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(54) **ACRYLIC FIBER FOR ARTIFICIAL HAIR, CRIMPED ACRYLIC FIBER FOR ARTIFICIAL HAIR, HAIR ORNAMENT PRODUCT INCLUDING THE SAME, AND PRODUCTION METHOD THEREFOR**

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D01D 5/253	(2006.01)
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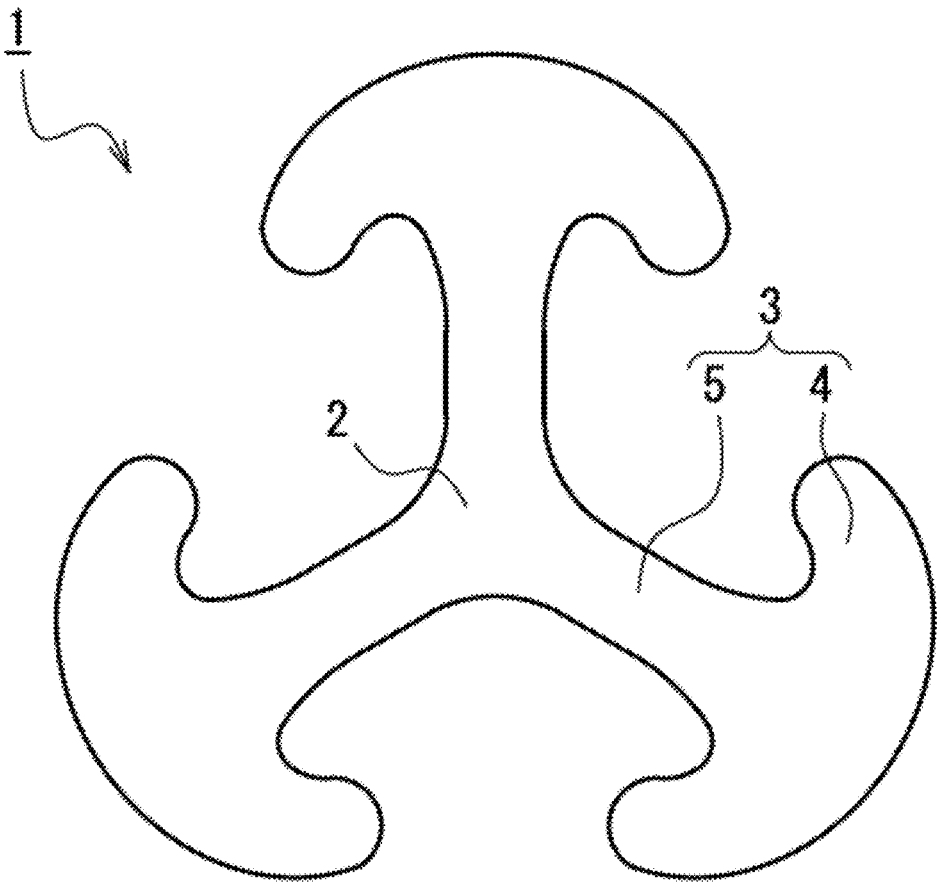
(57) **ABSTRACT**

The present invention relates to an acrylic fiber for artificial hair containing an acrylic copolymer. The dry-heat shrinkage ratio of the acrylic fiber after dry-heat treatment at 90 to 180° C. for 30 minutes is 30 to 70%, and the torsional rigidity thereof is 0.3 to 2.0 mg·cm^2. Also, one or more embodiments of the present invention relate to a crimped acrylic fiber for artificial hair containing an acrylic copolymer. In the crimped acrylic fiber, the number of crimps is 10 or more crimps per 10 cm, and the crimp height is 1.5 mm or more. In addition, in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.



