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(54) LYOCELL MATERIAL, FILTERS, SMOKING ARTICLES AND METHOD FOR PREPARING THEREOF

(57) The present application relates to a lyocell material, a filter for a smoking article, including the lyocell material, and a smoking article. The lyocell material and the filter for a smoking article, according to the present application, may replace a cellulose acetate material and a filter for a smoking article including the same, in the art.

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Description

Technical Field

[0001] The present application relates to a lyocell material, a filter including the same, a smoking article, and a method of preparing the lyocell material.

Background Art

[0002] Until now, cellulose acetate fibers have been mainly used as tobacco filter materials. Cellulose acetate is known to be a biodegradable material, but filters for a smoking article, made of cellulose acetate, remain in their original form for 1 to 2 years even after being buried in soil, and a considerable amount of time is required until the filters are completely biodegraded. Considering the amount and toxicity of tobacco products that are discarded and left in the living environment as well as tobacco products that are collected as waste after being used for smoking and then buried in a landfill, there is a need to further improve the biodegradability of filters for a smoking article. Accordingly, lyocell, which is more environmentally friendly, has recently been chosen as a material for replacing cellulose acetate.

Disclosure of Invention

Technical Problem

[0003] An object of the present application is to provide a lyocell material capable of replacing cellulose acetate commercialized for a filter for a smoking article.

[0004] Another object of the present application is to provide a lyocell material for a filter for a smoking article, of which a preparation process is environmentally friendly and which has excellent biodegradability when discarded.

[0005] Another object of the present application is to provide a lyocell filter for a smoking article.

[0006] Another object of the present application is to provide a smoking article (for example, a cigarette) including a lyocell filter.

Solution to Problem

[0007] According to the present application, there may be provided a lyocell material, a filter including the same, a smoking article, and the like.

[0008] The lyocell material may include one or more lyocell multifilaments.

[0009] The lyocell multifilament may include one or more lyocell monofilaments.

[0010] According to an aspect of the present application, there is provided a lyocell material including a lyocell multifilament imparted with crimps, wherein the lyocell material has a crimp factor calculated according to Equation 1 below in a range of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad-ea/inch).

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

[0011] In particular, the radian of the crimp in Equation 1 is calculated according to Equation 1-1 below.

Equation 1-1

$$\text{Radian of crimp} = \arctan(\text{length of crimp}/(2 \times \text{height of crimp}))$$

[0012] The lyocell multifilament imparted with crimps may include one or more lyocell monofilaments. The lyocell multifilament imparted with crimps may be considered as a lyocell multifilament in the present application.

[0013] In some embodiments, there may be provided a lyocell material of which a crimp efficiency index (CEI) represented by Equation 2 is in a range of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch).

Equation 2

$$CEI = \text{crimp energy} \times \text{crimp factor}$$

[0014] In Equation 2, crimp energy refers to energy required to straighten the crimp, and a unit of the crimp energy is joules (J).

[0015] In some embodiments, there may be provided a filter for a smoking article, including a lyocell material which has a crimp factor of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad-ea/inch).

[0016] In some embodiments, there may be provided a filter for a smoking article, including a lyocell material which has a CEI of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch).

[0017] According to another aspect of the present application, there may be provided a smoking article including the lyocell material or the filter.

[0018] According to another aspect of the present application, there may be provided a method of preparing the lyocell material, a filter including the same, and a smoking article.

[0019] As used herein, the term "smoking article" may refer to an article such as a tobacco (cigarette) or a cigar capable of generating aerosol. In this regard, the smoking article may include an aerosol-generating material or an aerosol-forming substrate. In addition, the smoking article may include a solid material based on a tobacco raw material such as a tobacco leaf, a cut tobacco, or a reconstituted tobacco. In addition, the smoking material may include a volatile compound.

[0020] As used herein, the term "lyocell multifilament" may refer to a multifilament made of lyocell cellulose. In particular, the lyocell multifilament may be a (multi)filament and/or fiber made of cellulose derived or mainly derived from wood pulp. In particular, the lyocell multifilament may be a semi-synthetic (multi)filament and/or fiber.

[0021] A used herein, the term "cellulose" may refer to "lyocell cellulose."

[0022] As used herein, the term "crimp" may refer to a weaved, curled, or undulated configuration imparted to materials such as a fiber, a (mono)filament, a multifilament, and/or yarn inherently or through mechanical, thermal, and/or chemical processes. The crimp may be characterized by a periodic deviation from a straight line axis along a length of a fiber, a (mono)filament, a multifilament, and/or yarn. In the fiber, the (mono)filament, the multifilament, and/or the yarn, one crimp may be defined as one repeating unit of the periodic deviation. The presence of the crimp affects properties such as elasticity, bulk, resilience, and texture of a material and a fabric made of the material.

[0023] As used herein, the term "length of a crimp" may refer to a dimension of the above-described one repeating unit of a crimp, which is placed in a straight line axis direction along a length of a fiber, a (mono)filament, a multifilament, and/or yarn.

[0024] As used herein, the term "height of a crimp" may refer to a periodic deviation of a crimp, which is formed perpendicular to a straight line axis along a length of a fiber, a (mono)filament, a multifilament, and/or yarn.

[0025] In the present specification, "length of crimp/(2×height of crimp)" may refer to a ratio of a base to a height of a right triangle of which a base length is half a length of a crimp and of which a height is a height of a crimp, wherein the right triangle is a right triangle having a base included in a straight line axis of a crimp along a length of a fiber, a (mono)filament, a multifilament, and/or yarn. The ratio may be used as a value representing a shape of a crimp. Meanwhile, the ratio may refer to a tangent function value for an opposite angle of the base in the right triangle.

[0026] As used herein, a radiation of a crimp represented by arctan(length of crimp /(2×height of crimp)) may refer to a size of an opposite angle of the base expressed as a radian in the right triangle. Therefore, the radian of the crimp may be used as a value representing a shape of a crimp. For example, as a radian of a crimp, which is a size of an opposite angle of a base, is increased, the radian of the crimp may represent a shape with a smaller deviation from a longitudinal axis as compared to a longitudinal dimension of one repeating unit of a crimp, or in other words, a relatively less protruding shape. On the other hand, as a radian of a crimp is increased, the radian of the crimp may represent a shape with a greater deviation from a longitudinal axis as compared to a longitudinal dimension of one repeating unit of a crimp, or in other words, a relatively more protruding shape. Here, as a degree by which a shape protrudes is decreased, the shape may be maintained more stably.

[0027] Meanwhile, in the ideal case in which crimps do not overlap each other, the number of crimps may be inversely proportional to a longitudinal dimension of a repeating unit of the crimps. Therefore, when a radian of a crimp is the same, as the number of crimps is increased, a longitudinal dimension of a repeating unit may be decreased, and thus a height of the crimp may also be decreased. On the other hand, when the number of crimps is excessively increased, the physical properties of a material imparted with crimps may be deteriorated due to the crimps and excessive overlapping between the crimps, which may limit post-processing.

[0028] Therefore, in the present specification, a crimp factor, which is expressed as the product of the number of crimps and a radian of a crimp, may be understood as a value representing the number and shape of crimps in a lyocell multifilament imparted with crimps. The crimp factor may be expressed, for example, in a unit of rad·ea/cm. For example, when crimps, in which one repeating unit of a crimp is small (that is, the number of crimps per unit length is large, and/or a

degree of protrusion from a longitudinal axis is relatively small (that is, a radian of a crimp is large), are formed, a crimp factor may be increased.

[0029] As used herein, the term "crimp energy" refers to energy required to straighten a crimp. The crimp energy may be expressed in a unit of energy (for example, J).

[0030] For example, the crimp energy may be calculated from a minimum weight imparted such that a crimp is not identified from a lyocell multifilament. That is, the crimp energy may be calculated from a weight imparted to a lyocell multifilament imparted with crimps. By imparting a weight to one end of a lyocell multifilament imparted with crimps, the lyocell multifilament imparted with crimps is stretched. When a weight of crimp energy or more is applied, a crimp is not identified from a lyocell multifilament. In this case, the crimp energy may be calculated from the product of a minimum weight applied such that a crimp is not identified from a lyocell multifilament and a length by which the lyocell multifilament is stretched up to a time point at which the crimp is not identified.

[0031] Relatively high crimp energy may be evaluated that crimps are more uniformly dispersed, that is, uniformity is high.

[0032] Therefore, in the present specification, a CEI, which is expressed as the product of crimp energy and a crimp factor, may be understood as a value representing the dispersion and form (or shape) of crimps. That is, when the crimp factor is the same, as crimps are more uniformly dispersed, a CEI may be higher. The crimp factor may be expressed, for example, in a unit of J·rad·ea/cm.

[0033] In the present specification, a "blooming index" is calculated by multiplying a blooming factor by the number of crimps. The blooming factor is calculated by dividing a change in width of a fiber constituting a material (for example, a lyocell material) before and after permanent deformation (for example, an opening process of a lyocell material) by a change in length of the fiber before and after permanent deformation of the material, and a unit thereof is %.

[0034] Therefore, in the present specification, the "blooming index" may refer to an amount (ratio) of an increase in width to a reduction in length due to crimps imparted to a material, wherein the amount (ratio) is an amount through the entire crimp (that is, a degree by which a material or the like blooms). Therefore, the blooming index may be an indicator of a change in surface area due to crimp imparting, and for example, a low blooming index may refer to a small surface area. Therefore, a lyocell material with a low blooming index may be unsuitable for use in a filter for a smoking article due to a small specific surface area thereof. In addition, the blooming index may indicate the uniformity of a crimp. For example, a high blooming index may indicate high crimp uniformity.

[0035] Aa used herein, the term "moisture regain" may mean a value in which a ratio of moisture included in a sample is expressed as wt% with respect to 100 wt% of a sample not including moisture and may be a value calculated according to Equation 3 below.

Equation 3

$$\text{Moisture regain (\%)} = (W-D)/D \times 100$$

[0036] In Equation 3, W denotes a weight of a sample measured before drying, and D denotes a weight of the sample measured after drying.

[0037] As used herein, the term "degree of polymerization (DPw)" may refer to the number of monomer units and/or repeating units in a macromolecule, a polymer, or an oligomer molecule. The DPw may be expressed as Mn/M0, wherein Mn is a number average molecular weight of a macromolecule, a polymer, or an oligomer molecule, and M0 is a molecular weight of a monomer or a repeating unit.

[0038] As used herein, the term "lyocell tow" includes at least one lyocell multifilament or consists of at least one lyocell multifilament.

[0039] As used herein, the term "bloomed" lyocell material, fiber, and/or multifilament refer to a lyocell material, a lyocell fiber, and/or a lyocell multifilament that are separated, uncoiled, unspooled, loosened, or unwrapped from an original compressed and/or rolled state.

[0040] As used herein, the term "multi-lobal cross section" may refer to a cross-sectional shape that deviates from a standard circular shape. The multi-lobal cross section may include three or more protrusions, for example, three protrusions. Here, the term "protrusion" may refer to a distinct and extended segment or arm extending outward from a central core or junction point of a monofilament cross section. For example, a cross-sectional shape may include a Y-shaped cross section, a rectangular cross section, a star-shaped cross section, a leaf-shaped cross section, a hexagonal cross section, a polygonal cross section, and the like. A multi-lobal cross section including three protrusions may be referred to as a "Y-shaped cross section." Lyocell tow may have a Y-shaped cross section for use in cigarette filters.

[0041] As used herein, the term "single fineness of a lyocell multifilament" refers to a fineness of one monofilament separated from a lyocell multifilament. As used herein, the term "single fineness of a filament" is considered as a "single fineness of a lyocell multifilament."

[0042] As used herein, the term "basis weight" refers to mass per unit area of wrapping paper and/or wrapper. The basis weight of wrapping paper and/or wrapper may be determined by measuring the mass and area of the wrapping paper and/or wrapper and dividing the mass of the wrapping paper and/or wrapper by the area.

[0043] Unless otherwise specifically defined in the present specification, a content (%) of a component may be wt%.

