2006.01)i
FI: D01F8/12 A

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)

D01D1/00-13/02, D01F8/00-8/18

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

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

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2017/098861 A1 (TORAY INDUSTRIES) 15 June 2017 (2017-06-15) claims, paragraphs [0045], [0049]	1-3
Y	JP 63-190007 A (KURARAY CO LTD) 05 August 1988 (1988-08-05) page 2, lower left column, lines 4-17, fig. 5	1-3
A	JP 2017-057513 A (TORAY INDUSTRIES) 23 March 2017 (2017-03-23)	1-3
A	WO 2017/082110 A1 (TORAY INDUSTRIES) 18 May 2017 (2017-05-18)	1-3

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

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search **08 November 2021**	Date of mailing of the international search report **22 November 2021**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/033633

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2017/098861 A1	15 June 2017	US 2018/0363169 A1 claims, paragraphs [0044], [0049] EP 3388562 A1 CN 108350608 A KR 10-2018-0090247 A	
JP 63-190007 A	05 August 1988	(Family: none)	
JP 2017-057513 A	23 March 2017	(Family: none)	
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- WO 201410709 A **[0006]**
- JP 2017057513 A **[0006]**