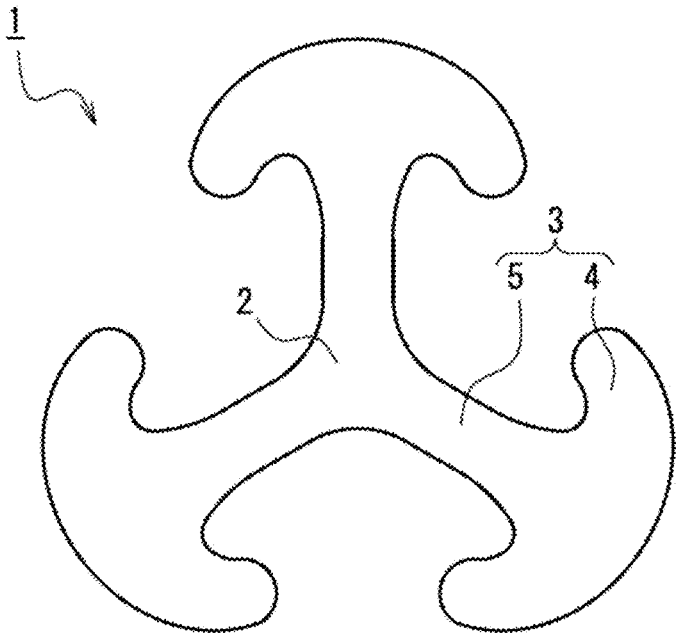


FIG. 1

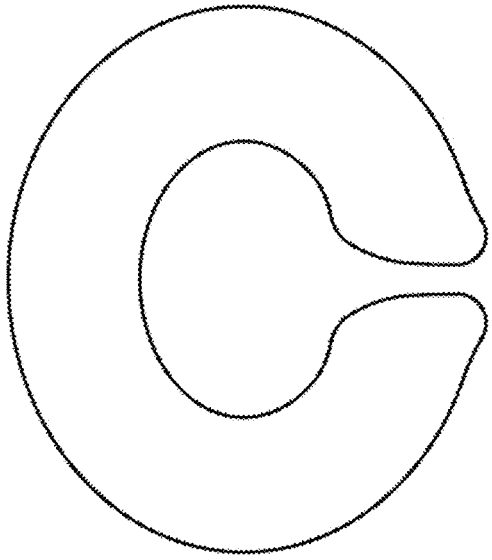


FIG. 2

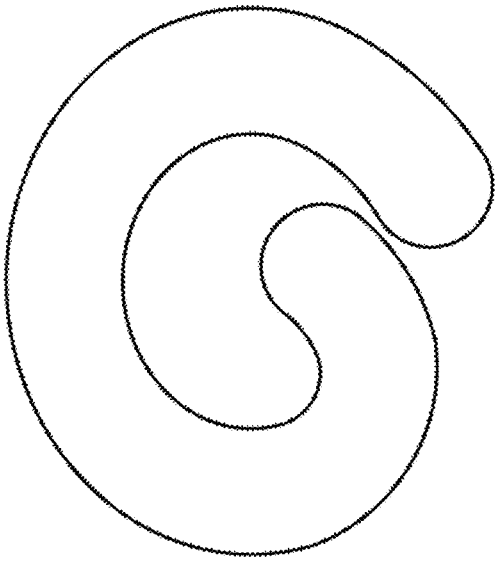


FIG. 3

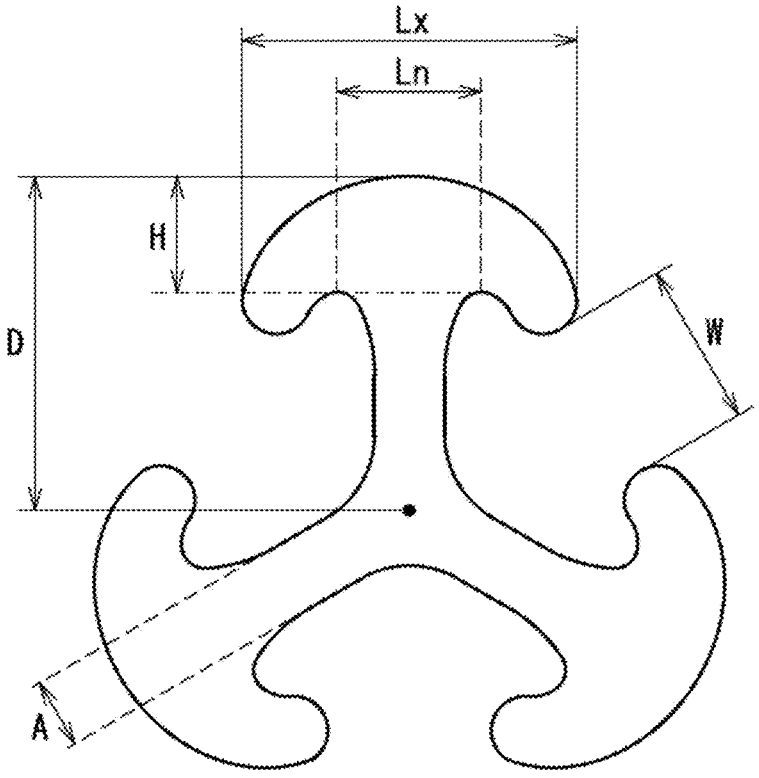


FIG. 4

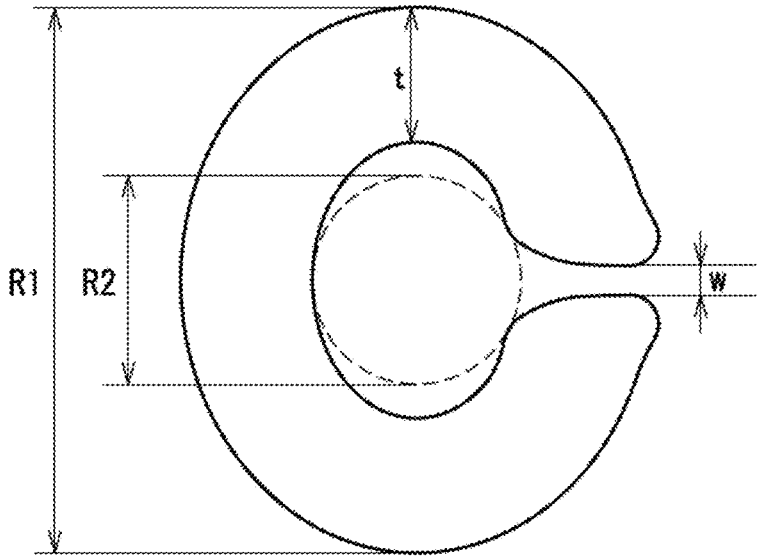


FIG. 5

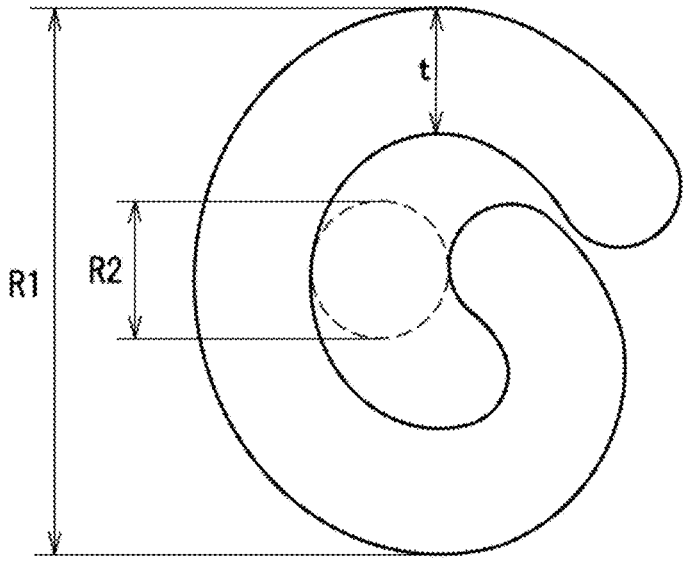


FIG. 6

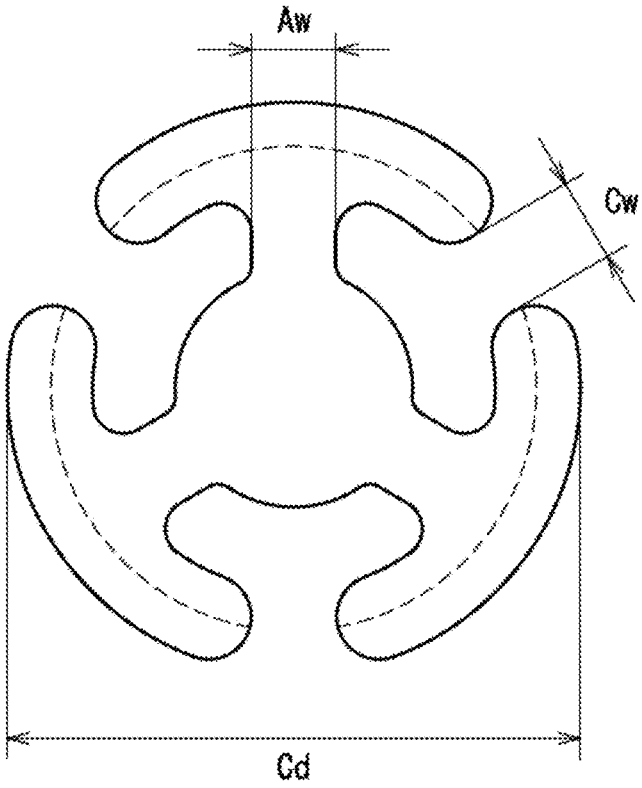


FIG. 7

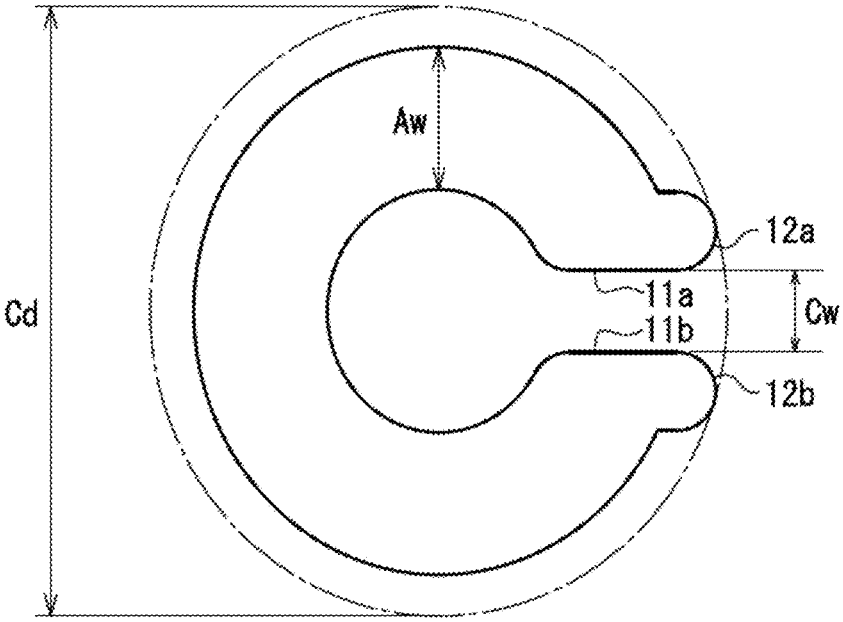


FIG. 8

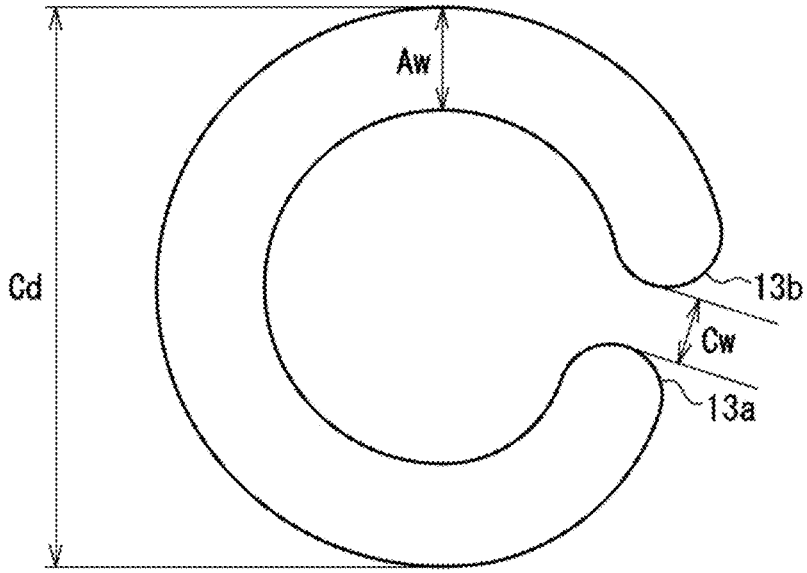


FIG. 9

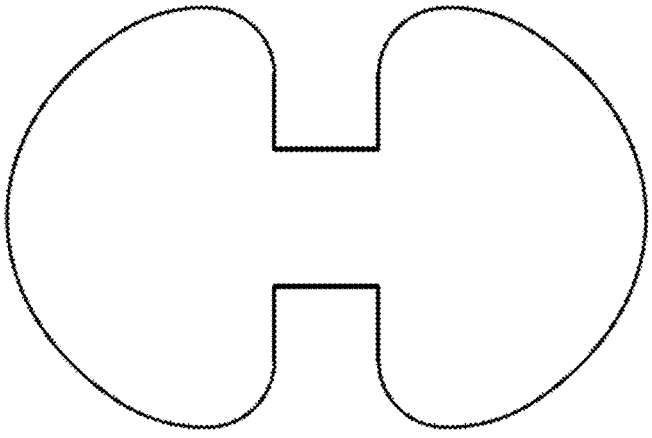


FIG. 10

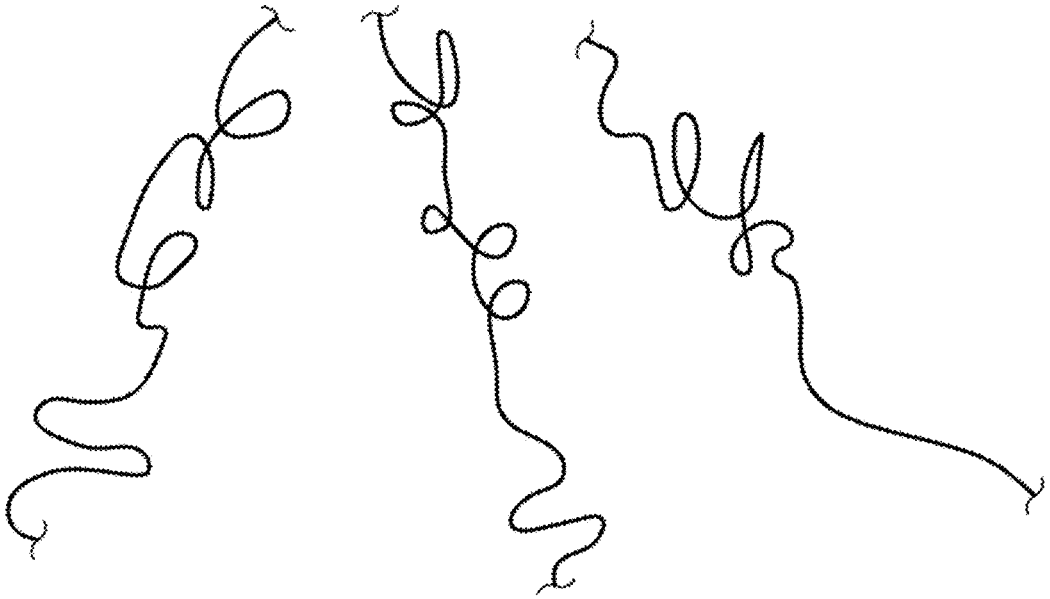


FIG. 11

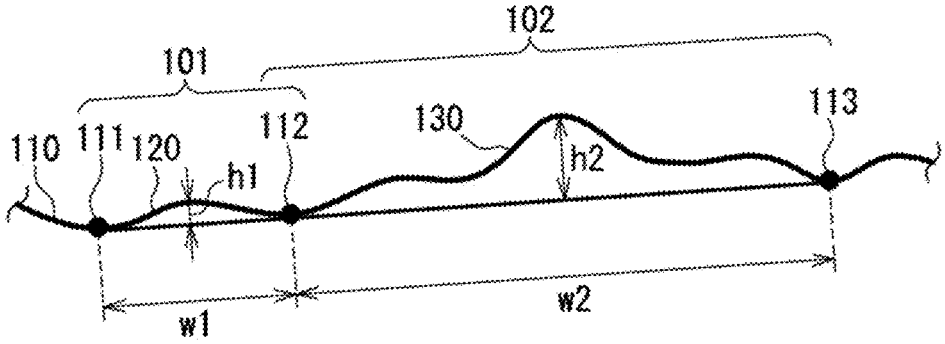


FIG. 12

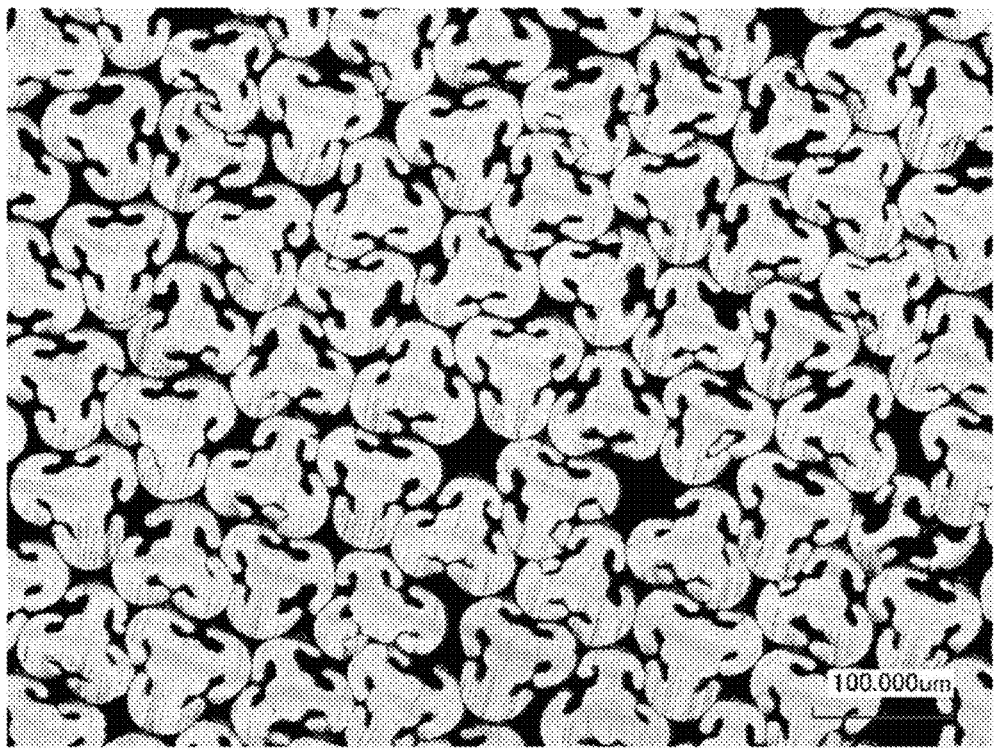


FIG. 13

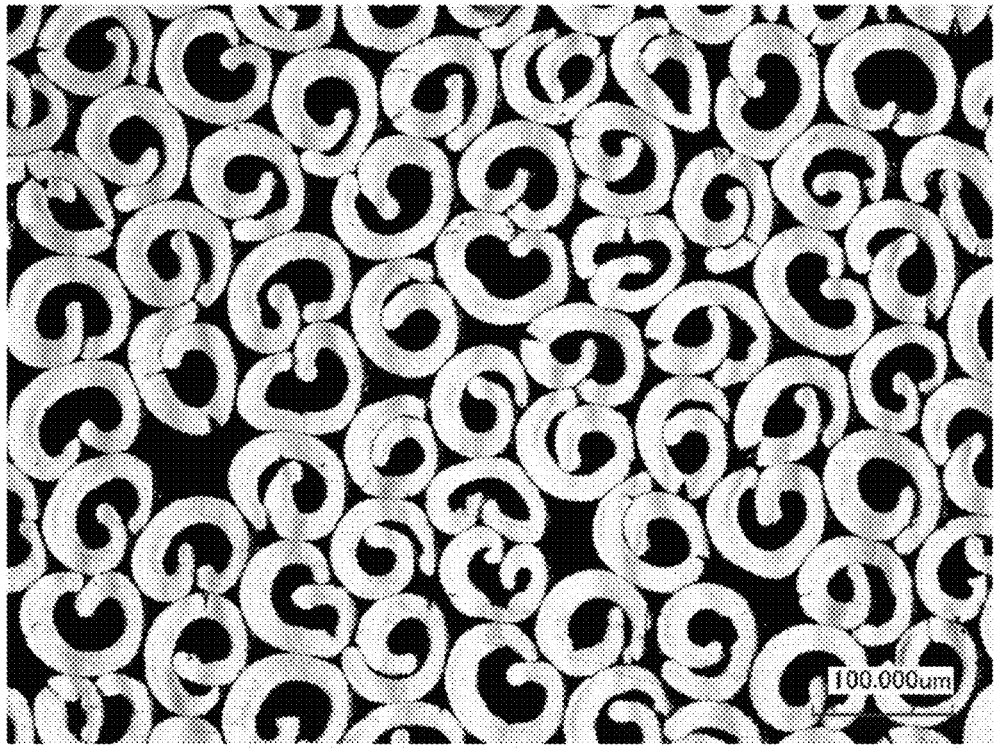


FIG. 14

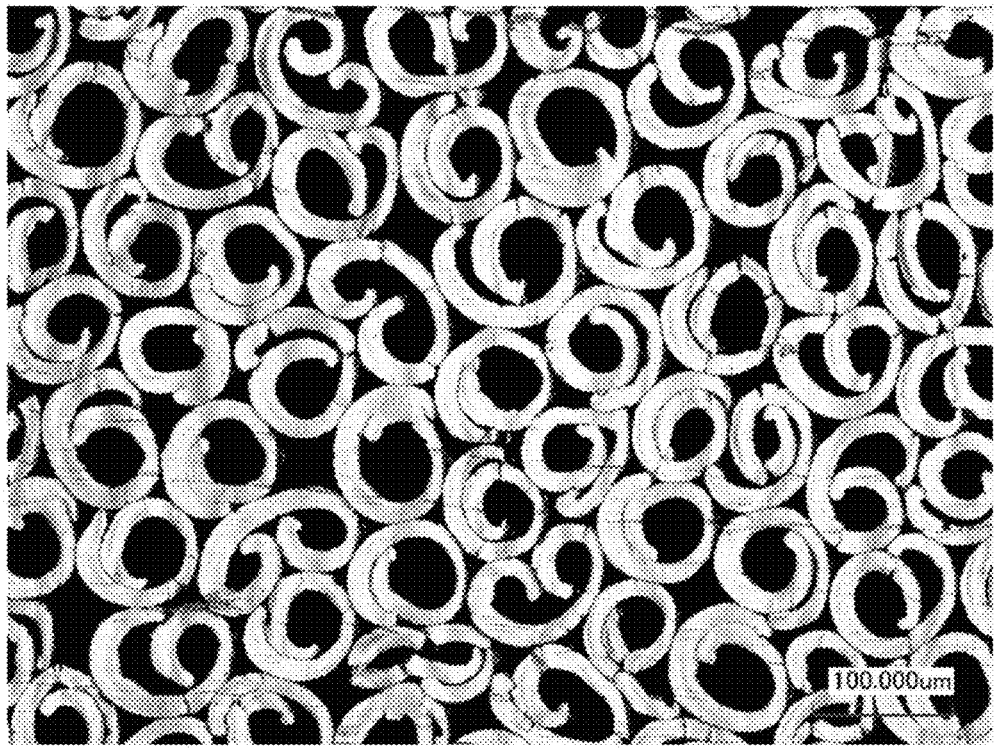


FIG. 15

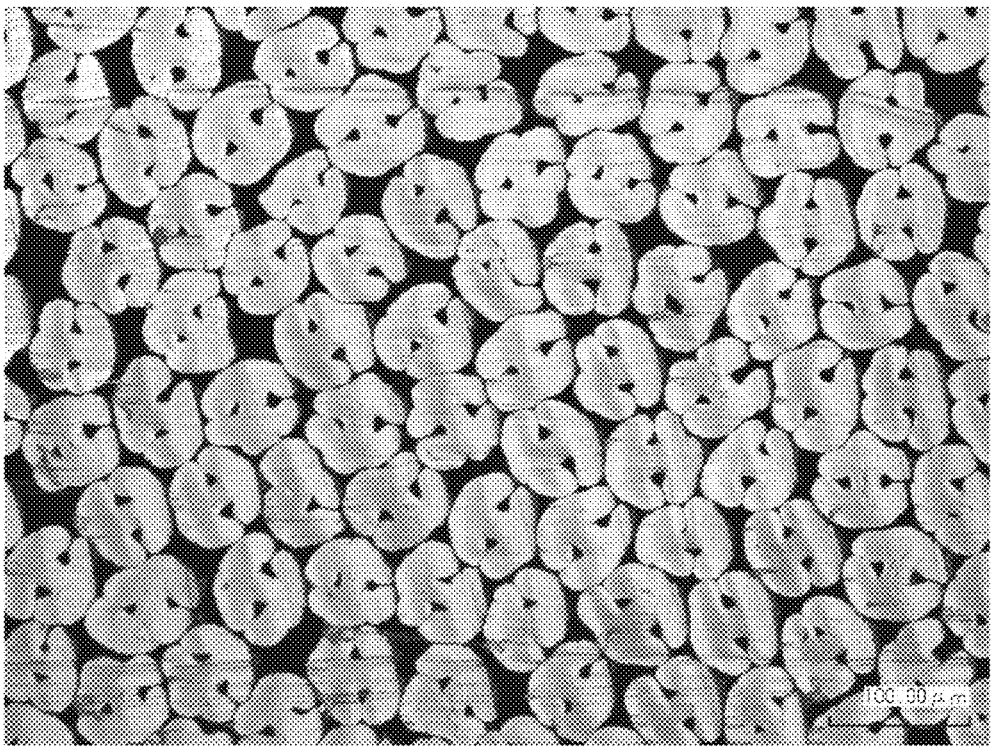


FIG. 16

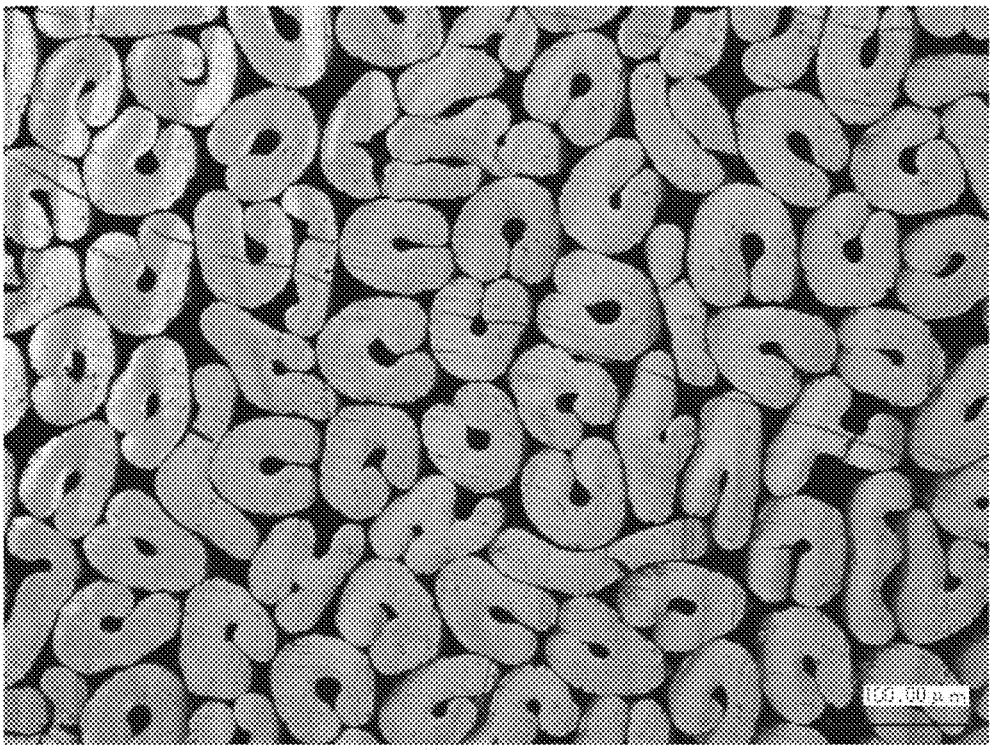


FIG. 17

ACRYLIC FIBER FOR ARTIFICIAL HAIR, CRIMPED ACRYLIC FIBER FOR ARTIFICIAL HAIR, HAIR ORNAMENT PRODUCT INCLUDING THE SAME, AND PRODUCTION METHOD THEREFOR

TECHNICAL FIELD

[0001] The present invention relates to an acrylic fiber for artificial hair and a crimped acrylic fiber for artificial hair that are to be used in a hair ornament product, a hair ornament product including the same, and a production method therefor.

BACKGROUND ART

[0002] Conventionally, acrylic fibers have been used as artificial hair for hair ornament products because their touch is soft and similar to that of human hair. For example, Patent Document 1 proposes an acrylic fiber for artificial hair that has a cross-section having a specific shape so that the volume is increased and the touch and twist processability are improved, and a hair ornament product produced using the same.

PRIOR ART DOCUMENTS

Patent Documents

[0003] Patent Document 1: WO 2006/135060

DISCLOSURE OF INVENTION

Problem to be Solved by the Invention