[0044] Unless specifically defined otherwise in the specification, when the properties of lyocell materials, filters for a smoking article, and components or compositions related thereto are affected by a temperature, the temperature at which the properties are confirmed or measured may be room temperature. In this case, the room temperature may be a temperature which is not particularly lowered or raised and may be, for example, in a range of 10 °C to 35 °C, in particular, in a range of 15 °C to 35 °C or 20 °C to 30 °C, or may be 25 °C.

[0045] Hereinafter, the present application is described in more detail.

[0046] The present application relates to a lyocell material. The lyocell material may be used in a smoking article, and although not particularly limited, the lyocell material may be used in a filter for a smoking article.

[0047] According to an aspect of the present application, there is provided a lyocell material including a lyocell multifilament imparted with crimps, wherein lyocell material has a crimp factor calculated according to Equation 1 below in a range of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad-ea/inch).

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

[0048] In particular, the radian of the crimp in Equation 1 is calculated according to Equation 1-1 below.

Equation 1-1

$$\text{Radian of crimp} = \arctan(\text{length of crimp}/(2 \times \text{height of crimp}))$$

[0049] In some embodiments, in the lyocell material, the crimp factor may be in a range of 13.78 rad·ea/cm to 25.59 rad·ea/cm (35 rad·ea/inch to 65 rad-ea/inch).

[0050] In some embodiments, in the lyocell material, the number of crimps may be in a range of 3.94 ea/cm to 23.62 ea/cm (10 ea/inch to 60 ea/inch). For example, the number of crimps may be in a range of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch).

[0051] In some embodiments, in the lyocell material, the radian of the crimp may be in a range of 1.02 to 1.50. For example, the radian of the crimp may be in a range of 1.05 and 1.35.

[0052] In some embodiments, in the lyocell material, a height of the crimp may be in a range of 0.01 mm to 0.10 mm. For example, the height of the crimp may be in a range of 0.04 mm and 0.10 mm.

[0053] In some embodiments, in the lyocell material, a length of the crimp may be in a range of 0.25 mm to 0.40 mm.

[0054] In some embodiments, in the lyocell material, the radian of the crimp may be in a range of 1.02 to 1.50, and the height of the crimp may be in a range of 0.01 mm to 0.10 mm.

[0055] In some embodiments, in the lyocell material, the radian of the crimp may be in a range of 1.02 to 1.50, and the length of the crimp may be in a range of 0.25 mm to 0.40 mm.

[0056] In some embodiments, in the lyocell material, a CEI represented by Equation 2 below may be in a range of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch).

Equation 2

$$\text{CEI} = \text{crimp energy} \times \text{crimp factor}$$

[0057] In Equation 2, crimp energy refers to energy required to straighten the crimp, and a unit of the crimp energy is joules (J).

[0058] In some embodiments, in the lyocell material, the CEI may be in a range of 9.06 J·rad·ea/cm to 27.56 J·rad·ea/cm (23 J·rad·ea/inch to 70 J·rad·ea/inch).

[0059] In some embodiments, in the lyocell material, the crimp energy may be in a range of 0.9 J to 1.6 J.

[0060] In addition, the crimp energy may be calculated from a weight imparted to the lyocell multifilament imparted with crimps. By imparting a weight to one end of a lyocell multifilament imparted with crimps, the lyocell multifilament imparted with crimps is stretched. When a weight of crimp energy or more is applied, a crimp is not identified from a lyocell multifilament. In particular, the crimp energy may be calculated from a minimum weight imparted such that a crimp is not

identified from a lyocell multifilament. The crimp energy may be calculated from the product of a minimum weight applied such that a crimp is not identified from a lyocell multifilament and a length by which the lyocell multifilament is stretched up to a time point at which the crimp is not identified.

[0061] In some embodiments, in the lyocell material, a single fineness of the lyocell multifilament may be in a range of 1.67 dtex to 8.89 dtex (1.5 denier to 8.0 denier).

[0062] In some embodiments, the lyocell material may have a total fineness of 1,667 tex to 6,111 tex (15,000 denier to 55,000 denier).

[0063] In some embodiments, the lyocell material may satisfy the following [condition i] and may further satisfy at least one of the following [condition ii] and [condition iii].

[condition i] A CEI is in a range of 9.06 J·rad·ea/cm to 27.56 J·rad·ea/cm (23 J·rad·ea/inch to 70 J·rad·ea/inch).
[condition ii] The number of crimps is in a range of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch).
[condition iii] A radian of the crimp is in a range of 1.02 to 1.50.

[0064] In some embodiments, the lyocell material may satisfy all of the following [condition i] to [condition iii].

[0065] In some embodiments, the lyocell material may satisfy the following [condition i] and may further satisfy at least one of the following [condition iv] and [condition v].

[condition i] A CEI is in a range of 9.06 J·rad·ea/cm to 27.56 J·rad·ea/cm (23 J·rad·ea/inch to 70 J·rad·ea/inch).
[condition iv] A height of a crimp is in a range of 0.01 mm to 0.10 mm.
[condition v] A length of the crimp is in a range of 0.25 mm to 0.40 mm.

[0066] In some embodiments, the lyocell material may satisfy all of the following [condition i], [condition iv], and [condition v].

[0067] In some embodiments, in the lyocell material, the lyocell multifilament may include one or more monofilaments, and one or more of the monofilaments may have a multi-lobal cross section.

[0068] In some embodiments, in the lyocell material, the lyocell multifilament may include one or more monofilaments, and the monofilaments may all have a multi-lobal cross section.

[0069] In some embodiments, the lyocell material may be lyocell tow.

[0070] In some embodiments, the lyocell material may be used for a filter for a smoking article.

[0071] In some embodiments, the lyocell material may not be used for a tire cord or a garment.

[0072] In addition, according to another aspect of the present application, there is provided a filter for a smoking article, including any one of lyocell materials.

[0073] In addition, according to another aspect of the present application, there is provided a smoking article including any one of filters for a smoking article.

[0074] In addition, according to another aspect of the present application, there is provided a method of preparing a lyocell material, the method including lyocell dope spinning, coagulation and lyocell multifilament obtainment, washing, emulsion treatment, and crimp imparting. In some embodiments, the operations are performed in this stated order.

[0075] In some embodiments, in the method of preparing a lyocell material, the emulsion treatment may be performed by using an emulsion solution having an emulsion concentration of 2 % to 10 % with respect to 100 % of the total weight of the emulsion solution, a temperature of the emulsion solution may be in a range of 20 °C to 80 °C, and a moisture regain of the lyocell multifilament may be adjusted before the crimping imparting.

[0076] In some embodiments, in the method of preparing a lyocell material, the moisture regain of the lyocell multifilament may be adjusted to within a range of 180 % to 360 %.

[0077] In some embodiments, in the method of preparing a lyocell material, the moisture regain of the lyocell multifilament may be reduced before the crimp imparting.

[0078] In some embodiments, in the method of preparing a lyocell material, the moisture regain of the lyocell multifilaments may be reduced in the crimp imparting.

[0079] In some embodiments, in the method of preparing a lyocell material, steam may not be used before the crimp imparting, during the crimp imparting, or before and during the crimp imparting.

[0080] The uniformity of a shape of the crimp may be a key factor in improving the properties of the lyocell material, in particular, improving the properties of a filter for a smoking article including the lyocell material and the preparing processability thereof. In particular, when a shape of the crimp imparted to the lyocell multifilament is non-uniform, during processing of the lyocell material for use in preparing a filter for a smoking article, blooming due to opening is reduced, or post-processing including opening is not performed.

[0081] Meanwhile, due to the crimps imparted to the lyocell multifilament, a permanent change of the lyocell material appear in the form of blooming. For example, the lyocell material blooms in a width direction and a length direction due to the opening and/or stretching of the lyocell material, and the blooming of the lyocell material progresses irreversibly. Due to

irreversible blooming, a specific surface area of the lyocell material rapidly increases, and thus the lyocell material has properties (for example, filtering performance) suitable for use in a filter for a smoking article.

[0082] Meanwhile, in the crimp imparting, the lyocell multifilament is pressed in a specific direction to impart the crimps to the lyocell multifilament. Typically, when the number of crimps is increased by simply increasing pressure, due to randomly formed crimps and/or excessive overlapping between the crimps, the physical properties of the lyocell material may be degraded, which may limit post-processing. On the other hand, when the number of crimps is reduced by simply reducing pressure, the lyocell material may not sufficiently bloom through opening and thus may be unsuitable for use in a filter for a smoking article.

[0083] That is, by improving the uniformity of a shape of the crimp, a lyocell material with improved blooming may be prepared, and due to an increase in blooming, the properties (for example, filtering performance) of a filter for a smoking article including the lyocell material may be improved. In addition, by improving the uniformity of the shape of the crimp, the opening of the lyocell material may be stably performed, and the processability of a process of preparing a filter for a smoking article may be improved.

[0084] Surprisingly, the present applicant has confirmed that the uniformity of a crimp is improved when both of the number of the crimps and a radian value of the crimp are adjusted. From this aspect, through in-depth research, the present applicant has deduced a new equation for the number of crimps and the radian value of the crimp in relation to an improvement of the uniformity of the crimp.

[0085] In some embodiments, the lyocell material according to an embodiment has a crimp factor of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad·ea/inch), and the crimp factor is calculated according to Equation 1 below.

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

[0086] By adjusting the crimp factor according to Equation 1, the uniformity of the crimp imparted to the lyocell multifilament is increased, and in particular, the uniformity of the shape of the crimp is further increased. Furthermore, the mechanical properties of the lyocell multifilament may be improved, and the properties (for example, filtering performance) of a filter for a smoking article including the lyocell multifilament may be improved.

[0087] The crimp factor may be adjusted within the above numerical range, thereby improving the uniformity of the crimp imparted to the lyocell multifilament. In particular, the crimp factor is adjusted within the above numerical range, thereby adjusting the number of the crimps, the radian of the crimp, or the number of the crimps and the radian of the crimp. Meanwhile, the number of the crimps and/or the radian of the crimp may be adjusted, thereby adjusting the crimp factor. In particular, the radian of the crimp may be adjusted, thereby directly adjusting the height and length of the crimp imparted to the lyocell multifilament. Meanwhile, the height and/or length of the crimp may be adjusted, thereby directly adjusting the radian of the crimp. As a result, the shape of the crimp imparted to the lyocell multifilament is consistently adjusted.

[0088] When the crimp factor is less than 9.84 rad·ea/cm (25 rad·ea/inch), a blooming index of the lyocell material may be significantly insufficient due to an insufficient number of formed crimps and/or the non-uniformity of the shape of the crimp. In light of the definition of a blooming index, a low blooming index refers to a small specific surface area and means that the lyocell material is unsuitable for use in a filter for a smoking article.

[0089] On the other hand, when the crimp factor exceeds 29.53 rad·ea/cm (75 rad·ea/inch), the blooming of the lyocell material may be limited due to an excessive number of crimps and/or the non-uniformity of the shape of the crimp. In particular, during a process of opening and/or stretching the lyocell material for use in preparing a filter for a smoking article, the lyocell material may break instead of blooming. As a result, the preparation of a filter for a smoking article may be limited.

[0090] In addition, the lyocell material according to some embodiments may have a CEI of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch), and the CEI may be calculated according to Equation 2 below.

Equation 2

$$\text{CEI} = \text{crimp energy} \times \text{crimp factor}$$

[0091] The CEI is adjusted within the above numerical range, thereby increasing the uniformity of the crimp imparted to the lyocell multifilament. In particular, the uniformity of the crimp is further increased throughout the entire lyocell multifilament. Energy required to impart the crimp and/or the shape of the crimp may be adjusted by adjusting the crimp energy, adjusting the crimp factor, or adjusting both the crimp energy and the crimp factor. As a result, the uniformity of a crimp of a monofilament taken from a central portion (for example, a central portion in a longitudinal direction) of the lyocell multifilament and the uniformity of a crimp of a monofilament taken from an end portion of the lyocell multifilament may be

improved.

[0092] When the CEI is less than 8.27 J·rad·ea/cm (21 J·rad·ea/inch), the blooming index of the lyocell material may be significantly insufficient. In light of the definition of a blooming index, a low blooming index refers to a small specific surface area and means that the lyocell material is unsuitable for use in a filter for a smoking article.

[0093] On the other hand, when the CEI exceeds 31.50 J·rad·ea/cm (80 J·rad·ea/inch), the blooming of the lyocell material may be limited due to excessively imparted crimps. In particular, during a process of opening and/or stretching the lyocell material for use in preparing a filter for a smoking article, the lyocell material may break instead of blooming. As a result, the preparation of a filter for a smoking article may be limited.

[0094] By adjusting the CEI within the above numerical range, the uniformity of the crimp imparted to the lyocell multifilament is increased, and in particular, the uniformity of the crimp imparted to the end portion of the lyocell multifilament is further increased. Furthermore, the formability the lyocell multifilament may be improved, and the properties (for example, filtering performance) and processability of a filter for a smoking article including the lyocell multifilament may be improved.

[Multi-lobal cross section]

[0095] One or more of lyocell monofilaments included in a lyocell material of the present application may have a multi-lobal cross section. The term "multi-lobal" may mean that a shape of an outline of a cross section is not circular, and the term "cross section" may be a cross section obtained by cutting a lyocell monofilament in a direction virtually or actually perpendicular to a longitudinal direction of a filament.

[0096] An outline of the multi-lobal cross section may touch each of a virtual first circle and a virtual second circle. In addition, the virtual second circle may be depicted inside the virtual first circle, and/or the virtual second circle may be placed inside the virtual first circle. The "virtual first circle" may also be referred to as a "virtual circumscribed circle" and/or a "circumscribed circle," and/or the "virtual second circle" may also be referred to as a "virtual inscribed circle" and/or a "inscribed circle."

[0097] The virtual first circle may be a circle with the smallest area value among circles drawn to completely encompass one cross section of a monofilament. The virtual second circle may be a circle with the largest area value among circles drawn inside a cross section of a monofilament.

[0098] When a circumscribed circle encompassing a across section of a monofilament may be drawn, the virtual first circle may be the circumscribed circle. When an inscribed circle may be drawn inside a cross section of a monofilament, the virtual second circle may be the inscribed circle.

[0099] The multi-lobal cross section may have a shape including a plurality of protrusions and may be, for example, a Y-shaped cross section including three protrusions. It may be understood that the plurality of protrusions are formed as an integral type with the virtual second circle as a central portion and have a shape of which an end touches the virtual first circle. The terms described herein have the same meanings as described above.

[0100] A modified ratio of a monofilament may be defined by Equation 1 below.

Equation 1

$$\text{Modified ratio} = r1/r2$$

[0101] Here, r1 is a radius of the virtual first circle, and r2 is a radius of the virtual second circle.

[0102] For example, the radius of the virtual first circle may be in a range of 4 μm to 40 μm, the radius of the virtual second circle may be in a range of 2 μm to 14 μm, and the modified ratio may be in a range of 1.01 to 10.

[0103] In addition, a space occupancy ratio of a monofilament may be defined by Equation 2.

Equation 2

$$\text{Space occupancy ratio} = (S1/S2) \times 100\ (\%)$$

[0104] Here, S1 is an area of the virtual first circle, and S2 is a cross-sectional area of a monofilament included in a lyocell fiber.

[0105] For example, a space occupancy ratio of a monofilament having a multi-lobal cross section may be in a range of about 120 % to about 600 %.

[0106] In some embodiments, in the lyocell material, the lyocell multifilament may include one or more monofilaments, and one or more of the monofilaments may have a multi-lobal cross section.

[0107] In some embodiments, in the lyocell material, the lyocell multifilament may include one or more monofilaments,

and the monofilaments may all have a multi-lobal cross section.

[Fineness]

[0108] A lyocell material of the present application may include a lyocell multifilament, and the lyocell multifilament may have a fineness suitable for preparing a filter for a smoking article and securing a function thereof.

[0109] For example, a single fineness of a filament constituting the lyocell multifilament may be in a range of 1.67 dtex to 8.89 dtex (1.5 denier to 8.0 denier). In this case, the single fineness of the filament refers to a fineness of one monofilament separated from the lyocell multifilament.

[0110] In particular, the single fineness of the filament may be, for example, 8.33 dtex (7.5 denier) or less, 7.78 dtex (7.0 denier) or less, 7.22 dtex (6.5 denier) or less, 6.67 dtex (6.0 denier) or less, 6.11 dtex (5.5 denier) or less, 5.56 dtex (5.0 denier) or less, 5.00 dtex (4.5 denier) or less, 3.89 dtex (3.5 denier) or less, 3.33 dtex (3.0 denier) or less, 2.78 dtex (2.5 denier) or less, or 2.22 dtex (2.0 denier) or less. A lower limit of the single fineness of the filament may be, for example, 2.22 dtex (2.0 denier) or more, 2.78 dtex (2.5 denier) or more, 3.33 dtex (3.0 denier) or more, 3.89 dtex (3.5 denier) or more, 4.44 dtex (4.0 denier) or more, 5.00 dtex (4.5 denier) or more, 5.56 dtex (5.0 denier) or more, 6.11 dtex (5.5 denier) or more, 6.67 dtex (6.0 denier) or more, 7.22 dtex (6.5 denier) or more, or 7.78 dtex (7.0 denier) or more. Satisfying the above range may be more advantageous in securing stable physical properties (for example, implementing hardness or suction resistance) and processability of a filter for a smoking article.

[0111] For example, the lyocell multifilament may have a total fineness of 1,667 tex to 6,111 tex (15,000 denier to 55,000 denier). For example, a lower limit of the total fineness may be, for example, 1,778 tex (16,000 denier) or more, 1,833 tex (16,500 denier) or more, 1,889 tex (17,000 denier) or more, 1,944 tex (17,500 denier) or more, 2,000 tex (18,000 denier) or more, 2,056 tex (18,500 denier) or more, 2,111 tex (19,000 denier) or more, 2,167 tex (19,500 denier) or more, 2,222 tex (20,000 denier) or more, 2,278 tex (20,500 denier) or more, 2,333 tex (21,000 denier) or more, 2,389 tex (21,500 denier) or more, 2,444 tex (22,000 denier) or more, 2,500 tex (22,500 denier) or more, 2,556 tex (23,000 denier) or more, 2,611 tex (23,500 denier) or more, 2,667 tex (24,000 denier) or more, 2,722 tex (24,500 denier) or more, 2,778 tex (25,000 denier) or more, 2,833 tex (25,500 denier) or more, 2,889 tex (26,000 denier) or more, 2,944 tex (26,500 denier) or more, 3,000 tex (27,000 denier) or more, 3,056 tex (27,500 denier) or more, 3,111 tex (28,000 denier) or more, 3,167 tex (28,500 denier) or more, 3,222 tex (29,000 denier) or more, 3,287 tex (29,500 denier) or more, 3,333 tex (30,000 denier) or more, 3,389 tex (30,500 denier) or more, 3,444 tex (31,000 denier) or more, 3,500 tex (31,500 denier) or more, 3,556 tex (32,000 denier) or more, 3,611 tex (32,500 denier) or more, 3,667 tex (33,000 denier) or more, 3,722 tex (33,500 denier) or more, 3,778 tex (34,000 denier) or more, 3,833 tex (34,500 denier) or more, 3,889 tex (35,000 denier) or more, 3,944 tex (35,500 denier) or more, 4,000 tex (36,000 denier) or more, 4,056 tex (36,500 denier) or more, 4,111 tex (37,000 denier) or more, 4,167 tex (37,500 denier) or more, 4,222 tex (38,000 denier) or more, 4,278 tex (38,500 denier) or more, 4,333 tex (39,000 denier) or more, 4,389 tex (39,500 denier) or more, 4,444 tex (40,000 denier) or more, 4,500 tex (40,500 denier) or more, 4,556 tex (41,000 denier) or more, 4,611 tex (41,500 denier) or more, 4,667 tex (42,000 denier) or more, 4,722 tex (42,500 denier) or more, 4,778 tex (43,000 denier) or more, 4,833 tex (43,500 denier) or more, 4,889 tex (44,000 denier) or more, 4,944 tex (44,500 denier) or more, 5,000 tex (45,000 denier) or more, 5,056 tex (45,500 denier) or more, 5,111 tex (46,000 denier) or more, 5,167 tex (46,500 denier) or more, 5,222 tex (47,000 denier) or more, 5,278 tex (47,500 denier) or more, 5,333 tex (48,000 denier) or more, 5,389 tex (48,500 denier) or more, 5,444 tex (49,000 denier) or more, 5,500 tex (49,500 denier) or more, 5,556 tex (50,000 denier) or more, 5,611 tex (50,500 denier) or more, 5,667 tex (51,000 denier) or more, 5,722 tex (51,500 denier) or more, 5,778 tex (52,000 denier) or more, 5,833 tex (52,500 denier) or more, 5,889 tex (53,000 denier) or more, 5,944 tex (53,500 denier) or more, 6,000 tex (54,000 denier) or more, or 6,056 tex (54,500 denier) or more. An upper limit of the total fineness may be, for example, 6,056 tex (54,500 denier) or less, 6,000 tex (54,000 denier) or less, 5,944 tex (53,500 denier) or less, 5,889 tex (53,000 denier) or less, 5,833 tex (52,500 denier) or less, 5,778 tex (52,000 denier) or less, 5,722 tex (51,500 denier) or less, 5,667 tex (51,000 denier) or less, 5,611 tex (50,500 denier) or less, 5,556 tex (50,000 denier) or less, 5,500 tex (49,500 denier) or less, 5,444 tex (49,000 denier) or less, 5,389 tex (48,500 denier) or less, 5,333 tex (48,000 denier) or less, 5,278 tex (47,500 denier) or less, 5,222 tex (47,000 denier) or less, 5,167 tex (46,500 denier) or less, 5,111 tex (46,000 denier) or less, 5,056 tex (45,500 denier) or less, 5,000 tex (45,000 denier) or less, 4,944 tex (44,500 denier) or less, 4,889 tex (44,000 denier) or less, 4,833 tex (43,500 denier) or less, 4,778 tex (43,000 denier) or less, 4,722 tex (42,500 denier) or less, 4,667 tex (42,000 denier) or less, 4,611 tex (41,500 denier) or less, 4,556 tex (41,000 denier) or less, 4,500 tex (40,500 denier) or less, 4,444 tex (40,000 denier) or less, 4,389 tex (39,500 denier) or less, 4,333 tex (39,000 denier) or less, 4,278 tex (38,500 denier) or less, 4,222 tex (38,000 denier) or less, 4,167 tex (37,500 denier) or less, 4,111 tex (37,000 denier) or less, 4,056 tex (36,500 denier) or less, 4,000 tex (36,000 denier) or less, 3,944 tex (35,500 denier) or less, 3,889 tex (35,000 denier) or less, 3,833 tex (34,500 denier) or less, 3,778 tex (34,000 denier) or less, 3,722 tex (33,500 denier) or less, 3,667 tex (33,000 denier) or less, 3,611 tex (32,500 denier) or less, 3,556 tex (32,000 denier) or less, 3,500 tex (31,500 denier) or less, 3,444 tex (31,000 denier) or less, 3,389 tex (30,500 denier) or less, 3,333 tex (30,000 denier) or less, 3,278 tex (29,500 denier) or less, 3,222 tex (29,000 denier) or less, 3,167 tex (28,500 denier) or less, 3,111 tex (28,000 denier) or less, 3,056 tex (27,500 denier) or less, 3,000 tex (27,000

denier) or less, 2,944 tex (26,500 denier) or less, 2,889 tex (26,000 denier) or less, 2,833 tex (25,500 denier) or less, 2,778 tex (25,000 denier) or less, 2,722 tex (24,500 denier) or less, 2,667 tex (24,000 denier) or less, 2,611 tex (23,500 denier) or less, 2,556 tex (23,000 denier) or less, 2,500 tex (22,500 denier) or less, 2,444 tex (22,000 denier) or less, 2,389 tex (21,500 denier) or less, 2,333 tex (21,000 denier) or less, 2,278 tex (20,500 denier) or less, 2,222 tex (20,000 denier) or less, 2,167 tex (19,500 denier) or less, 2,111 tex (19,000 denier) or less, 2,056 tex (18,500 denier) or less, 2,000 tex (18,000 denier) or less, 1,944 tex (17,500 denier) or less, 1,889 tex (17,000 denier) or less, 1,833 tex (16,500 denier) or less, 1,778 tex (16,000 denier) or less, or 1,722 tex (15,500 denier) or less. When the total fineness is out of the above range, the preparation processability of a filter for a smoking article may not be good (continuous process is not possible due to cutting), and when an amount of tow filling filter paper during preparation of a filter for a smoking article is too small or too large, it may be difficult to secure sufficient filter physical properties (for example, hardness or suction resistance).