[0004] A braid produced by braiding artificial hair is known as an example of hair ornament products. It is possible to enjoy changing a hairstyle by attaching a braid to natural hair. In the case of a braid for a person with hair of non-uniform length, particularly for a young child with insufficient hair growth, it is desired that artificial hair is provided with non-uniform or irregular crimps in order to improve compatibility with natural hair.

[0005] However, when conventional acrylic fibers such as acrylic fibers disclosed in Patent Document 1 are subjected to processing for forming irregular crimps, the fibers have excellent touch but poor volume. In addition, there is a problem in that crimps with excellent compatibility with natural hair are unlikely to be formed.

[0006] In order to solve the aforementioned problems, the present invention provides an acrylic fiber for artificial hair that has favorable touch and a high volume and can develop crimps with excellent compatibility with natural hair even when provided with irregular crimps, a crimped acrylic fiber for artificial hair, a hair ornament product including the same, and a production method therefor.

Means for Solving Problem

[0007] One or more embodiments of the present invention relate to an acrylic fiber for artificial hair including an acrylic copolymer, wherein a dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is 30% or more and 70% or less, and a torsional rigidity of the acrylic fiber for artificial hair is 0.3 $mg \cdot cm^2$ or more and 2.0 $mg \cdot cm^2$ or less.

[0008] One or more embodiments of the present invention relate to a crimped acrylic fiber for artificial hair including an acrylic copolymer, wherein the number of crimps of the crimped acrylic fiber for artificial hair is 10 or more crimps per 10 cm, an average crimp height per 10-cm fiber is 1.5 mm or more, and in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.

[0009] One or more embodiments of the present invention relate to a hair ornament product including the acrylic fiber for artificial hair or the crimped acrylic fiber for artificial hair.

[0010] One or more embodiments of the present invention relate to a method for producing the acrylic fiber for artificial hair, the method including: a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle; a primary drawing process for subjecting the obtained coagulated filaments to wet drawing; and a secondary drawing process for subjecting obtained primary drawn filaments to dry drawing, wherein a relaxation treatment is not performed after the secondary drawing process.

[0011] One or more embodiments of the present invention relate to a method for producing the crimped acrylic fiber for artificial hair, the method including: a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle; a primary drawing process for subjecting the obtained coagulated filaments to wet drawing; a secondary drawing process for subjecting obtained primary drawn filaments to dry drawing; and a crimping process for providing crimps to obtained secondary drawn filaments by allowing the secondary drawn filaments to thermally shrink under no tension at a temperature of 90° C. or higher and 150° C. or lower for 5 minutes or more and 60minutes or less.

Effects of the Invention

[0012] With one or more embodiments of the present invention, it is possible to provide an acrylic fiber for artificial hair that has favorable touch and a high volume and can develop crimps with excellent compatibility with natural hair even when provided with irregular crimps.

[0013] With one or more embodiments of the present invention, it is possible to provide a crimped acrylic fiber for artificial hair that has been provided with irregular crimps, has favorable touch and a high volume, and has developed crimps with excellent compatibility with natural hair.

[0014] With the production methods according to one or more embodiments of the present invention, it is possible to obtain an acrylic fiber for artificial hair that has favorable touch and a high volume and can develop crimps with excellent compatibility with natural hair even when provided with irregular crimps.

[0015] With the production methods according to one or more embodiments of the present invention, it is possible to obtain a crimped acrylic fiber for artificial hair that has been provided with irregular crimps, has favorable touch and a high volume, and has developed crimps with excellent compatibility with natural hair.

BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. **1** is a schematic cross-sectional view showing an anchor-like-Y-shaped fiber cross-section according to an example.

[0017] FIG. **2** is a schematic cross-sectional view showing a C-shaped fiber cross-section according to an example.

[0018] FIG. **3** is a schematic cross-sectional view showing a figure-6-shaped fiber cross-section according to an example.

[0019] FIG. **4** is a schematic cross-sectional view illustrating the dimensions of an anchor-like-Y-shaped fiber cross-section according to an example.

[0020] FIG. **5** is a schematic cross-sectional view illustrating the dimensions of a C-shaped fiber cross-section according to an example.

[0021] FIG. **6** is a schematic cross-sectional view illustrating the dimensions of a figure-6-shaped fiber cross-section according to an example.

[0022] FIG. **7** is a schematic cross-sectional view of a wet-spinning nozzle according to an example.

[0023] FIG. **8** is a schematic cross-sectional view of a wet-spinning nozzle according to an example.

[0024] FIG. **9** is a schematic cross-sectional view of a wet-spinning nozzle according to an example.

[0025] FIG. **10** is a schematic cross-sectional view of a wet-spinning nozzle according to an example.

[0026] FIG. **11** is a schematic diagram showing the appearance of crimped acrylic fibers with irregular crimps.

[0027] FIG. **12** is a schematic diagram illustrating the crimp height and the crimp width in a crimped acrylic fiber according to an example.

[0028] FIG. **13** is a photograph (400-fold magnification) showing the cross-sections of acrylic fibers according to Example 1.

[0029] FIG. **14** is a photograph (400-fold magnification) showing the cross-sections of acrylic fibers according to Example 2.

[0030] FIG. **15** is a photograph (400-fold magnification) showing the cross-sections of acrylic fibers according to Example 3.

[0031] FIG. **16** is a photograph (400-fold magnification) showing the cross-sections of acrylic fibers according to Comparative Example 1.

[0032] FIG. **17** is a photograph (400-fold magnification) showing the cross-sections of acrylic fibers according to Comparative Example 6.

DESCRIPTION OF THE INVENTION

Acrylic Fiber for Artificial Hair

[0033] The inventors of the present invention found that, even when an acrylic fiber for artificial hair containing an acrylic copolymer is provided with irregular crimps, setting the dry-heat shrinkage ratio after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes and the torsional rigidity to be within predetermined ranges (specifically, increasing the dry-heat shrinkage ratio and reducing the torsional rigidity) allows the acrylic fiber to have favorable touch and a high volume and develop crimps with excellent compatibility with natural hair. The wording "irregular crimps" as used herein means that, in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.

[0034] The acrylic fiber for artificial hair has a dry-heat shrinkage ratio after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes (also referred to merely as a "dry-heat shrinkage ratio" hereinafter) of 30% or more and 70% or less. Due to the dry-heat shrinkage ratio being 30% or more, the acrylic fiber for artificial hair has a high volume and can develop crimps with excellent compatibility with natural hair even when provided with irregular crimps. In addition, due to the dry-heat shrinkage ratio being 70% or less, natural touch and appearance can be achieved.

[0035] The upper limit of the dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is preferably 65% or less, 60% or less, 55% or less, 50% or less, 49% or less, 48% or less, 47% or less, or 46% or less.

[0036] The lower limit of the dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is preferably 33% or more, 35% or more, or 37% or more.

[0037] All combinations of the above-described upper limits and lower limits may be employed as a preferable range of the dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180°° C. or lower for 30 minutes.

[0038] More specifically, the dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is preferably 33% or more and 60% or less, more preferably 35% or more and 50% or less, and even more preferably 37% or more and 46% or less.

[0039] It is preferable that the dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 95° C. or higher and 170° C. or lower for 30 minutes is within the above-described range, it is more preferable that the dry-heat shrinkage ratio after dry-heat treatment at a temperature of 100° C. or higher and 160° C. or lower for 30 minutes is within the above-described range, it is even more preferable that the dry-heat shrinkage ratio after dry-heat treatment at a temperature of 110° C. or higher and 150° C. or lower for 30 minutes is within the above-described range, and it is particularly preferable that the dry-heat shrinkage ratio after dry-heat treatment at 120° C. for 30 minutes is within the above-described range.

[0040] In this specification, the dry-heat shrinkage ratio is determined as follows: a fiber bundle of predetermined fibers is subjected to dry-heat treatment for 30 minutes under no tension in a uniform heating dryer set at a predetermined temperature, and then the dry-heat shrinkage ratio is calculated using Formula 1 below based on the fiber lengths of the fiber bundle before and after the dry-heat treatment. In Formula 1 below, La is the fiber length of the fiber bundle under a load of 50 g before the dry-heat treatment, and Lb is the fiber length of the fiber bundle under a load of 50 g after the dry-heat treatment.

$$\text{Dry-heat shrinkage ratio } (\%) = (La - Lb)/La \times 100 \qquad \text{Formula 1}$$

[0041] The acrylic fiber for artificial hair has a torsional rigidity of 0.3 mg·cm^2 or more and 2.0 mg·cm^2 or less. Due to the torsional rigidity being 2.0 mg·cm^2 or less, the acrylic fiber for artificial hair has a high volume and can develop crimps with excellent compatibility with natural hair even when provided with irregular crimps. In addition, due to the torsional rigidity being 0.3 mg·cm^2 or more, strength against external force is increased. In this specification, the "torsional rigidity" is measured under the conditions that the number of twists is ±3 twists and the torsion speed is 12°/sec. Specifically, the torsional rigidity can be measured as described in Examples.

[0042] The lower limit of the torsional rigidity of the acrylic fiber for artificial hair is preferably 0.4 mg·cm^2 or more, 0.5 mg·cm^2 or more, 0.6 mg·cm^2 or more, 0.7 mg·cm^2 or more, or 0.8 mg·cm^2 or more.

[0043] The upper limit of the torsional rigidity of the acrylic fiber for artificial hair is preferably 1.95 mg·cm^2 or less, 1.90 mg·cm^2 or less, 1.85 mg·cm^2 or less, 1.80 mg·cm^2 or less, 1.75 mg·cm^2 or less, or 1.70 mg·cm^2 or less.

[0044] All combinations of the above-described upper limits and lower limits may be employed as a preferable range of the torsional rigidity of the acrylic fiber for artificial hair.

[0045] More specifically, the torsional rigidity of the acrylic fiber for artificial hair is preferably 0.4 mg·cm^2 or more and 1.9 mg·cm^2 or less, and more preferably 0.5 mg·cm^2 or more and 1.7 mg·cm^2 or less.

[0046] The fineness of the acrylic fiber for artificial hair is not particularly limited, but is preferably 25 dtex or more and 95 dtex or less, more preferably 30 dtex or more and 75 dtex or less, and even more preferably 35 dtex or more and 65 dtex or less, from the viewpoint of making the acrylic fiber suitable for artificial hair.

[0047] Although the cross-sectional shape of the acrylic fiber for artificial hair is not particularly limited, examples thereof include a Y-shape, an anchor-like-Y-shape, a C-shape, a figure-6-shape, a dumbbell-shape, a horseshoe-shape, an elliptical shape, and a circular shape. In this specification, the wording "fiber cross-section" means a lateral cross-section. It is preferable that the acrylic fiber for artificial hair has a hollow portion from the viewpoint of development of a sufficient volume when crimps are provided. It is more preferable that the acrylic fiber for artificial hair has one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6-shape from the viewpoint that the torsional rigidity is likely to be within the above-described range and a sufficient volume is developed when crimps are provided. It is even more preferable that the acrylic fiber for artificial hair has an anchor-like-Y-shape from the viewpoint of further improving the touch.

[0048] The anchor-like-Y-shaped fiber cross-section includes, for example, three T-shaped protrusions that extend radially from the central portion, and each of the T-shaped protrusions has an arc-shaped upper side that bulges in a direction away from the central portion. The wording "arc shape" refers to all shapes similar to an arc. For example, the arc shape may include not only an arc of a perfect circle, but also any shape that is considered to be the same as the arc based on common technical knowledge, such as a curved shape including a part of an ellipse. The arc shape may also include a linear portion in part. The arc shape may either be or not be bilaterally symmetrical.

[0049] FIG. **1** is a schematic cross-sectional view of an acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section according to an example. An acrylic fiber for artificial hair **1** has a cross-section that includes three T-shaped protrusions **3** extending radially from a central portion **2**, and each of the T-shaped protrusions has an arc-shaped upper side (portion) **4** that bulges in a direction away from the central portion **2**. The T-shaped protrusion **3** includes the upper side (portion) **4** and a lower extended portion **5**. The central portion **2** may have a substantially circular shape or a substantially elliptical shape.

[0050] In the acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section, the distance between adjacent ends of the corresponding upper sides of the adjacent T-shaped protrusions is not particularly limited but is preferably 16.0 μm or more, for example, from the viewpoint of further increasing the volume. Also, in the acrylic fiber for artificial hair, the distance between adjacent ends of the corresponding upper sides of the adjacent T-shaped protrusions is not particularly limited but is preferably 50.0 μm or less and more preferably 35.0 μm or less, for example, from the viewpoint of further improving the touch. In FIG. **4**, the distance between adjacent ends of the corresponding upper sides of the adjacent T-shaped protrusions is indicated as W.

[0051] In the acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section, the thickness of the upper side portion of each T-shaped protrusion is not particularly limited but is preferably 10% or more and 50% or less, and more preferably 25% or more and 45% or less, of the circumradius of the fiber cross-section, for example, from the viewpoint of further increasing the twistability and the volume. The wording "thickness of the upper side portion of the T-shaped protrusion" as used herein means a vertical distance from the top of the upper side portion of the T-shaped protrusion to a line connecting two points of intersection of the upper side portion of the T-shaped protrusion with the lower extended portion of the T-shaped protrusion. In this specification, the top of the upper side portion of the T-shaped protrusion is farthest from the central point of the fiber cross-section. In FIG. **4**, the thickness of the upper side portion of the T-shaped protrusion is indicated as H.