[0112] A method of measuring a fineness is not particularly limited, but for example, a lyocell material to be measured, for example, a 2 m sample of lyocell tow, is taken, left, and stabilized in a room with a constant temperature and humidity at a temperature of 20 °C and a humidity of 65 % for 24 hours. One end of the stabilized lyocell tow is fixed, and a 2 kg weight is attached to the other end thereof. The tow stretched due to a load thereof is maintained (stabilized) for 5 seconds and then cut into 90 cm length to obtain a sample and measure a weight of the sample (total fineness). A fineness is converted to a denier scale and calculated as a measured weight×10,000 according to a denier conversion method. A single fineness of a monofilament in the sample is calculated by dividing the total fineness of the sample by the number of strands of monofilaments in the sample.

[0113] A total fineness of the lyocell multifilament may be determined according to the single fineness of the monofilament and the number of crimps. In the present application, a single fineness and the number of crimps may be controlled, and the total fineness of a lyocell material (for example, lyocell tow) suitable for preparing a filter for a smoking article and securing a function thereof may be secured.

[Crimp]

[0114] In some embodiments, there is provided a lyocell material including a lyocell multifilament imparted with crimps, wherein the lyocell material has a crimp factor calculated according to Equation 1 below in a range of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad-ea/inch).

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

[0115] The crimp factor may be adjusted within the above numerical range, thereby improving the uniformity of the crimp imparted to the lyocell multifilament. In particular, the crimp factor is adjusted within the above numerical range, thereby adjusting the number of the crimps, the radian of the crimp, or the number of the crimps and the radian of the crimp. In particular, the radian of the crimp may be adjusted, thereby directly adjusting the height and length of the crimp imparted to the lyocell multifilament. As a result, the shape of the crimp imparted to the lyocell multifilament is consistently adjusted.

[0116] A lower limit of the crimp factor may be 11.81 rad·ea/cm (30 rad·ea/inch) or more, 13.78 rad·ea/cm (35 rad·ea/inch) or more, 15.75 rad·ea/cm (40 rad·ea/inch) or more, 17.72 rad·ea/cm (45 rad·ea/inch) or more, 19.69 rad·ea/cm (50 rad·ea/inch) or more, 21.65 rad·ea/cm (55 rad·ea/inch) or more, 23.62 rad·ea/cm (60 rad·ea/inch) or more, 25.59 rad·ea/cm (65 rad·ea/inch) or more, or 27.56 rad·ea/cm (70 rad·ea/inch) or more, and an upper limit of the crimp factor may be 27.56 rad·ea/cm (70 rad·ea/inch) or less, 25.59 rad·ea/cm (65 rad·ea/inch) or less, 23.62 rad·ea/cm (60 rad·ea/inch) or less, 21.65 rad·ea/cm (55 rad·ea/inch) or less, 19.69 rad·ea/cm (50 rad·ea/inch) or less, 17.72 rad·ea/cm (45 rad·ea/inch) or less, 15.75 rad·ea/cm (40 rad·ea/inch) or less, 13.78 rad·ea/cm (35 rad·ea/inch) or less, or 11.81 rad·ea/cm (30 rad·ea/inch) or less.

[0117] In some embodiments, the crimp factor may be in a range of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad·ea/inch), 9.84 rad·ea/cm to 27.56 rad·ea/cm (25 rad·ea/inch to 70 rad·ea/inch), 9.84 rad·ea/cm to 25.59 rad·ea/cm (25 rad·ea/inch to 65 rad·ea/inch), 9.84 rad·ea/cm to 23.62 rad·ea/cm (25 rad·ea/inch to 60 rad·ea/inch), 9.84 rad·ea/cm to 21.65 rad·ea/cm (25 rad·ea/inch to 55 rad·ea/inch), 9.84 rad·ea/cm to 19.69 rad·ea/cm (25 rad·ea/inch to 50 rad·ea/inch), 9.84 rad·ea/cm to 17.72 rad·ea/cm (25 rad·ea/inch to 45 rad·ea/inch), 9.84 rad·ea/cm to 15.75 rad·ea/cm (25 rad·ea/inch to 40 rad·ea/inch), 9.84 rad·ea/cm to 13.78 rad·ea/cm (25 rad·ea/inch to 35 rad·ea/inch), 9.84 rad·ea/cm to 11.81 rad·ea/cm (25 rad·ea/inch to 30 rad·ea/inch), 11.81 rad·ea/cm to 29.53 rad·ea/cm (30 rad·ea/inch to 75 rad·ea/inch), 11.81 rad·ea/cm to 27.56 rad·ea/cm (30 rad·ea/inch to 70 rad·ea/inch), 11.81 rad·ea/cm to 25.59 rad·ea/cm (30 rad·ea/inch to 65 rad·ea/inch), 11.81 rad·ea/cm to 23.62 rad·ea/cm (30 rad·ea/inch to 60 rad·ea/inch), 11.81 rad·ea/cm to 21.65 rad·ea/cm (30 rad·ea/inch to 55 rad·ea/inch), 11.81 rad·ea/cm to 19.69 rad·ea/cm (30 rad·ea/inch to 50 rad·ea/inch), 11.81 rad·ea/cm to 17.72 rad·ea/cm (30 rad·ea/inch to 45 rad·ea/inch), 11.81 rad·ea/cm to 15.75 rad·ea/cm (30 rad·ea/inch to 40

rad·ea/inch), 11.81 rad·ea/cm to 13.78 rad·ea/cm (30 rad·ea/inch to 35 rad·ea/inch), 13.78 rad·ea/cm to 29.53 rad·ea/cm (35 rad·ea/inch to 75 rad·ea/inch), 13.78 rad·ea/cm to 27.56 rad·ea/cm (35 rad·ea/inch to 70 rad·ea/inch), 13.78 rad·ea/cm to 25.59 rad·ea/cm (35 rad·ea/inch to 65 rad·ea/inch), 13.78 rad·ea/cm to 23.62 rad·ea/cm (35 rad·ea/inch to 60 rad·ea/inch), 13.78 rad·ea/cm to 21.65 rad·ea/cm (35 rad·ea/inch to 55 rad·ea/inch), 13.78 rad·ea/cm to 19.69 rad·ea/cm (35 rad·ea/inch to 50 rad·ea/inch), 13.78 rad·ea/cm to 17.72 rad·ea/cm (35 rad·ea/inch to 45 rad·ea/inch), 13.78 rad·ea/cm to 15.75 rad·ea/cm (35 rad·ea/inch to 40 rad·ea/inch), 15.75 rad·ea/cm to 29.53 rad·ea/cm (40 rad·ea/inch to 75 rad·ea/inch), 15.75 rad·ea/cm to 27.56 rad·ea/cm (40 rad·ea/inch to 70 rad·ea/inch), 15.75 rad·ea/cm to 25.59 rad·ea/cm (40 rad·ea/inch to 65 rad·ea/inch), 15.75 rad·ea/cm to 23.62 rad·ea/cm (40 rad·ea/inch to 60 rad·ea/inch), 15.75 rad·ea/cm to 21.65 rad·ea/cm (40 rad·ea/inch to 55 rad·ea/inch), 15.75 rad·ea/cm to 19.69 rad·ea/cm (40 rad·ea/inch to 50 rad·ea/inch), 15.75 rad·ea/cm to 17.72 rad·ea/cm (40 rad·ea/inch to 45 rad·ea/inch), 17.72 rad·ea/cm to 29.53 rad·ea/cm (45 rad·ea/inch to 75 rad·ea/inch), 17.72 rad·ea/cm to 27.56 rad·ea/cm (45 rad·ea/inch to 70 rad·ea/inch), 17.72 rad·ea/cm to 25.59 rad·ea/cm (45 rad·ea/inch to 65 rad·ea/inch), 17.72 rad·ea/cm to 23.62 rad·ea/cm (45 rad·ea/inch to 60 rad·ea/inch), 17.72 rad·ea/cm to 21.65 rad·ea/cm (45 rad·ea/inch to 55 rad·ea/inch), 17.72 rad·ea/cm to 19.69 rad·ea/cm (45 rad·ea/inch to 50 rad·ea/inch), 19.69 rad·ea/cm to 29.53 rad·ea/cm (50 rad·ea/inch to 75 rad·ea/inch), 19.69 rad·ea/cm to 27.56 rad·ea/cm (50 rad·ea/inch to 70 rad·ea/inch), 19.69 rad·ea/cm to 25.59 rad·ea/cm (50 rad·ea/inch to 65 rad·ea/inch), 19.69 rad·ea/cm to 23.62 rad·ea/cm (50 rad·ea/inch to 60 rad·ea/inch), 19.69 rad·ea/cm to 21.65 rad·ea/cm (50 rad·ea/inch to 55 rad·ea/inch), 21.65 rad·ea/cm to 29.53 rad·ea/cm (55 rad·ea/inch to 75 rad·ea/inch), 21.65 rad·ea/cm to 27.56 rad·ea/cm (55 rad·ea/inch to 70 rad·ea/inch), 21.65 rad·ea/cm to 25.59 rad·ea/cm (55 rad·ea/inch to 65 rad·ea/inch), 21.65 rad·ea/cm to 23.62 rad·ea/cm (55 rad·ea/inch to 60 rad·ea/inch), 23.62 rad·ea/cm to 29.53 rad·ea/cm (60 rad·ea/inch to 75 rad·ea/inch), 23.62 rad·ea/cm to 27.56 rad·ea/cm (60 rad·ea/inch to 70 rad·ea/inch), 23.62 rad·ea/cm to 25.59 rad·ea/cm (60 rad·ea/inch to 65 rad·ea/inch), 25.59 rad·ea/cm to 29.53 rad·ea/cm (65 rad·ea/inch to 75 rad·ea/inch), 25.59 rad·ea/cm to 27.56 rad·ea/cm (65 rad·ea/inch to 70 rad·ea/inch), or 27.56 rad·ea/cm to 29.53 rad·ea/cm (70 rad·ea/inch to 75 rad-ea/inch).

[0118] When the crimp factor is less than 9.84 rad·ea/cm (25 rad·ea/inch), a blooming index of the lyocell material may be significantly insufficient due to the insufficient formation of the crimp and/or the non-uniformity of the shape of the crimp. In light of the definition of a blooming index, a low blooming index refers to a small specific surface area and means that the lyocell material is unsuitable for use in a filter for a smoking article.

[0119] On the other hand, when the crimp factor exceeds 29.53 rad·ea/cm (75 rad·ea/inch), the blooming of the lyocell material may be limited due to the non-uniformity of the shape of the crimp. In particular, during a process of opening and/or stretching the lyocell material for use in preparing a filter for a smoking article, the lyocell material may break instead of blooming. As a result, the preparation of a filter for a smoking article may be limited.

[0120] In some embodiments, in the lyocell material, a radian of the crimp may be in a range of 1.02 to 1.50.