[0052] In the acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section, the maximum length of the upper side portion of each T-shaped protrusion is not particularly limited but is preferably 1.5 times or more and 4 times or less, and more preferably 1.9 times or more and 2.6 times or less, the minimum length of the upper side portion of each T-shaped protrusion, for example, from the viewpoint of further increasing the twistability and the volume. The wording "maximum length of the upper side portion of the T-shaped protrusion" as used herein means a length between two ends of the upper side portion of the T-shaped protrusion, and the wording "minimum length of the upper side portion of the T-shaped protrusion" as used herein means a length of a line connecting two points of intersection of the upper side portion of the T-shaped protrusion with the lower extended portion of the T-shaped protrusion. In FIG. **4**, the maximum length of the upper side portion of the T-shaped protrusion is indicated as Lx, and the minimum length of the upper side portion of the T-shaped protrusion is indicated as Ln.

[0053] In the acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section, the circumradius of the

fiber cross-section is not particularly limited but is preferably 45.0 μm or more and 60.0 μm or less, for example, from the viewpoint of further increasing the volume and the touch. The wording "circumcircle of the fiber cross-section" means a circle that passes the tops of the upper side portions of the three T-shaped protrusions. In FIG. **4**, the circumradius is indicated as D.

[0054] In the acrylic fiber for artificial hair with an anchor-like-Y-shaped fiber cross-section, the width of each T-shaped protrusion in the fiber cross-section is not particularly limited but is preferably 11.0 μm or more and 26.0 μm or less, and more preferably 12.0 μm or more and 20.0 μm or less, for example, from the viewpoint of preventing the cracking of the fiber cross-section and increasing the volume. In FIG. **4**, the width of the T-shaped protrusion is indicated as A.

[0055] FIG. **2** is a schematic cross-sectional view of an acrylic fiber for artificial hair with a C-shaped cross-section according to an example. In the C-shaped fiber cross-section shown in FIG. **2**, the two ends of the C-shape are apart from each other, and thus an opening is formed. However, the two ends of the C-shape may be in contact with each other.

[0056] FIG. **3** is a schematic cross-sectional view of an acrylic fiber for artificial hair with a figure-6-shaped cross-section according to an example. In this specification, the figure-6-shape can also be considered as a modified C-shape, and specifically, it can also be considered as a shape in which one end of the C-shape is located on the inside with respect to the other end. In the figure-6-shaped fiber cross-section shown in FIG. **3**, the two ends of the figure-6-shape are apart from each other, and thus an opening is formed. However, the two ends of the figure-6-shape may be in contact with each other.

[0057] In the acrylic fiber for artificial hair with a C-shaped or figure-6-shaped fiber cross-section, the diameter of the circumcircle of the fiber cross-section (also referred to as the "diameter of the circumcircle" hereinafter) is not particularly limited but is preferably 75 μm or more and 100 μm or less, and more preferably 80 μm or more and 95 μm or less, for example, from the viewpoint of further improving the volume and the touch. In FIGS. **5** and **6**, the diameter of the circumcircle is indicated as R**1**.

[0058] In the acrylic fiber for artificial hair with a C-shaped or figure-6-shaped fiber cross-section, the diameter of an imaginary circle inscribed to the hollow portion of the fiber cross section (also referred to as the "diameter of the inscribed circle" hereinafter) is not particularly limited but is preferably 30 μm or more and 50 μm or less, and more preferably 32 μm or more and 48 μm or less, for example, from the viewpoint of making it likely to set the torsional rigidity to be within the above-described range and further improving the volume and the touch. In FIGS. **5** and **6**, the diameter of the inscribed circle is indicated as R**2**.

[0059] In the acrylic fiber for artificial hair with a C-shaped or figure-6-shaped fiber cross-section, the thickness of the fiber cross-section is not particularly limited but is preferably 10 μm or more and 26 μm or less, and more preferably 11 μm or more and 25 μm or less, for example, from the viewpoint that the torsional rigidity is likely to be within the above-described range and the volume and the touch are further improved. In FIGS. **5** and **6**, the thickness is indicated as t.

[0060] In the acrylic fiber for artificial hair with a C-shaped fiber cross-section, the distance between the two ends in the fiber cross-section is not particularly limited but is preferably 10 μm or less, and more preferably 5 μm or less, for example, from the viewpoint of further improving the volume and the touch. In FIG. **5**, the distance between the two ends in the fiber cross-section is indicated as W. Note that when the two ends in the C-shaped fiber cross-section are in contact with each other, W is 0 μm. In one or more embodiments of the present invention, when the fiber cross-section has a figure-6-shape, the distance between the two ends in the fiber cross-section is 0 μm.

[0061] In the acrylic fiber for artificial hair, the hollow ratio of the fiber cross-section is not particularly limited but is preferably 20% or more and 50% or less, more preferably 30% or more and 50% or less, and even more preferably 35% or more and 45% or less, from the viewpoint that a sufficient volume is developed when crimps are provided. In this specification, the area of the circumcircle of the fiber cross-section and the area of the fiber cross-section are calculated, and then the hollow ratio is determined using Formula 2 below. The area of the circumcircle of the fiber cross-section is the area of a circle whose diameter corresponds to the length of the longest line segment among line segments connecting any two points on the circumference of the fiber cross-section.

$$\text{Hollow ratio (\%)} = 100 \times (\text{area of circumcircle of fiber cross-section} - \text{area of fiber cross-section}) / \text{area of circumcircle of fiber cross-section} \quad \text{Formula 2}$$

[0062] All the acrylic fibers for artificial hair do not necessarily have the same fineness, cross-sectional shape, and cross-sectional size, and fibers that are different in fineness, cross-sectional shape, and cross-sectional size may be mixed.

[0063] An acrylic copolymer contained in the acrylic fiber for artificial hair is not particularly limited, and, for example, the acrylic copolymer contains acrylonitrile in an amount of less than 95 wt % and another monomer in an amount of more than 5 wt %, and preferably acrylonitrile in an amount of less than 80 wt % and another monomer in an amount of more than 20 wt %. As the other monomer, a monomer copolymerizable with acrylonitrile can be used as appropriate. Specifically, it is more preferable that the acrylic copolymer contained in the acrylic fiber for artificial hair contains acrylonitrile in an amount of 29.5 wt % or more and 79.5 wt % or less, vinyl chloride and/or vinylidene chloride in an amount of 20 wt % or more and 70 wt % or less, and a sulfonic acid group-containing vinyl monomer in an amount of 0.5 wt % or more and 5 wt % or less. That is to say, it is more preferable that the acrylic copolymer is obtained through polymerization performed using a monomer mixture containing acrylonitrile in an amount of 29.5 wt % or more and 79.5 wt % or less, vinyl chloride and/or vinylidene chloride in an amount of 20 wt % or more and 70 wt % or less, and a sulfonic acid group-containing vinyl monomer in an amount of 0.5 wt % or more and 5 wt % or less with the total content thereof being 100 wt %. When the content of acrylonitrile in the acrylic copolymer is 29.5 wt % or more and 79.5 wt % or less, the heat resistance is favorable. When the content of vinyl chloride and/or vinylidene chloride in

the acrylic copolymer is 20 wt % or more and 70 wt % or less, the flame retardance is favorable. The hydrophilicity is increased due to the acrylic copolymer containing a sulfonic acid group-containing vinyl monomer in an amount of 0.5 wt % or more and 5 wt % or less. The acrylic copolymer even more preferably contains acrylonitrile in an amount of 34.5 wt % or more and 74.5 wt % or less, vinyl chloride and/or vinylidene chloride in an amount of 25 wt % or more and 65 wt % or less, and a sulfonic acid group-containing vinyl monomer in an amount of 0.5 wt % or more and 5 wt % or less, and particularly preferably acrylonitrile in an amount of 39.5 wt % or more and 74.5 wt % or less, vinyl chloride in an amount of 25 wt % or more and 60 wt % or less, and a sulfonic acid group-containing vinyl monomer in an amount of 0.5 wt % or more and 5 wt % or less. It is preferable that the acrylic copolymer contains vinyl chloride from the viewpoint of achieving better touch.

[0064] Although the sulfonic acid group-containing vinyl monomer is not particularly limited, examples thereof include allylsulfonic acid, methallylsulfonic acid, styrenesulfonic acid, isoprenesulfonic acid, and 2-acrylamido-2-methylpropanesulfonic acid, and metallic salts (e.g., sodium salts) thereof and amine salts thereof. One of the sulfonic acid group-containing vinyl monomers may be used alone, or two or more of the sulfonic acid group-containing vinyl monomers may be used in combination.

[0065] The acrylic fiber for artificial hair may contain other additives to improve the fiber characteristics if necessary as long as the effects of the present invention are not inhibited. Examples of the additives include the following functional agents: gloss control agents such as titanium dioxide, silicon dioxide, and esters and ethers of cellulose derivatives including cellulose acetate; coloring agents such as organic pigments, inorganic pigments, and dyes; stabilizers for improving light resistance and heat resistance; fiber sizing agents such as a urethane polymer and a cationic ester polymer for improving the processability of the fibers during braiding or twisting; inorganic or organic deodorants that capture isovaleric acid that is an odor component generated from the scalp; and aromatic agents for giving an aroma such as a citrus aroma to the artificial hair fibers.

Method for Producing Acrylic Fiber for Artificial Hair

[0066] The above-described acrylic fiber for artificial hair can be produced through, for example, wet spinning using a spinning solution containing an acrylic copolymer. The spinning solution can be obtained by, for example, dissolving the acrylic copolymer in an organic solvent. As the acrylic copolymer, the above-described acrylic copolymers can be used as appropriate.

[0067] The organic solvent is not particularly limited, and a good solvent for the acrylic copolymer can be used as appropriate. Examples of the organic solvent include dimethyl sulfoxide (DMSO), dimethylacetamide (DMAc), N,N-dimethylformamide (DMF), and acetone. Acetone may be used from the viewpoint of versatility. The spinning solution may contain a small amount of water, such as water in an amount of 1.5 wt % or more and 4.8 wt % or less.

[0068] The spinning solution may contain other additives to improve the fiber characteristics if necessary as long as the effects of the present invention are not inhibited. Examples of the additives include: gloss control agents such as titanium dioxide, silicon dioxide, and esters and ethers of cellulose derivatives including cellulose acetate; coloring agents such as organic pigments, inorganic pigments, and dyes; and stabilizers for improving light resistance and heat resistance.

[0069] The method for producing an acrylic fiber for artificial hair includes at least a coagulation process, a primary drawing process, and a secondary drawing process, and it is preferable that a relaxation treatment is not performed after the secondary drawing process. Fibers that have not been subjected to the relaxation treatment have a high dry-heat shrinkage ratio. The wording "relaxation treatment" as used herein means relaxation treatment that is commonly performed in the field of fibers, and an example thereof is heat treatment at a temperature of 100° C. or higher and 200° C. or lower with which fibers shrink in the fiber-axis direction. The rate of the shrinkage of a fiber in the relaxation treatment is represented by a relaxation rate. The relaxation rate in the relaxation treatment is generally 5% or more. "The relaxation rate is 5%" means that a fiber shrinks by 5% due to the relaxation treatment, that is, the fiber length of a fiber after the relaxation treatment is 95% of the fiber length of the fiber before the relaxation treatment.

[0070] First, in the coagulation process, the spinning solution is discharged through a spinning nozzle into a coagulation bath, where the discharged spinning solution is coagulated to form filaments (coagulated filaments).

[0071] The nozzle used for the wet spinning is not particularly limited, and a nozzle corresponding to a desired fiber cross-section can be used as appropriate. For example, using a nozzle with an anchor-like-Y-shaped cross-section makes it possible to obtain an acrylic fiber with an anchor-like-Y-shaped cross-section. FIG. **7** is a schematic cross-sectional view of a nozzle with an anchor-like-Y-shaped cross-section according to an example. In the spinning nozzle, an axial width Aw is not particularly limited but may be 0.02 mm or more and 1.0 mm or less, a canal width Cw is not particularly limited but may be 0.02 mm or more and 1.0 mm or less, a diameter Cd of a circumcircle is not particularly limited but may be 0.01 mm or more and 1.0 mm or less, and a hole area is not particularly limited but may be 0.05 mm^2 or more and 1.0 mm^2 or less.

[0072] Using a nozzle with a C-shaped cross-section makes it possible to obtain an acrylic fiber with a C-shaped or figure-6-shaped cross-section.

[0073] FIG. **8** is a schematic cross-sectional view of a nozzle (also referred to as a "type-I spinning nozzle" hereinafter) that has a cross-section with a C-shape whose two ends are apart from each other and in which each of the ends of the C-shape includes a linear portion and a protrusion bulging outward and the linear portions of the two ends are parallel to each other. In the cross-section of the type-I spinning nozzle, one of the two ends of the C-shape includes a linear portion **11***a* and a protrusion **12***a*, and the other includes a linear portion **11***b* and a protrusion **12***b*, the linear portions **11***a* and **11***b* being parallel to each other. The linear portions and the protrusions can be adjusted as appropriate in accordance with the target fiber cross-sectional shape and size. In the type-I spinning nozzle, the diameter Cd of a circumcircle may be 0.37 mm or more and 0.60 mm or less, the canal width Cw may be 0.06 mm or more and 0.24 mm or less, a slit width Aw may be 0.06 mm or more and 0.15 mm or less, and the hole area may be 0.0850 mm^2 or more and 0.1256 mm^2 or less.

[0074] FIG. **9** is a schematic cross-sectional view of a nozzle (also referred to as a "type-II spinning nozzle" hereinafter) that has a cross-section with a C-shape in which one end of the C-shape is located on the inside with respect to the other end. In the type-II spinning nozzle, one end **13***a* of the C-shape is located on the inside with respect to the other end **13***b*. The degree of a difference between the positions of the two ends can be adjusted as appropriate in accordance with the target fiber cross-sectional shape and size. In the cross-section of the type-II spinning nozzle, the diameter Cd of a circumcircle may be 0.37 mm or more and 0.60 mm or less, the canal width Cw may be 0.06 mm or more and 0.24 mm or less, the slit width Aw may be 0.06 mm or more and 0.15 mm or less, and the hole area may be 0.0850 mm^2 or more and 0.1256 mm^2 or less.

[0075] The spinning rate is not particularly limited, but is preferably 2 m/min or more and 17 m/min or less, for example, from the viewpoint of industrial productivity. The nozzle draft is not particularly limited, but is preferably 0.8 or more and 2.0 or less, for example, from the viewpoint of the stability of the production process. An acrylic fiber having a predetermined cross-sectional shape and a predetermined cross-sectional size can be obtained by adjusting the cross-sectional shape and cross-sectional size of the spinning nozzle, the spinning conditions such as the spinning rate and the nozzle draft, and the draw ratio, which will be described later, as appropriate.

[0076] An aqueous solution containing a good solvent such as dimethyl sulfoxide at a concentration of 20 wt % or more and 70 wt % or less can be used for the coagulation bath. The temperature of the coagulation bath can be set to 5° C. or higher and 40° C. or lower. If the concentration of the organic solvent in the coagulation bath is too low, the coagulation is accelerated, and thus it is likely that a coagulation structure will be coarse and voids will be formed inside the fiber.

[0077] Next, in the primary drawing process (also referred to as a "bath drawing process"), wet drawing is performed on the coagulated filaments, and thus primary drawn filaments are obtained. In the bath drawing process, the acrylic fibers (coagulated filaments) are preferably subjected to bath drawing in a drawing bath. For the drawing bath, an aqueous solution containing a good solvent such as dimethyl sulfoxide at a concentration lower than that in the coagulation bath can be used. The temperature during the wet drawing, specifically the temperature of the drawing bath, is preferably 30° C. or higher and 100° C. or lower, more preferably 40° C. or higher and 95° C. or lower, and even more preferably 50° C. or higher and 93° C. or lower, from the viewpoint of spinning stability. The draw ratio is not particularly limited, but is preferably 2 to 8 times from the viewpoint of increasing the fiber strength and the productivity. Note that when the primary drawing is performed using a water bath, the bath drawing process may be performed after the water-washing process, which will be described later, or the primary drawing and the water washing may be performed simultaneously.

[0078] Next, in the water-washing process, it is desirable that the organic solvent such as acetone should be removed from the acrylic fibers by washing the acrylic fibers with warm water at 30° C. or higher. Alternatively, the primary drawing and the water washing may be performed simultaneously after the coagulated filaments are introduced into warm water at 30° C. or higher. In the water-washing process, using warm water at, for example, 70° C. or higher makes it easy to remove the good solvent such as acetone in the acrylic fibers. It is desirable that the upper limit of the temperature of the water during the water washing is 95° C. or lower from the viewpoint of spinning stability.

[0079] Next, the primary drawn filaments are dried, and the secondary drawing is performed. That is to say, the secondary drawing is dry drawing. The drying temperature is not particularly limited, but is, for example, 110° C. or higher and 190° C. or lower. The drawing temperature during the secondary drawing is not particularly limited, but is preferably the same as the drying temperature, 110° C. or higher and 190° C. or lower, for example, from the viewpoint of spinning stability. The draw ratio is not particularly limited, but is preferably, for example, 1 to 4 times, more preferably 1 to 3 times, and even more preferably 1 to 2 times. The total draw ratio, multiplied by the draw ratios of the primary drawing and the secondary drawing, is preferably 2 to 10 times, more preferably 2 to 8 times, even more preferably 2 to 6 times, and particularly preferably 2 to 4 times.

[0080] An oil application may be performed using an oil solution if necessary before the drying process. The oil solution may contain other additives to improve the fiber characteristics if necessary as long as the effects of the present invention are not inhibited. Examples of the additives include fiber sizing agents and the like.

Crimped Acrylic Fiber for Artificial Hair and Production Method Therefor

[0081] The inventors of the present invention found that a crimped acrylic fiber for artificial hair containing an acrylic copolymer has favorable touch, a high volume, and crimps with favorable compatibility with natural hair when the following conditions are satisfied: the number of the crimps is 10 crimps or more per 10 cm, and the crimp height is 1.5 mm or more; and, in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions (i.e., the crimped acrylic fiber for artificial hair has irregular crimps). FIG. **11** is a schematic diagram showing the appearance of crimped acrylic fibers for artificial hair with irregular crimps, that is, crimped acrylic fiber for artificial hair in which at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.

[0082] The number of the crimps in the crimped acrylic fiber for artificial hair is preferably 11 crimps or more per 10 cm, and more preferably to be 12 crimps or more per 10 cm, from the viewpoint of further increasing the volume and the compatibility of the crimps with natural hair. The upper limit of the number of the crimps in the crimped acrylic fiber for artificial hair is not particularly limited but is preferably 30 crimps or less per 10 cm, more preferably 25 crimps or less per 10 cm, and even more preferably 20 crimps or less per 10 cm, for example, from the viewpoint of the touch. Specifically, the number of the crimps in the crimped acrylic fiber for artificial hair is preferably 10 crimps or more per 10 cm and 30 crimps or less per 10 cm, more preferably 11 crimps or more per 10 cm and 25 crimps or less per 10 cm, and even more preferably 12 crimps or more per 10 cm and 20 crimps or less per 10 cm.

[0083] In this specification, the number of the crimps in the crimped acrylic fiber for artificial hair is determined as follows: five crimped acrylic fibers for artificial hair are randomly selected, the two ends of each fiber (with a fiber length of 20 cm) are fixed to an A4-size graph paper, the number of the crimps formed per 10-cm fiber length in each fiber is measured, and the average of the results from the five fibers is determined and is taken as the number of the crimps. The term "crimp" as used herein means a crimped portion formed by two contact points where the fiber is in contact with the graph paper and a portion of the fiber that is located between the two contact points and is not in contact with the graph paper, and one crimp may have two or more protrusions.

[0084] In the crimped acrylic fiber for artificial hair, the average crimp height per 10-cm fiber is preferably 1.6 mm or more, more preferably 1.7 mm or more, even more preferably 1.8 mm or more, and particularly preferably 1.9 mm or more, from the viewpoint of further increasing the volume and the compatibility of the crimps with natural hair. In the crimped acrylic fiber for artificial hair, the upper limit of the average crimp height per 10-cm fiber is not particularly limited but is preferably 3.0 mm or less, more preferably 2.9 mm or less, even more preferably 2.8 mm or less, even more preferably 2.7 mm or less, and even more preferably 2.5 mm or less, from the viewpoint of the touch. Specifically, in the crimped acrylic fiber for artificial hair, the average crimp height per 10-cm fiber is 1.5 mm or more and 3.0 mm or less, 1.6 mm or more and 2.9 mm or less, 1.7 mm or more and 2.8 mm or less, 1.8 mm or more and 2.7 mm or less, or 1.9 mm or more and 2.5 mm or less.

[0085] In the crimped acrylic fiber for artificial hair, the average crimp height per 10-cm fiber is determined as follows: five crimped acrylic fibers for artificial hair are randomly selected, the two ends of each fiber (with a fiber length of 20 cm) are fixed to an A4-size graph paper, the heights (crimp heights) of protrusions of all the crimps formed in a fiber length of 10 cm are measured, and the average of the results obtained is determined and is taken as the average crimp height. In this specification, when one crimp includes two or more protrusions, the crimp height means the height of the highest protrusion.

[0086] The volume of the crimped acrylic fiber for artificial hair is preferably 25 mm or more, more preferably 26 mm or more, even more preferably 27 mm or more, and particularly preferably 28 mm or more. The upper limit of the volume of the crimped acrylic fiber for artificial hair is not particularly limited but is preferably 50 mm or less, more preferably 48 mm or less, even more preferably 47 mm or less, and even more preferably 45 mm or less, for example, from the viewpoint of natural appearance. Specifically, the volume of the crimped acrylic fiber for artificial hair is 25 mm or more and 50 mm or less, 26 mm or more and 48 mm or less, 27 mm or more and 47 mm or less, or 28 mm or more and 45 mm or less.

[0087] In this specification, the volume of the crimped acrylic fiber for artificial hair can be measured as follows.

[0088] (1) The crimped acrylic fibers for artificial hair are used to form a 38-inch fiber bundle (about 96.5 cm and about 50 g), a rubber band is put around the central portion of the fiber bundle, the fiber bundle is folded back at the central portion, and the resulting half-folded fiber bundle is used as a sample.

[0089] (2) The sample is placed on a support base (with a length of 12 cm, a width of 1.6 cm, and a height of 10 cm) of a bulkiness meter such that the length direction of the fibers corresponds to the length direction of the bulkiness meter, a rectangular weight (with a length of 17 cm, a width of 1.5 cm, a height of 0.5 cm, and a weight of 20 g) is placed on the sample in a parallel manner such that the length direction of the fibers in the sample corresponds to the length direction of the weight, the bulkiness (height) of the sample at a position where the weight is disposed is measured, and thus the volume is determined.

[0090] It is preferable that the torsional rigidity, the fiber cross-sectional shape, the cross-sectional size, the fineness, and the hollow ratio of the crimped acrylic fiber for artificial hair are similar to the torsional rigidity, the fiber cross-sectional shape, the cross-sectional size, the fineness, and the hollow ratio described above for the acrylic fiber for artificial hair. The contents of the descriptions of the acrylic fiber for artificial hair described above can be applied as they are, and the detailed descriptions of the torsional rigidity, the fiber cross-sectional shape, the cross-sectional size, the fineness, and the hollow ratio of the crimped acrylic fiber for artificial hair are omitted.