[0121] In some embodiments, the radian of the crimp may be in a range of 1.02 to 1.50, 1.02 to 1.45, 1.02 to 1.40, 1.02 to 1.35, 1.02 to 1.30, 1.02 to 1.25, 1.02 to 1.20, 1.02 to 1.15, 1.02 to 1.10, 1.02 to 1.05, 1.05 to 1.50, 1.05 to 1.45, 1.05 to 1.40, 1.05 to 1.35, 1.05 to 1.30, 1.05 to 1.25, 1.05 to 1.20, 1.05 to 1.15, 1.05 to 1.10, 1.10 to 1.50, 1.10 to 1.45, 1.10 to 1.40, 1.10 to 1.35, 1.10 to 1.30, 1.10 to 1.25, 1.10 to 1.20, 1.10 to 1.15, 1.15 to 1.50, 1.15 to 1.45, 1.15 to 1.40, 1.15 to 1.35, 1.15 to 1.30, 1.15 to 1.25, 1.15 to 1.20, 1.20 to 1.50, 1.20 to 1.45, 1.20 to 1.40, 1.20 to 1.35, 1.20 to 1.30, 1.20 to 1.25, 1.25 to 1.50, 1.25 to 1.45, 1.25 to 1.40, 1.25 to 1.35, 1.25 to 1.30, 1.30 to 1.50, 1.30 to 1.45, 1.30 to 1.40, 1.30 to 1.35, 1.35 to 1.50, 1.35 to 1.45, 1.35 to 1.40, 1.40 to 1.50, 1.40 to 1.45, or 1.45 to 1.50.

[0122] When the radian of the crimp is 1.01 or less, the blooming of the lyocell material due to the entanglement between the crimps may not occur sufficiently. In particular, the blooming index of the lyocell material may be less than 196.85 %·ea/cm (500 %·ea/inch). As a result, the blooming of the lyocell material may not be sufficient, which may make it inappropriate to use the lyocell material as a filter material. For example, due to the insufficient blooming of the lyocell material, the filtering performance of a filter including the lyocell material may be insufficient, and the filter may be excessively filled with the lyocell material to function as a filter.

[0123] In particular, the radian of the crimp in Equation 1 is calculated according to Equation 1-1 below.

Equation 1-1

$$\text{Radian of crimp} = \arctan(\text{length of crimp}/(2\times\text{height of crimp}))$$

[0124] In some embodiments, in the lyocell material, a height of the crimp may be in a range of 0.01 mm to 0.10 mm. For example, the height of the crimp may be in a range of 0.02 mm to 0.10 mm, 0.03 mm to 0.10 mm, 0.04 mm to 0.10 mm, 0.04 mm to 0.09 mm, 0.04 mm to 0.08 mm, or 0.04 mm to 0.07 mm. The height of the crimp may satisfy the above range so that the blooming index of the lyocell material may be improved.

[0125] In some embodiments, in the lyocell material, a length of the crimp may be in a range of 0.25 mm to 0.40 mm. For example, a lower limit of the length of the crimp may be 0.26 mm or more, 0.28 mm or more, 0.30 mm or more, 0.32 mm or

more, 0.34 mm or more, 0.36 mm or more, or 0.38 mm or more, and an upper limit of the length of the crimp may be 0.38 mm or less, 0.36 mm or less, 0.34 mm or less, 0.32 mm or less, or 0.30 mm or less.

[0126] In some embodiments, in the lyocell material, the radian of the crimp may be in a range of 1.02 to 1.50, and the height of the crimp may be in a range of 0.01 mm to 0.10 mm. By satisfying both of the range of the radian of the crimp and the range of the height of the crimp, the uniformity of the crimp imparted to the lyocell material may be further improved. An improvement of the uniformity of the crimp may lead to an increase in blooming index.

[0127] In some embodiments, in the lyocell material, the radian of the crimp may be in a range of 1.02 to 1.50, and the length of the crimp may be in a range of 0.25 mm to 0.40 mm. By satisfying both of the range of the radian of the crimp and the range of the length of the crimp, the uniformity of the crimp imparted to the lyocell material may be further improved. An improvement of the uniformity of the crimp may lead to an increase in blooming index.

[0128] Thus, the uniformity of the crimp imparted to the lyocell multifilament is increased, and in particular, the uniformity of the shape of the crimp is further increased. Furthermore, the mechanical properties of the lyocell multifilament may be improved, and the properties (for example, filtering performance) of a filter for a smoking article including the lyocell multifilament may be improved.

[0129] In some embodiments, in the lyocell material, a CEI represented by Equation 2 below may be in a range of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch).

Equation 2

$$\text{CEI} = \text{crimp energy} \times \text{crimp factor}$$

[0130] In Equation 2, crimp energy refers to energy required to straighten the crimp, and a unit of the crimp energy is joules (J).

[0131] In some embodiments, in the lyocell material, a lower limit of the CEI may be 9.06 J·rad·ea/cm (23 J·rad·ea/inch) or more, 9.84 J·rad·ea/cm (25 J·rad·ea/inch) or more, 11.81 J·rad·ea/cm (30 J·rad·ea/inch) or more, 13.78 J·rad·ea/cm (35 J·rad·ea/inch) or more, 15.75 J·rad·ea/cm (40 J·rad·ea/inch) or more, 17.72 J·rad·ea/cm (45 J·rad·ea/inch) or more, 19.69 J·rad·ea/cm (50 J·rad·ea/inch) or more, 21.65 J·rad·ea/cm (55 J·rad·ea/inch) or more, 23.62 J·rad·ea/cm (60 J·rad·ea/inch) or more, 25.59 J·rad·ea/cm (65 J·rad·ea/inch) or more, 27.56 J·rad·ea/cm (70 J·rad·ea/inch) or more, 29.53 J·rad·ea/cm (75 J·rad·ea/inch) or more, 31.50 J·rad·ea/cm (80 J·rad·ea/inch) or more, 33.46 J·rad·ea/cm (85 J·rad·ea/inch) or more, 35.43 J·rad·ea/cm (90 J·rad·ea/inch) or more, or 37.40 J·rad·ea/cm (95 J·rad·ea/inch) or more, and an upper limit of the CEI may be 37.40 J·rad·ea/cm (95 J·rad·ea/inch) or less, 35.43 J·rad·ea/cm (90 J·rad·ea/inch) or less, 33.46 J·rad·ea/cm (85 J·rad·ea/inch) or less, 31.50 J·rad·ea/cm (80 J·rad·ea/inch) or less, 29.53 J·rad·ea/cm (75 J·rad·ea/inch) or less, 27.56 J·rad·ea/cm (70 J·rad·ea/inch) or less, 25.59 J·rad·ea/cm (65 J·rad·ea/inch) or less, 23.62 J·rad·ea/cm (60 J·rad·ea/inch) or less, 21.65 J·rad·ea/cm (55 J·rad·ea/inch) or less, 19.69 J·rad·ea/cm (50 J·rad·ea/inch) or less, 17.72 J·rad·ea/cm (45 J·rad·ea/inch) or less, 15.75 J·rad·ea/cm (40 J·rad·ea/inch) or less, 13.78 J·rad·ea/cm (35 J·rad·ea/inch) or less, 11.81 J·rad·ea/cm (30 J·rad·ea/inch) or less, or 9.84 J·rad·ea/cm (25 J·rad·ea/inch) or less.

[0132] The CEI is adjusted within the above numerical range, thereby increasing the uniformity of the crimp imparted to the lyocell multifilament. In particular, the uniformity of the crimp is further increased throughout the entire lyocell multifilament. Energy required to impart the crimp and/or the shape of the crimp may be adjusted by adjusting the crimp energy, adjusting the crimp factor, or adjusting both the crimp energy and the crimp factor. As a result, the uniformity of a crimp of a monofilament taken from a central portion of the lyocell multifilament and the uniformity of a crimp of a monofilament taken from an end portion of the lyocell multifilament may be improved.

[0133] In some embodiments, in the lyocell material, the crimp energy may be in a range of 0.9 J to 1.6 J. In particular, the crimp energy may be in a range of 0.9 J to 1.6 J, 1.0 J to 1.6 J, 1.1 J to 1.6 J, 1.2 J to 1.6 J, 1.3 J to 1.6 J, 1.4 J to 1.6 J, 1.5 J to 1.6 J, 0.9 J to 1.5 J, 0.9 J to 1.4 J, 0.9 J to 1.3 J, 0.9 J to 1.2 J, 0.9 J to 1.1 J, or 0.9 J to 1.0 J. By adjusting the crimp energy within the above range, the uniformity of the crimp may be further increased, and the blooming index may be increased.

[0134] In addition, the crimp energy may be calculated from a weight imparted to the lyocell multifilament imparted with crimps. By imparting a weight to one end of a lyocell multifilament imparted with crimps, the lyocell multifilament imparted with crimps is stretched. When a weight of crimp energy or more is applied, a crimp is not identified from a lyocell multifilament. In particular, the crimp energy may be calculated from a minimum weight imparted such that a crimp is not identified from a lyocell multifilament. The crimp energy may be calculated from the product of a minimum weight applied such that a crimp is not identified from a lyocell multifilament and a length by which the lyocell multifilament is stretched up to a time point at which the crimp is not identified.

[0135] When the CEI is less than 8.27 J·rad·ea/cm (21 J·rad·ea/inch), the blooming index of the lyocell material may be significantly insufficient. In light of the definition of a blooming index, a low blooming index refers to a small specific surface area and means that the lyocell material is unsuitable for use in a filter for a smoking article.

[0136] On the other hand, when the CEI exceeds 31.50 J·rad·ea/cm (80 J·rad·ea/inch), the blooming of the lyocell

material may be limited due to excessively imparted crimps. In particular, during a process of opening and/or stretching the lyocell material for use in preparing a filter for a smoking article, the lyocell material may break instead of blooming. As a result, the preparation of a filter for a smoking article may be limited.

[0137] In some embodiments, the lyocell material may satisfy the following [condition i] and may further satisfy at least one of the following [condition ii] and [condition v].

[condition i] A CEI is in a range of 9.06 J·rad·ea/cm to 27.56 J·rad·ea/cm (23 J·rad·ea/inch to 70 J·rad·ea/inch).
[condition ii] The number of crimps is in a range of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch).
[condition iii] A radian of the crimp is in a range of 1.02 to 1.50.
[condition iv] A height of the crimp is in a range of 0.01 mm to 0.10 mm.
[condition v] A length of the crimp is in a range of 0.25 mm to 0.40 mm.

[0138] Thus, the uniformity of the crimp imparted to the lyocell multifilament is increased, and in particular, the uniformity of the crimp imparted to the end portion of the lyocell multifilament is further increased. Furthermore, the formability of the lyocell multifilament may be improved, and the properties (for example, filtering performance) and processability of a filter for a smoking article including the lyocell multifilament may be improved.

[0139] In particular, in some embodiments, the lyocell material may satisfy [condition i] and further satisfy at least one of [condition ii] and [condition iii]. Alternatively, the lyocell material may satisfy [condition i] and further satisfy at least one of [condition iv] and [condition v].

[0140] For example, the lyocell multifilament may have 3.94 to 23.62 crimps per centimeter (10 to 60 crimps per inch). For example, the number of crimps may be 5.91 ea/cm (15 ea/inch) or more, 7.87 ea/cm (20 ea/inch) or more, 9.84 ea/cm (25 ea/inch) or more, 11.81 ea/cm (30 ea/inch) or more, 13.78 ea/cm (35 ea/inch) or more, 15.75 ea/cm (40 ea/inch) or more, or 17.72 ea/cm (45 ea/inch) or more, and an upper limit of the number of crimps may be, for example, 21.65 ea/cm (55 ea/inch) or less, 19.69 ea/cm (50 ea/inch) or less, 17.72 ea/cm (45 ea/inch) or less, 15.75 ea/cm (40 ea/inch) or less, 13.78 ea/cm (35 ea/inch) or less, 11.81 ea/cm (30 ea/inch) or less, or 9.84 ea/cm (25 ea/inch) or less. The number of crimps and the uniformity thereof may be controlled through pressure and temperature conditions or the like related to crimping which will be described below.

[0141] Although not particularly limited, the number of crimps may be measured by using, for example, a single fiber property evaluation device (for example, Favimat). In particular, a sample of a prepared lyocell material (for example, lyocell tow) may be left and stabilized for 24 hours under conditions of a temperature of 20±2 °C and a humidity of 65±4 %. A specimen may be taken from the stabilized sample such that the crimp is not damaged. The specimen may include some or all of lyocell multifilaments imparted with crimps. The taken specimen may be mounted on a dedicated jig with a length (gauge length) of 10 mm to 30 mm. An initial load during measurement may be 0.44 cN/tex (0.05 g/de), and crimp sensitivity may be 0.01 mm. The number of crimps may be measured under the above-described conditions (that is, a temperature of 20±2 °C and a humidity of 65±4 %).

[0142] Although not particularly limited, a lyocell material prepared to satisfy the single fineness, the total fineness, the number of crimps, the crimp factor, and/or the CEI described above may be used in a smoking article.

[Binder]

[0143] In some embodiments, the lyocell material may further include a binder. The binder may be present, for example, on a surface of the lyocell multifilament or between the lyocell multifilaments and/or between the monofilaments. The binder may further increase the hardness of a filter for a smoking article, thereby preventing problems such as filter jamming during a process of preparing a filter or a process of preparing a smoking article (for example, a tobacco).

[0144] Types of available binders are not particularly limited, and any known binder may be used at a level that does not impede the purpose of the disclosure. For example, a binder capable of providing sufficient compatibility with an emulsion used in the present application, improving the hardness of a filter, and providing excellent bonding strength may be used.

[0145] For example, the binder may include a polyester-based binder, a cellulose-based binder, and/or a vinyl-based binder.

[0146] Although not particularly limited, as the polyester-based binder, a polyester binder including at least one selected from alkylene, arylene, and heteroarylene having 5 to 12 carbon atoms may be used.

[0147] Examples of the cellulose-based binder may include hydroxypropyl methyl cellulose (HPMC), ethyl cellulose (EC), methyl cellulose (MC), and/or carboxymethyl cellulose (CMC), but one or more embodiments are not limited thereto.

[0148] In some embodiments, the cellulose-based binder is selected from the group consisting of HPMC, EC, MC, CMC, and a combination thereof.

[0149] Examples of the vinyl-based binder may include polyvinylpyrrolidone (PVP), polyvinyl alcohol (PVA), and/or ethylene vinyl acetate (EVAc), but one or more embodiments are not limited thereto.

[0150] In some embodiments, the vinyl-based binder is selected from the group consisting of PVP, PVA, EVAc, and a

combination thereof.

[0151] A method of applying the binder to a lyocell material (for example, coating) will be described below.

[Emulsion]

[0152] The lyocell material may include a lyocell multifilament, and an emulsion applied onto the lyocell multifilament. The emulsion may include: (a) an esterified product of a fatty acid having 16 or more carbon atoms and aliphatic monohydric alcohol; and (b) an esterified product of sorbitan and a fatty acid having 16 or more carbon atoms. The emulsion may be applied onto some or all of monofilaments or multifilaments constituting the lyocell material. In addition, the emulsion may permeate between filaments.

[0153] The emulsion including at least components (a) and (b) may have hydrophobicity. As a result, the lyocell material treated with the emulsion may have excellent spreading properties.

[0154] In some embodiments, the lyocell material may include a certain content of the emulsion. In this case, the content of the emulsion may refer to OPU (wt%) which will be described below. "OPU" may refer to "oil pick up ratio." For example, the lyocell material may include the emulsion in a content of 0.2 wt% or more with respect to 100 wt% of the total weight of the lyocell material. In particular, the content of the emulsion may be 2.5 wt% or more or 3.0 wt% or more, in particular, 3.5 wt% or more, 4.0 wt% or more, 4.2 wt% or more, 4.5 wt% or more, 5.0 wt% or more, 5.5 wt% or more, 6.0 wt% or more, 6.5 wt% or more, 7.0 wt% or more, 7.5 wt% or more, 8.0 wt% or more, 8.5 wt% or more, 9.0 wt% or more, or 9.5 wt% or more. An upper limit of the content of the emulsion may be, for example, 20.0 wt% or less, 18.0 wt% or less, 17.0 wt% or less, 16.0 wt% or less, 15.0 wt% or less, 14.5 wt% or less, 14.0 wt% or less, 13.5 wt% or less, 13.0 wt% or less, 12.5 wt% or less, 12.0 wt% or less, 11.5 wt% or less, 11.0 wt% or less, 10.5 wt% or less, 10 wt% or less, 9.5 wt% or less, 9.0 wt% or less, 8.5 wt% or less, 8.0 wt% or less, 7.8 wt% or less, or 7.6 wt% or less.

[0155] As a method of measuring the content (OPU) of the emulsion, for example, an extrusion method may be used. For example, a sample (for example, in a content of 2 g to 5 g, in particular, about 2.5 g) is taken (in this case, a weight of the taken sample is referred to as a sample weight), and the sample is put into a syringe-shaped container. A material of the container is not particularly limited, but may be a stainless steel (SUS) material. Next, a solvent (for example, methanol) is put into the container into which the sample is put (an amount of the put solvent may be 10 ml or less (for example, about 8 ml)). When the solvent is added to the sample, a dropping method may be used, and a dropping speed may be uniformly adjusted. As described above, the solvent put into the container is allowed to drop on a plate from one end of the syringe-shaped container. In this case, the plate is pre-weighed (a measured weight is referred to as plate weight A), and the plate is installed such that the solvent dropped on the plate is removed away (that is, evaporated) at a temperature of 120 °C to 130 °C (for example, 125 °C). The above-described solvent addition and solvent dropping are performed three times, and pressure (for example, 98 kgf/cm^2 (10 kgf/cm^2) or less, 49 N/cm^2 (5 kgf/cm^2) or less, or 18 N/cm^2 to 39 N/cm^2 (2 kgf/cm^2 to 4 kgf/cm^2)) is applied to the sample by using a syringe-shaped container to press the sample once. Thus, the solvent and emulsion present in the sample are sufficiently extruded. The sample is squeezed out by applying pressure until no solvent comes out. Afterwards, the plate is stored in a desiccator for 5 minutes to 10 minutes, and a weight (plate weight B) of the plate containing the sample is measured. Then, a content of the emulsion is calculated according to a formula below.

Content of emulsion by extrusion (OPU, % or wt%) = {(plate weight B-plate weight A)/(sample weight)} $\times$ 100 <Formula>

[0156] In addition, a lyocell material that is used as a reference for the content of the emulsion may be a lyocell multifilament treated with an emulsion. For example, the lyocell material may be a lyocell multifilament to which primary emulsion treatment (to be described below) has been applied, a lyocell multifilament to which primary emulsion treatment and secondary emulsion treatment (to be described below) have been applied, or a lyocell multifilament treated with the above-described emulsion and also treated with a binder to be described below. In addition, the lyocell multifilament treated with the emulsion and/or the binder may be imparted with crimps.

[0157] In relation to the emulsion of the present application, component (a) may be a compound that may function as a type of lubricant or oil and may be a component that is harmless to the human body enough to be used in food. Component (a) may provide lubricity to fibers put into a crimper. When the lubricity is not sufficient, lyocells may clump together and may not escape the crimper, and when the lubricity is too high, there may be a problem in that a crimp is not formed properly. In consideration of such functions, a content of component (a) may be controlled as described below.

[0158] Regarding component (a), types of fatty acids having 16 or more carbon atoms forming the esterified product are not particularly limited. Fatty acids having 16 or more carbon atoms may be used as long as the fatty acids may provide esterified products that are harmless to the human body enough to be used in food.

[0159] For example, saturated fatty acids and/or unsaturated fatty acids may be used as fatty acids having one or more 16 carbon atoms.

[0160] Examples of the saturated fatty acids may include a palmitic acid (hexadecanoic acid, $CH_3(CH_2)_{14}COOH$), a margaric acid (heptadecanoic acid, $CH_3(CH_2)_{15}COOH$), a stearic acid (octadecanoic acid, $CH_3(CH_2)_{16}COOH$), a nonadecylic acid (nonadecanoic acid, $CH_3(CH_2)_{17}COOH$), or an arachidic acid (eicosanoic acid, $CH_3(CH_2)_{18}COOH$). However, types of available saturated fatty acids are not limited thereto.

[0161] Examples of the unsaturated fatty acids may include a palmitoleic acid ($CH_3(CH_2)_5CH=CH(CH_2)_7COOH$), an oleic acid ($CH_3(CH_2)_7CH=CH(CH_2)_7COOH$), a linoleic acid ($C_{18}H_{32}O_2$), or an arachidonic acid ($C_{20}H_{32}O_2$). However, types of available unsaturated fatty acids are not limited thereto.

[0162] An upper limit of a carbon number of the fatty acid having 16 or more carbon atoms is not particularly limited, but may be, for example, 40 or less, 36 or less, 32 or less, 28 or less, 24 or less, or 20 or less.

[0163] In some embodiments, the fatty acid is selected from the group consisting of a palmitic acid, a margaric acid, a stearic acid, a nonadecylic acid, an arachidic acid, a palmitoleic acid, an oleic acid, a linoleic acid, and an arachidonic acid.

[0164] Regarding component (a), types of aliphatic monohydric alcohols forming the ester compound are also not particularly limited. Aliphatic monohydric alcohols may be used as long as the aliphatic monohydric alcohols may provide esterified products that are harmless to the human body enough to be used in foods.

[0165] For example, component (a) may be saturated aliphatic alcohol or unsaturated aliphatic alcohol, which may have a linear or branched form.

[0166] For example, a carbon number of the aliphatic monohydric alcohol may be in a range of 1 to 40. In particular, the carbon number of the aliphatic monohydric alcohol may be, for example, 4 or more, 8 or more, 12 or more, 16 or more, or 20 or more.

[0167] Examples of the aliphatic monohydric alcohol may include methanol, ethanol, butanol, lauryl alcohol, isotridecanol, or stearyl alcohol, but one or more embodiments are not limited thereto.

[0168] In some embodiments, the aliphatic monohydric alcohol is selected from the group consisting of methanol, ethanol, butanol, lauryl alcohol, isotridecanol, and stearyl alcohol.

[0169] In a specific example of the present application, an esterified product of isotridecanol and a stearic acid (for example, isotridecyl stearate) may be used as component (a). However, types of available component (a) are not limited thereto.

[0170] As will be described below, a content of component (a) included in the emulsion may be adjusted in consideration of the function of the emulsion or the function of component (a).

[0171] Component (b), that is, an esterified product of sorbitan and a fatty acid having 16 or more carbon atoms, is a compound that may function as a type of emulsifier and may be a component harmless to the human body enough to be used in food.

[0172] Since component (b) has both hydrophilicity and hydrophobicity due to polyhydric alcohol (that is, sorbitan), component (b) enables component (a), which provides lubricity to the fiber, to be well dispersed in water, which will be described below. In addition, components (a) and (b) used together not only may increase the dispersibility of the emulsion as described above, but also may lower a melting point, thereby ensuring the use/handling and stability of the emulsion. In consideration of such functions, a content of component (b) may be controlled as described below.

[0173] Regarding component (b), types of fatty acids having 16 or more carbon atoms forming the esterified product are not particularly limited. Fatty acids having 16 or more carbon atoms may be used as long as the fatty acids may provide esterified products that are harmless to the human body enough to be used in food.

[0174] For example, saturated fatty acids and/or unsaturated fatty acids may be used as fatty acids having one or more 16 carbon atoms.

[0175] Examples of the saturated fatty acids may include a palmitic acid (hexadecanoic acid, $CH_3(CH_2)_{14}COOH$), a margaric acid (heptadecanoic acid, $CH_3(CH_2)_{15}COOH$), a stearic acid (octadecanoic acid, $CH_3(CH_2)_{16}COOH$), a nonadecylic acid (nonadecanoic acid, $CH_3(CH_2)_{17}COOH$), or an arachidic acid (eicosanoic acid, $CH_3(CH_2)_{18}COOH$). However, types of available saturated fatty acids are not limited thereto.