[0091] In addition, the crimped acrylic fiber for artificial hair can contain an acrylic copolymer similar to the acrylic copolymer described above for the acrylic fiber for artificial hair. The contents of the descriptions of the acrylic fiber for artificial hair described above can be applied as they are, and the detailed description of the acrylic copolymer contained in the crimped acrylic fiber for artificial hair is omitted.

[0092] It is preferable that the crimped acrylic fiber for artificial hair is the above-described acrylic fiber for artificial hair provided with irregular crimps. That is to say, the crimped acrylic fiber for artificial hair can be produced by providing irregular crimps to the above-described acrylic fiber for artificial hair.

[0093] The crimps are not limited as long as they are irregular crimps, but the crimps are preferably irregular crimps provided by allowing the above-described acrylic fiber for artificial hair to thermally shrink under no tension (i.e., in a state of being free). The crimped acrylic fiber for artificial hair that has a sufficient volume and has crimps with much better compatibility with natural hair when worn by a young child can be obtained by providing irregular crimps through thermal shrinkage.

[0094] When the crimping process is a thermal shrinkage process, the temperature and time of the heat treatment are not particularly limited, but the temperature is preferably 90° C. or higher and 150° C. or lower, more preferably 100° C. or higher and 140° C. or lower, and even more preferably 105° C. or higher and 135° C. or lower, and the time is preferably 5 minutes or more and 60 minutes or less, more preferably 10 minutes or more and 50 minutes or less, and even more preferably 15 minutes or more and 40 minutes or less, for example, from the viewpoint that a crimped acrylic fiber for artificial hair that has a sufficient volume and has crimps with much better compatibility with natural hair even when worn by a young child is likely to be obtained.

[0095] In addition to thermal shrinkage of a fiber, another example of the crimping process is gear crimping. However, with the gear crimping, fine crimps are provided to a fiber at regular intervals, and thus the crimps are likely to be regular crimps. The crimping process may include the thermal

shrinkage of a fiber and the gear crimping in combination, but preferably includes only the thermal shrinkage of a fiber.

[0096] More specifically, the method for producing a crimped acrylic fiber for artificial hair preferably includes a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle, a primary drawing process for subjecting the obtained coagulated filaments to wet drawing, a secondary drawing process for subjecting the obtained primary drawn filaments to dry drawing, and a crimping process for providing crimps to the obtained secondary drawn filaments by allowing the secondary drawn filaments to thermally shrink at a temperature of 90° C. or higher and 150° C. or lower for 5 minutes or more and 60 minutes or less. The coagulation process, the primary drawing process, and the secondary drawing process can be performed in the same manner as in the description of the method for producing an acrylic fiber for artificial hair, and the descriptions thereof are omitted herein.

Hair Ornament Product

[0097] Hair ornament products can be produced using the above-described acrylic fibers for artificial hair and/or crimped acrylic fibers for artificial hair. The hair ornament product may include another artificial hair and natural fibers such as human hair and animal hair in addition to the above-described acrylic fibers for artificial hair and/or crimped acrylic fibers for artificial hair. The other artificial hair is not particularly limited, but examples thereof include polyvinyl chloride fibers, nylon fibers, polyester fibers, and regenerated collagen fibers.

[0098] Examples of the hair ornament products include a fiber bundle for hair, weaving hair, a wig, a braid, a toupee, a hair extension, and a hair accessory, and a braid is particularly preferable.

EXAMPLES

[0099] Hereinafter, one or more embodiments of the present invention will be specifically described by way of examples, but the present invention is not limited to the following examples.

Example 1

Production of Acrylic Fiber

[0100] An acrylic copolymer containing 49 mass % of acrylonitrile, 50 mass % of vinyl chloride, and 1 mass % of sodium styrenesulfonate was dissolved in acetone to produce a spinning solution having a resin concentration of 29.5 mass %. An anchor-like-Y-shaped spinning nozzle having a cross-sectional shape shown in FIG. **7** and a cross-sectional size shown in Table 1 was used to extrude the spinning solution into a coagulation bath containing a 25 mass % aqueous solution of acetone at 25° C. so that wet spinning was performed at a spinning rate of 3 m/min and a nozzle draft of 1.17. The obtained fibers were drawn to 1.6 times their original length in a drawing bath containing a 20 mass % aqueous solution of acetone at 50° C. The obtained drawn fibers were washed with warm water at 80° C., were dried at 130° C., and then were drawn to 1.9 times their original length. Acrylic fibers were thus obtained.

Production of Crimped Acrylic Fiber

[0101] The obtained acrylic fibers were allowed to thermally shrink under no tension at 120° C. for 30 minutes and thus were provided with irregular crimps. Crimped acrylic fibers were thus obtained.

Example 2

[0102] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 1, except that a C-shaped nozzle having a cross-sectional shape shown in FIG. **9** and a cross-sectional size shown in Table 1 was used.

Example 3

[0103] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 1, except that a C-shaped nozzle having a cross-sectional shape shown in FIG. **9** and a cross-sectional size shown in Table 1 was used.

Comparative Example 1

[0104] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 1, except that a dumbbell-shaped nozzle shown in FIG. **10** was used.

Comparative Example 2

[0105] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Comparative Example 1, except that relaxation was performed at a relaxation rate of 10% at 150° C. after drawing performed at 130° C.

Comparative Example 3

[0106] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 1, except that relaxation was performed at a relaxation rate of 10% at 150° C. after drawing performed at 130° C.

Comparative Example 4

[0107] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 2, except that relaxation was performed at a relaxation rate of 10% at 150° C. after drawing performed at 130° C.

Comparative Example 5

[0108] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 3, except that relaxation was performed at a relaxation rate of 10% at 150° C. after drawing performed at 130° C.

Comparative Example 6

[0109] Acrylic fibers and crimped acrylic fibers were obtained in the same manner as in Example 1, except that a circular nozzle was used and relaxation was performed at a relaxation rate of 10% at 150° C. after drawing performed at 130° C.

TABLE 1

	Nozzle	Nozzle cross-sectional size			
	cross-sectional shape	Aw* (mm)	Cw* (mm)	Cd* (mm)	a Hole area (mm^2)
Ex. 1	FIG. 7	0.06	0.06	0.45	0.0962
Ex. 2	FIG. 9	0.09	0.07	0.47	0.352
Ex. 3	FIG. 9	0.07	0.07	0.55	0.353

Aw*: slit width;
Cw*: canal width;
Cd*: circumcircle

[0110] The single fiber fineness, the dry-heat shrinkage ratio, and the torsional rigidity of the acrylic fibers of the examples and the comparative examples were measured as follows. The volume, the number of crimps, and the crimp height of the crimped acrylic fibers of the examples and the comparative examples were measured as follows. Table 2 shows the results.

Single Fiber Fineness

[0111] The fineness of a single acrylic fiber was measured using an autovibro type fineness meter (DENICON DC-21A, manufactured by Search) at a measurement length of 50 mm, and the average value of the results from 20 fibers in total was taken as the single fiber fineness.

Dry-Heat Shrinkage Ratio

[0112] A fiber bundle was formed using the acrylic fibers, and its total fineness was adjusted to 3,333 dtex. Markings were made on the fiber bundle with cotton threads such that the fiber length (effective sample length) under a load of 50 g was 200 mm. Then, the fiber bundle was used as a measurement sample. The measurement sample was thermally treated at 120° C. under no tension for 30 minutes using a uniform heating dryer. The measurement sample was taken out of the dryer and cooled to room temperature, and then the fiber length (effective sample length) LD (mm) of the measurement sample was measured under a load of 50 g. The dry-heat shrinkage ratio was determined based on Formula 1 below.

$$\text{Dry-heat shrinkage ratio (\%)} = 100 \times (200 - LD)/200 \quad \text{Formula 1}$$

Torsional Rigidity

[0113] The acrylic fiber (single filament) with a length of 3 cm was set in a torsion tester (KES-YN1, manufactured by KATO TECH CO., LTD.), and the torsional rigidity was measured under the conditions that the number of twists was ±3 twists and the torsion speed was 12°/sec. The average value of the results from 5 measurements was calculated as the value of the torsional rigidity (unit: $mg \cdot cm^2$).

Volume

[0114] (1) The acrylic fibers were used to form a 38-inch fiber bundle (about 96.5 cm and about 50 g), a rubber band was put around the central portion of the fiber bundle in the longitudinal direction, the fiber bundle was folded back at the central portion, and the resulting half-folded fiber bundle was used as a sample.

[0115] (2) The sample was hung inside a dryer and was heated at 120° C. for 30 minutes under no-load conditions (i.e., in a state of being free) to be crimped.

[0116] (3) The sample was placed on a support base (with a length of 12 cm, a width of 1.6 cm, and a height of 10 cm) of a bulkiness meter such that the length direction of the fibers corresponded to the length direction of the bulkiness meter, a rectangular weight (with a length of 17 cm, a width of 1.5 cm, a height of 0.5 cm, and a weight of 20 g) was placed on the sample in a parallel manner such that the length direction of the fibers in the sample corresponded to the length direction of the weight, the bulkiness (height) of the crimped sample at a position where the weight was disposed was measured, and thus the volume was determined. When being 25 mm or more, the volume was determined as being acceptable.

Number of Crimps

[0117] Five crimped acrylic fibers were randomly selected, the two ends of each fiber (with a fiber length of 20 cm) were fixed to an A4-size graph paper, the number of the crimps formed in a fiber length of 10 cm was measured, and the number of crimps was determined by calculating the average of the results from the five fibers. When being 10 crimps or more per 10 cm, the number of crimps was determined as being acceptable from the viewpoint of the compatibility with natural hair.

[0118] The term "crimp" here means a crimped portion formed by two contact points where the fiber is in contact with the graph paper and a portion of the fiber that is located between the two contact points and is not in contact with the graph paper, and one crimp may have two or more protrusions.

Average Crimp Height

[0119] Five crimped acrylic fibers were randomly selected, the two ends of each fiber (with a fiber length of 20 cm) were fixed to an A4-size graph paper, the heights of protrusions of all the crimps formed in a fiber length of 10 cm (i.e., crimp heights) were measured. The average crimp height per 10-cm fiber was determined by calculating the average of the results from the five fibers. When being 1.5 mm or more, the average crimp height per 10-cm fiber was determined as being acceptable from the viewpoint of the compatibility with natural hair.

[0120] As described above, the term "crimp" means a crimped portion formed by two contact points where the fiber is in contact with the graph paper and a portion of the fiber that is located between the two contact points and is not in contact with the graph paper, and when one crimp has two or more protrusions, the crimp height means the height of the highest protrusion.

[0121] For example, as shown in FIG. **12**, a crimp **101** means a crimped portion formed by a contact point **111** and a contact point **112** where a fiber **110** is in contact with a graph paper (not illustrated) and a portion **120** of the fiber that is located between the contact points **111** and **112** and is not in contact with the graph paper, and a crimp **102** means a crimped portion formed by the contact point **112** and a contact point **113** where the fiber **110** is in contact with the graph paper and a portion **130** of the fiber that is located between the contact points **112** and **113** and is not in contact

with the graph paper. The crimp heights of the crimp **101** and the crimp **102** are indicated as h**1** and h**2**, respectively.

Crimp Width

[0122] Five crimped acrylic fibers were randomly selected, the two ends of each fiber (with a fiber length of 20 cm) were fixed to an A4-size graph paper, the crimp widths of all the crimps formed in a fiber length of 10 cm were measured.

[0123] As described above, the term "crimp" means a crimped portion formed by two contact points where the fiber is in contact with the graph paper and a portion of the fiber that is located between the two contact points and is not in contact with the graph paper, and the crimp width means the distance between the two contact points where the fiber is in contact with the graph paper. For example, in FIG. **12**, the crimp widths of the crimp **101** and the crimp **102** are indicated as w**1** and w**2**, respectively.