[0176] Examples of the unsaturated fatty acids may include a palmitoleic acid ($CH_3(CH_2)_5CH=CH(CH_2)_7COOH$), an oleic acid ($CH_3(CH_2)_7CH=CH(CH_2)_7COOH$), a linoleic acid ($C_{18}H_{32}O_2$), or an arachidonic acid ($C_{20}H_{32}O_2$). However, types of available unsaturated fatty acids are not limited thereto.

[0177] An upper limit of a carbon number of the fatty acid having 16 or more carbon atoms is not particularly limited, but may be, for example, 40 or less, 36 or less, 32 or less, 28 or less, 24 or less, or 20 or less.

[0178] In some embodiments, the fatty acid is selected from the group consisting of a palmitic acid, a margaric acid, a stearic acid, a nonadecylic acid, an arachidic acid, a palmitoleic acid, an oleic acid, a linoleic acid, and an arachidonic acid.

[0179] In a specific example of the present application, an esterified product of sorbitan and an oleic acid (for example, sorbitan monooleate) may be used as component (b). However, types of available component (b) are not limited thereto.

[0180] A content of component (b) may be adjusted in consideration of the function of component (b) and the function of the emulsion as described above.

[0181] For example, the emulsion may include (b) an esterified product of sorbitan and a fatty acid having 16 or more carbon atoms in a content of 20 parts by weight to 60 parts by weight with respect to 100 parts by weight of (a) an esterified

product of a fatty acid having 16 or more carbon atoms and aliphatic monohydric alcohol.

[0182] In particular, the emulsion of the present application may include component (b) in a content of 25 parts by weight or more, 30 parts by weight or more, 35 parts by weight or more, 40 parts by weight or more, 45 parts by weight or more, or 50 parts by weight or more with respect to 100 parts by weight of component (a). An upper limit of the content of component (b) with respect to 100 parts by weight of component (a) may be, for example, 55 parts by weight or less, 50 parts by weight or less, 45 parts by weight or less, 40 parts by weight or less, 35 parts by weight or less, 30 parts by weight or less, or 25 parts by weight or less. When the above range of the content is satisfied, a surface of a lyocell multifilament or lyocell tow treated with an emulsion may have hydrophobicity.

[0183] For example, the emulsion may include (a) the esterified product of the fatty acid having 16 or more carbon atoms and aliphatic monohydric alcohol in a content of 40 wt% to 80 wt% with respect to 100 wt% of the total weight of the emulsion. In particular, the content of component (a) may be 45 wt% or more, 50 wt% or more, 55 wt% or more, 60 wt% or more, or 65 wt% or more, 70 wt% or more, or 75 wt% or more with respect to 100 wt% of the total weight of the emulsion. An upper limit of the content of component (a) may be, for example, 75 wt% or less, 70 wt% or less, 65 wt% or less, 60 wt% or less, 55 wt% or less, 50 wt% or less, or 45 wt% or less.

[0184] For example, the emulsion may include an excess amount of component (a).

[0185] For example, the emulsion may include (b) the esterified product of sorbitan and the fatty acid having 16 or more carbon atoms in a content of 15 wt% to 55 wt% with respect to 100 wt% of the total weight of the emulsion. In particular, the content of component (b) may be 20 wt% or more, 25 wt% or more, 30 wt% or more, 35 wt% or more, 40 wt% or more, 45 wt% or more, or 50 wt% or more with respect to 100 wt% of the total weight of the emulsion. An upper limit of the content of component (b) may be, for example, 50 wt% or less, 45 wt% or less, 40 wt% or less, 35 wt% or less, 30 wt% or less, or 25 wt% or less.

[0186] For example, the emulsion may further include water. A small amount of water may assist in emulsifying. As used herein, the terms "treated with emulsion" and "emulsified" may be used interchangeably.

[0187] A content of water is not particularly limited, but water may be included in the remaining content excluding the total content of components (a) and (b) with respect to 100 wt% of the total weight of the emulsion. The content of water in the emulsion (that is, the remaining content excluding the total content of the remaining components excluding water) may be, for example, 10 wt% or less, 9 wt% or less, 8 wt% or less, 7 wt% or less, 6 wt% or less, 5 wt% or less, 4 wt% or less, 3 wt% or less, 2 wt% or less, or 1 wt% or less. A lower limit of the content of water may be, for example, 0 wt% or more, 0.1 wt% or more, 0.5 wt% or more, or 1 wt% or more.

[Method of preparing lyocell material]

[0188] The present application relates to a method of preparing a lyocell material. Through the method, a lyocell material may be prepared and used in a smoking article.

[0189] In particular, the method of preparing a lyocell material includes: a lyocell dope spinning; coagulation and multifilament obtainment; washing; emulsion treatment; and crimp imparting. In addition, the method of preparing a lyocell material may further include: binder treatment; and other operations.

[0190] The emulsion treatment may be performed before the crimp imparting, after the crimp imparting, or before and after the crimp imparting.

[0191] Emulsion treatments may each independently be performed, for example, by spraying an emulsion with the above-described composition onto a lyocell multifilament or immersing the lyocell multifilament in the emulsion. As described above, the emulsion treatment may be performed such that a content of an emulsion (for example, OPU (wt%)) in the lyocell material satisfies a certain range.

[0192] The crimp imparting may be performed, for example, by applying steam and/or pressure to the lyocell multifilament.

[0193] The method of preparing a lyocell material according to a specific embodiment of the present application, including the emulsion treatment and the crimp imparting, will be described in more detail below. The method of the present application may be performed by including one or more of operations described below.

<Lyocell dope spinning (a)>

[0194] A corresponding operation may be an operation of spinning a spinning dope including lyocell cellulose (or lyocell cellulose pulp) and N-methylmorpholine-N-oxide (NMMO).

[0195] Commercialized cellulose acetate filters are pointed out as the major cause of microplastics. However, since an amine oxide-based solvent used in preparing lyocell fibers is recyclable and biodegradable even when disposed of, lyocell materials do not generate any pollutants during a production process thereof. Furthermore, since lyocell tow is biodegraded and removed within a relatively short period of time, a lyocell is a more environmentally friendly material than cellulose acetate.

[0196] For example, a content of cellulose in the spinning dope may be 5 wt% to 15 wt% with respect to 100 wt% of the total weight of the spinning dope. When the content of cellulose is too low, it may be difficult to implement the properties of a lyocell fiber, and when the content exceeds the above range, it may be difficult to dissolve cellulose in a solvent. In consideration of the difficulties, the content of cellulose in the spinning dope may be 6 wt% or more, 7 wt% or more, 8 wt% or more, 9 wt% or more, or 10 wt% or more with respect to 100 wt% of the total weight of the spinning dope, and an upper limit thereof may be, for example, 14 wt% or less, 13 wt% or less, 12 wt% or less, 11 wt% or less, 10 wt% or less, or 9 wt% or less, with respect to 100 wt% of the total weight of the spinning dope.

[0197] For example, the spinning dope may include an aqueous solution of NMMO. The aqueous solution may include, for example, NMMO in a content of 80 parts by weight to 95 parts by weight and water in a content of 5 parts by weight to 20 parts by weight in consideration of a degree of dissolution of cellulose and a process temperature.

[0198] For example, the cellulose or cellulose pulp may include alpha-cellulose in a content of 85 wt% to 97 wt% with respect to 100 wt% of the total weight of the cellulose and/or cellulose pulp.

[0199] For example, the cellulose or cellulose pulp may include hemicellulose in a content of 1 wt% to 15 wt% with respect to 100 wt% of the total weight of the cellulose and/or cellulose pulp. By adjusting the content of the hemicellulose within the above range, the stable physical properties (for example, hardness or suction resistance implementation) and processability of a lyocell material may be more easily secured.

[0200] In addition, in some embodiments, a DPw of the cellulose may be in a range of 600 to 1,700. In some embodiments, the DPw refers to the number of repeating units and/or monomers of the cellulose, alpha-cellulose, and/or hemicellulose in the cellulose pulp.

[0201] In the spinning, a shape of a spinneret for discharging the spinning dope is not particularly limited. For example, a donut-shaped spinneret may be used.

[0202] A nozzle temperature of the spinneret, in particular, a spinning temperature thereof, may be appropriately selected by a person skilled in the art. Considering that the viscosity of the spinning dope may vary according to the spinning temperature, and thus discharging may not be performed well, the spinning temperature may be, for example, in a range of 100 °C to 120 °C or 100 °C to 110 °C.

[0203] For example, the spinning of the spinning dope may be performed under spinning conditions in which a fineness of a filament is controlled to be in a range of 1.67 dtex to 8.894 dtex (1.5 denier to 8.0 denier). For example, one or more spinning conditions of a discharge amount and a spinning speed of the spinning dope may be appropriately controlled so that a single fineness of a filament included in a lyocell material may satisfy a range of 1.67 dtex to 8.89 dtex (1.5 denier to 8.0 denier). In this case, a single fineness of a filament may refer to a fineness of a single monofilament separated from a multifilament.

[0204] In particular, the single fineness of the filament may be, for example, 8.33 dtex (7.5 denier) or less, 7.78 dtex (7.0 denier) or less, 7.22 dtex (6.5 denier) or less, 6.67 dtex (6.0 denier) or less, 6.11 dtex (5.5 denier) or less, 5.56 dtex (5.0 denier) or less, 5.00 dtex (4.5 denier) or less, 3.89 dtex (3.5 denier) or less, 3.33 dtex (3.0 denier) or less, 2.78 dtex (2.5 denier) or less, or 2.22 dtex (2.0 denier) or less. A lower limit of the single fineness of the filament may be, for example, 2.22 dtex (2.0 denier) or more, 2.78 dtex (2.5 denier) or more, 3.33 dtex (3.0 denier) or more, 3.89 dtex (3.5 denier) or more, 4.44 dtex (4.0 denier) or more, 5.00 dtex (4.5 denier) or more, 5.56 dtex (5.0 denier) or more, 6.11 dtex (5.5 denier) or more, 6.67 dtex (6.0 denier) or more, 7.22 dtex (6.5 denier) or more, or 7.78 dtex (7.0 denier) or more. Satisfying the above range may be more advantageous in implementing stable suction resistance and securing processability of a filter for a smoking article.

[0205] The spinning dope discharged through the spinneret may undergo the coagulation which will be described below.

<Coagulation and multifilament obtainment (b)>

[0206] In a corresponding operation, the spun spinning dope may be coagulated, and a lyocell multifilament may be obtained.

[0207] For the coagulation, a method in which the spinning dope comes into contact with air and/or a coagulating solution may be used.

[0208] For example, the coagulation may include primary coagulation of supplying cooling air to the spun lyocell dope; and secondary coagulation of adding a primarily coagulated spinning dope to a coagulating solution to coagulate the spinning dope.

[0209] According to such a coagulation method, the lyocell dope discharged through the spinneret may be primarily coagulated in a space (air gap section) between the spinneret and a coagulation tank. For example, cooling air may be supplied to the air gap section from an air cooling part positioned inside the spinneret in a direction from the inside to the outside of the spinneret. In addition, primary coagulation may be achieved through a known so-called air quenching method or means in the related field.

[0210] For example, an upper limit of a temperature of the cooling air used in the primary coagulation may be 15°C or less. In particular, the cooling air may be air with a temperature of 14 °C or less, 13 °C or less, 12 °C or less, 11 °C or less, or

10 °C or less. When the above temperature is exceeded, the spinning dope may not be sufficiently coagulated by air, and spinning-related processability may not be good.

[0211] A lower limit of the temperature of the cooling air may be determined in consideration of spinning processability and/or cross-sectional uniformity of a filament. For example, when the temperature of the cooling air is less than 4 °C, a surface of the spinneret may cool, a surface of the filament may become non-uniform, and the spinning processability may also deteriorate. In consideration of this, the cooling air may have a temperature of 5 °C or more, 6 °C or more, 7 °C or more, 8 °C or more, or 9 °C or more.