Crimp Direction

[0124] Five crimped acrylic fibers were randomly selected, the two ends of each fiber (with a fiber length of 20 cm) were fixed to an A4-size graph paper, it was checked which direction the adjacent crimps were aligned in, the X-Y axis direction, the X-Z axis direction, the Y-Z axis direction, and the X-Y-Z axis direction (where the X axis extended along the graph paper in the fiber axial direction, the Y axis extended along the graph paper and was orthogonal to the fiber axis, and the Z axis was orthogonal to the graph paper), and thus the crimp direction was determined.

Method for Evaluating Irregular Crimps

[0125] Based on the results of the above-described crimp height, crimp width, and crimp direction, it was determined that irregular crimps were provided in the case where the following conditions were satisfied: in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.

Evaluation of Touch

[0126] With regard to the touch of the crimped acrylic fiber, a sensory evaluation was performed based on the evaluation criteria below. When the evaluation value was 3 or higher, the touch was determined as being acceptable.

Evaluation Criteria

[0127] 5: Very soft

[0128] 4: Soft

[0129] 3: Slightly soft

[0130] 2: Slightly hard

[0131] 1: Hard

Comprehensive Evaluation

[0132] The crimped acrylic fibers were comprehensively evaluated based on the evaluation criteria below.

[0133] Good: All of the volume, the number of crimps, the average crimp height, the irregular crimps, and the touch were determined as being acceptable.

[0134] Poor: At least one of the volume, the number of crimps, the average crimp height, the irregular crimps, and the touch was determined as being unacceptable.

Evaluation of Cross-Section

Preparation of Sample

[0135] The acrylic fibers or crimped acrylic fibers were cut into 15 cm long, and an appropriate amount of the acrylic fibers or crimped acrylic fibers were packed in a heat-shrinkable tube (manufactured by Junkosha Inc., model number "FEP-040," inner diameter before shrinkage: φ4.5 mm, inner diameter after shrinkage: φ3.3 mm, length: 1 m). The tube was allowed to stand in an oven at 105° C. for 5 minutes. Then, the tube was taken out of the oven and left to cool. After the heat-shrinkable tube was cooled, the tube that had shrunk and been filled with the acrylic fibers or crimped acrylic fibers was cut to a length of about 3 mm with a razor blade. Thus, samples for observation of the fiber cross-section were prepared.

Observation and Photography

[0136] The samples for observation of the fiber cross-section were observed and photographed using a laser microscope (VK-X260, manufactured by KEYENCE CORPORATION) in a range of observation and measurement of 675 μm in width×506 μm in length. The observation and photography were performed at a total of 5 points of each of the samples. FIGS. **13** to **17** show photographs of the cross-sections of the fibers of Examples 1 to 3 and Comparative Examples 1 and 6, respectively.

Method for Analyzing Photograph of Cross-Section

[0137] Image analysis software (WinROOF, Mitsubishi Shosha Co., Ltd.) was used to import the photographs of the cross-sections, the areas of the circumcircles of the fiber cross-sections and the areas of the fiber cross-sections were calculated, and then the hollow ratios were determined using Formula 2 below. The area of the circumcircle of the fiber cross-section is the area of a circle whose diameter corresponds to the length of the longest line segment among line segments connecting any two points on the circumference of the fiber cross-section.

$$\text{Hollow ratio (\%)} = 100 \times (\text{area of circumcircle of fiber cross-section} - \text{area of fiber cross-section}) / \text{area of circumcircle of fiber cross-section} \quad \text{Formula 2}$$

TABLE 2

	Acrylic fiber/ Crimped acrylic fiber			Acrylic fiber		Crimped acrylic fiber					
	Cross-sectional shape	Single-fiber fineness (dtex)	Hollow ratio (%)	Torsional rigidity (mg/cm^2)	Dry-heat shrinkage ratio (%)	Volume (mm)	Number of crimps (crimps/ 10 cm)	Average crimp height (mm)	Irregular crimps	Touch	Comprehensive evaluation
Ex. 1	Anchor-like-Y-shape	51	41	1.66	37.1	29	12	2.3	Yes	4	Good
Ex. 2	Figure-6-shape/ C-shape	48	32	1.08	44.6	36.5	13	2.44	Yes	3	Good
Ex. 3	Figure-6-shape	48	45	0.81	43	43	16	1.97	Yes	3	Good
Comp. Ex. 1	Dumbbell	47	12	3.03	45.5	21	6	1.32	Yes	5	Poor
Comp. Ex. 2	Dumbbell	47	17	2.6	1.6	7.5	1	0.43	Yes	5	Poor
Comp. Ex. 3	Anchor-like-Y-shape	51	38	1.73	2.4	9	2	0.7	Yes	4	Poor
Comp. Ex. 4	Figure-6-shape/ C-shape	46	42	1.25	2.1	11	1	0.6	Yes	5	Poor
Comp. Ex. 5	Figure-6-shape	46	43	0.56	2.8	12	2	0.52	Yes	4	Poor
Comp. Ex. 6	C-shape	56	12	4.24	2	8	1	0.43	Yes	5	Poor

[0138] As is clear from the data shown in Table 2, the acrylic fibers of the examples had favorable touch and a high volume and developed crimps with excellent compatibility with natural hair even when provided with irregular crimps.

[0139] On the other hand, the acrylic fibers of Comparative Example 1, which had a torsional rigidity of more than 2.0 mg/cm^2, the acrylic fibers of Comparative Example 2, which had a torsional rigidity of more than 2.0 mg/cm^2 and a dry-heat shrinkage ratio of less than 30%, and the acrylic fibers of Comparative Examples 3 to 6, which had a dry-heat shrinkage ratio of less than 30%, had favorable touch but had a low volume and poor compatibility with natural hair when provided with irregular crimps.

[0140] The present invention is not particularly limited, but encompasses at least the following embodiments.

[0141] [1] An acrylic fiber for artificial hair including an acrylic copolymer,

[0142] wherein a dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is 30% or more and 70% or less, and

[0143] a torsional rigidity of the acrylic fiber for artificial hair is 0.3 mg·cm^2 or more and 2.0 mg·cm^2 or less.

[0144] [2] The acrylic fiber for artificial hair according to [1], having one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6-shape.

[0145] [3] The acrylic fiber for artificial hair according to [1] or [2], wherein a single fiber fineness of the acrylic fiber for artificial hair is 25 dtex or more and 95 dtex or less.

[0146] [4] The acrylic fiber for artificial hair according to any one of [1] to [3], wherein a fiber cross-section of the acrylic fiber for artificial hair has a hollow ratio of 20% or more and 50% or less.

[0147] [5] A crimped acrylic fiber for artificial hair including an acrylic copolymer,

[0148] wherein the number of crimps of the crimped acrylic fiber for artificial hair is 10 or more crimps per 10 cm,

[0149] an average crimp height per 10-cm fiber is 1.5 mm or more, and

[0150] in ten continuous crimps, at least two crimps differ in crimp width and at least two crimps differ in crimp height, while the crimps are formed in two or more different crimp directions.

[0151] [6] The crimped acrylic fiber for artificial hair according to [5], having one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6-shape.

[0152] [7] The crimped acrylic fiber for artificial hair according to [5] or [6], wherein a single fiber fineness of the crimped acrylic fiber for artificial hair is 25 dtex or more and 95 dtex or less.

[0153] [8] The crimped acrylic fiber for artificial hair according to any one of [5] to [7], wherein a fiber cross-section of the crimped acrylic fiber for artificial hair has a hollow ratio of 20% or more and 50% or less.

[0154] [9] A hair ornament product including the acrylic fiber for artificial hair according to any one of [1] to [4], or the crimped acrylic fiber for artificial hair according to any one of [5] to [8].

[0155] [10] The hair ornament product according to [9], which is at least one selected from the group consisting of a fiber bundle for hair, weaving hair, a wig, a braid, a toupee, a hair extension, and a hair accessory.

[0156] [11] A method for producing the acrylic fiber for artificial hair according to any one of [1] to [4], including:

[0157] a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle;

[0158] a primary drawing process for subjecting the obtained coagulated filaments to wet drawing; and

[0159] a secondary drawing process for subjecting obtained primary drawn filaments to dry drawing,

[0160] wherein a relaxation treatment is not performed after the secondary drawing process.

[0161] [12] A method for producing the crimped acrylic fiber for artificial hair according to any one of [5] to [8], including:

[0162] a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle;

[0163] a primary drawing process for subjecting the obtained coagulated filaments to wet drawing;

[0164] a secondary drawing process for subjecting obtained primary drawn filaments to dry drawing; and

[0165] a crimping process for providing crimps to obtained secondary drawn filaments by allowing the secondary drawn filaments to thermally shrink under no tension at a temperature of 90° C. or higher and 150° C. or lower for 5 minutes or more and 60 minutes or less.

REFERENCE CHARACTER LIST

[0166] **1** Acrylic fiber for artificial hair

[0167] **2** Central portion

[0168] **3** T-shaped protrusion

[0169] **4** Upper side

[0170] **5** Lower extended portion

[0171] **11***a*, **11***b* Linear portion

[0172] **12***a*, **12***b* Protrusion

[0173] **13***a*, **13***b* End

[0174] **101**, **102** Crimp

[0175] **110** Fiber

[0176] **111**, **112**, **113** Contact point

[0177] **120**, **130** Portion of fiber located between two contact points

1. An acrylic fiber for artificial hair comprising an acrylic copolymer,

wherein a dry-heat shrinkage ratio of the acrylic fiber for artificial hair after dry-heat treatment at a temperature of 90° C. or higher and 180° C. or lower for 30 minutes is 30% or more and 70% or less, and

a torsional rigidity of the acrylic fiber for artificial hair is 0.3 mg·cm^2 or more and 2.0 mg·cm^2 or less.

2. The acrylic fiber for artificial hair according to claim **1**,

having one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6 shape.

3. The acrylic fiber for artificial hair according to claim **1**,

wherein a single fiber fineness of the acrylic fiber for artificial hair is 25 dtex or more and 95 dtex or less.

4. The acrylic fiber for artificial hair according to claim **1**,

wherein a fiber cross-section of the acrylic fiber for artificial hair has a hollow ratio of 20% or more and 50% or less.

5-8. (canceled)

9. A hair ornament product comprising the acrylic fiber for artificial hair according to claim **1**.

10. The hair ornament product according to claim **9**,

which is at least one selected from the group consisting of a fiber bundle for hair, weaving hair, a wig, a braid, a toupee, a hair extension, and a hair accessory.

11. A method for producing the acrylic fiber for artificial hair according to claim **1**, comprising:

a coagulation process for obtaining coagulated filaments by subjecting a spinning solution containing an acrylic copolymer to wet spinning using a spinning nozzle;

a primary drawing process for subjecting the obtained coagulated filaments to wet drawing; and

a secondary drawing process for subjecting obtained primary drawn filaments to dry drawing,

wherein a relaxation treatment is not performed after the secondary drawing process.

12. (canceled)

13. The hair ornament product according to claim **9**,

wherein the acrylic fiber for artificial hair has one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6-shape.

14. The hair ornament product according to claim **9**,

wherein a single fiber fineness of the acrylic fiber for artificial hair is 25 dtex or more and 95 dtex or less.

15. The hair ornament product according to claim **9**,

wherein a fiber cross-section of the acrylic fiber for artificial hair has a hollow ratio of 20% or more and 50% or less.

16. The method for producing the acrylic fiber for artificial hair according to claim **11**,

wherein the acrylic fiber for artificial hair has one or more cross-sectional shapes selected from the group consisting of an anchor-like-Y-shape, a C-shape, and a figure-6-shape.

17. The method for producing the acrylic fiber for artificial hair according to claim **11**,

wherein a single fiber fineness of the acrylic fiber for artificial hair is 25 dtex or more and 95 dtex or less.

18. The method for producing the acrylic fiber for artificial hair according to claim **11**,

wherein a fiber cross-section of the acrylic fiber for artificial hair has a hollow ratio of 20% or more and 50% or less.

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