[0212] A degree by which the cooling air is supplied may be adjusted in consideration of sufficient coagulation, spinning processability, and an influence on the physical properties of the filament. For example, the cooling air may be supplied to the discharged spinning dope at an air flow rate of 70 Nm^3/h to 400 Nm^3/h per one spinneret. In particular, the air flow rate may be 100 Nm^3/h or more, 150 Nm^3/h or more, 200 Nm^3/h or more, or 250 Nm^3/h or more, and an upper limit thereof may be, for example, 350 Nm^3/h or less, 300 Nm^3/h or less, 250 Nm^3/h or less, 200 Nm^3/h or less, or 150 Nm^3/h or less.

[0213] After the primary coagulation as described above, the cooled spinning dope may be supplied to a coagulation tank or bath containing a coagulating solution (secondary coagulation). For proper coagulation, a temperature of the coagulating solution may be, for example, 30 °C or less or 25 °C or less. The temperature of the coagulating solution may be 10 °C or more, 15 °C or more, or 20 °C or more. When the above temperature is maintained, a coagulation speed may be appropriately maintained.

[0214] A type of a coagulating solution for the secondary coagulation as described above is not particularly limited. For example, the coagulating solution may include at least one selected from water and NMMO.

[0215] Although not particularly limited, when the coagulating solution includes water and NMMO, with respect to 100 wt% of the total weight of the coagulating solution, a content of water in the coagulating solution may be in a range of 60 wt% to 90 wt%, and a content of NMMO may be in a range of 10 wt% to 40 wt%. Alternatively, the coagulating solution may include water in a content of about 70 wt% to about 80 wt% and NMMO in a content of about 20 wt% to about 30 wt% with respect to 100 wt% of the total weight of the coagulating solution. By using sensors or the like, a concentration of the coagulating solution may be controlled to be maintained during a preparation process.

<Washing (c)>

[0216] If necessary, the washing may be performed on a lyocell multifilament after the above-described coagulation and multifilament obtainment. Through such washing, NMMO and/or other impurities remaining in the filament may be removed.

[0217] A method of performing washing is not particularly limited. For example, washing may be performed by introducing a coagulated lyocell multifilament into a washing tank by using a traction roller. Alternatively, the washing may be performed by spraying a washing solution while moving to a subsequent operation by a traction roller.

[0218] Components of the washing solution are not particularly limited. For example, the washing solution may include water and may optionally further include one or more known additives.

[0219] In some embodiments, the washing solution further includes water and one or more known additives.

[0220] In addition, in consideration of reuse after washing, the washing solution may be used by adjusting a temperature thereof to 100 °C or less.

<Emulsion treatment (d)>

[0221] If required, an operation of treating the lyocell multifilament with an emulsion may be performed. The operation may be an operation of applying an emulsion with the above-described components onto a surface of the filament. Friction applied to the filament may be reduced through emulsion treatment, and a crimp may be formed well in the crimp imparting which will be described below. When the emulsion treatment is performed twice or more as described below, the emulsion treatment may be referred to as primary emulsion treatment and secondary emulsion treatment according to the order.

[0222] Although not particularly limited, the emulsion treatment may be performed by immersing the lyocell multifilament in a bath filled with an emulsion such that the lyocell multifilament is completely immersed in the emulsion. Alternatively/additionally, the lyocell multifilament may be treated with an emulsion by spraying the emulsion while moving to a subsequent operation by a traction roller.

[0223] In order to ensure that an amount of the emulsion applied onto the lyocell multifilament is constant after the emulsion treatment as described above, a process in which rolls or the like positioned before and/or after the emulsion treatment squeeze out an emulsion of a surface of the lyocell multifilament may be additionally performed.

[0224] For example, the emulsion treatment may be performed such that a content (OPU (wt%)) of the emulsion is 1.0 wt% or more with respect to 100 wt% of a lyocell multifilament which has been at least treated with an emulsion. In this case, the lyocell multifilament which has been at least treated with the emulsion, for example, the lyocell material, may be a lyocell multifilament to which primary emulsion treatment has been applied, a lyocell multifilament to which primary

emulsion treatment and secondary emulsion treatment (see the description below) have been applied, or a lyocell multifilament to which the emulsion treatment as described above and a binder described below have been applied together. The lyocell multifilament treated with the emulsion and/or the binder as described above may be imparted with crimps.

[0225] In particular, in the lyocell multifilament which has been at least treated with the emulsion, a content of the emulsion may be 0.5 wt% or more, 1.0 wt% or more, 1.5 wt% or more, 2.0 wt% or more, 2.5 wt% or more, or 3.0 wt% or more, in particular, 3.5 wt% or more, 4.0 wt% or more, 4.2 wt% or more, 4.5 wt% or more, 5.0 wt% or more, 5.5 wt% or more, 6.0 wt% or more, 6.5 wt% or more, 7.0 wt% or more, 7.5 wt% or more, 8.0 wt% or more, 8.5 wt% or more, 9.0 wt% or more, or 9.5 wt% or more with respect to 100 wt% of the lyocell multifilament which has been at least treated with the emulsion. An upper limit of the content of the emulsion may be, for example, 20.0 wt% or less, 18.0 wt% or less, 17.0 wt% or less, 16.0 wt% or less, 15.0 wt% or less, 14.5 wt% or less, 14.0 wt% or less, 13.5 wt% or less, 13.0 wt% or less, 12.5 wt% or less, 12.0 wt% or less, 11.5 wt% or less, 11.0 wt% or less, 10.5 wt% or less, 10 wt% or less, 9.5 wt% or less, 9.0 wt% or less, 8.5 wt% or less, 8.0 wt% or less, 7.8 wt% or less, or 7.6 wt% or less with respect to 100 wt% of the lyocell multifilament which has been at least treated with the emulsion. In this case, the above content may refer to a dry weight after a solvent (for example, water) or liquid component that may be included in the emulsion has evaporated.

[0226] When the lyocell multifilament is treated with the emulsion with the above-described composition within the above range of the content, the hydrophilic properties of the lyocell material may be supplemented.

[0227] In some cases, the emulsion may be dried after the emulsion treatment as described above.

[0228] In a specific example of the present application, one or more of the above-described operations may be controlled such that a single fineness of a filament constituting the lyocell multifilament may be in a range of 1.67 dtex to 8.89 dtex (1.5 denier to 8.0 denier). The single fineness of the filament may refer to a fineness of a single monofilament separated from a multifilament.

[0229] In particular, the single fineness of the filament may be, for example, 8.33 dtex (7.5 denier) or less, 7.78 dtex (7.0 denier) or less, 7.22 dtex (6.5 denier) or less, 6.67 dtex (6.0 denier) or less, 6.11 dtex (5.5 denier) or less, 5.56 dtex (5.0 denier) or less, 5.00 dtex (4.5 denier) or less, 3.89 dtex (3.5 denier) or less, 3.33 dtex (3.0 denier) or less, 2.78 dtex (2.5 denier) or less, or 2.22 dtex (2.0 denier) or less. A lower limit of the single fineness of the filament may be, for example, 2.22 dtex (2.0 denier) or more, 2.78 dtex (2.5 denier) or more, 3.33 dtex (3.0 denier) or more, 3.89 dtex (3.5 denier) or more, 4.44 dtex (4.0 denier) or more, 5.00 dtex (4.5 denier) or more, 5.56 dtex (5.0 denier) or more, 6.11 dtex (5.5 denier) or more, 6.67 dtex (6.0 denier) or more, 7.22 dtex (6.5 denier) or more, or 7.78 dtex (7.0 denier) or more. Satisfying the above range may be more advantageous in implementing stable suction resistance and securing processability of a filter for a smoking article.

[0230] In some embodiments, in the method of preparing a lyocell material, the emulsion treatment may be performed by using an emulsion solution including an emulsion in a content of 2 wt% to 10 wt% with respect to 100 % of the total weight of the emulsion solution. Since the content of the emulsion with which the lyocell multifilament is treated satisfies the above range, on average, the number of crimps of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch) may be imparted in the crimp imparting.

[0231] When the emulsion treatment is omitted (that is, when the content of the emulsion is 0 wt%), the friction between a crimp machine (hereinafter also referred to as "crimper") and a lyocell multifilament in the crimp machine may excessively increase, and the discharge of the lyocell multifilament from the crimp machine may be restricted. As a result, an operation of imparting crimps to the lyocell multifilament may not be performed.

[0232] Meanwhile, when the content of the emulsion is less than 2 wt%, the number of imparted crimps may be excessive, and due to an increase in frictional force, the uniformity of crimps imparted to a central portion and sides of the lyocell material may be insufficient. On the other hand, when the content of the emulsion exceeds 10 wt%, the number of imparted crimps may be insufficient, resulting in a significantly low blooming index.

[0233] In some embodiments, in the method of preparing a lyocell material, a temperature of the emulsion solution may be in a range of 20 °C to 80 °C. Since the temperature of the emulsion with which the lyocell multifilament is treated satisfies the above range, the lyocell multifilament may be uniformly treated with the emulsion, and on average, the number of crimps of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch) may be provided in the crimp imparting.

[0234] Meanwhile, when the temperature of the emulsion is less than 20 °C, due to excessive viscosity of the emulsion, the lyocell multifilament may be non-uniformly treated with the emulsion, and due to a partial increase in friction, rather, the number of imparted crimps may be excessive. In addition, due to an increase in friction, the uniformity of the crimp imparted to an end portion of the lyocell material may be insufficient. On the other hand, when the temperature of the emulsion exceeds 80 °C, the viscosity of the emulsion may decrease, and thus the number of imparted crimps may be insufficient. As a result, a blooming index may be significantly lowered.

[0235] In some embodiments, in the method of preparing a lyocell material, a moisture regain of the lyocell multifilament may be adjusted. The moisture regain may be a value measured according to Equation 3 below.

Equation 3

$$\text{Moisture regain (\%)} = (W-D)/D \times 100$$

[0236] In Equation 3, W denotes a weight of a sample measured before drying, and D denotes a weight of the sample measured after drying.

[0237] In some embodiments, in the lyocell material, the moisture regain may be a value measured from a washed lyocell multifilament, or the moisture regain may be a value measured from a lyocell multifilament treated with an emulsion. For example, when the method of preparing a lyocell multifilament includes the emulsion treatment, the moisture regain may be a value measured from a lyocell multifilament treated with an emulsion. In addition, when the method of preparing a lyocell multifilament includes two or more emulsion treatments, the moisture regain may be a value measured in the emulsion treatment finally performed before the crimp imparting.

[0238] In some embodiments, in the method of preparing a lyocell material, the moisture regain of the lyocell multifilament may be adjusted to within a range of 180 % to 360 %. Since the lyocell multifilament satisfies the above range of the moisture, on average, the number of crimps of 9.84 ea/cm to 19.69 ea/cm (25 ea/inch to 50 ea/inch) may be imparted in the crimp imparting.

[0239] When the moisture regain is less than a lower limit, the number of imparted crimps may be insufficient, resulting in a significantly low blooming index. On the other hand, when the moisture regain exceeds an upper limit, the number of imparted crimps may be excessive, resulting in a breakage of the lyocell material during a blooming process.

[0240] The moisture regain may be a value measured from the lyocell filament before crimps are imparted. In addition, the moisture regain may be a value measured from the lyocell filament immediately before crimps are imparted. For example, when the washing is performed immediately before the crimp imparting, the moisture regain may be a value measured from the lyocell multifilament after the washing is ended.

[0241] Meanwhile, in preparing a lyocell material according to some embodiments, the moisture regain of the lyocell multifilament may be adjusted before an operation of imparting crimps to the lyocell multifilament.

[0242] In some embodiments, in the method of preparing a lyocell material, the moisture regain of the lyocell multifilament may be reduced before the crimp imparting. Alternatively, the moisture regain of the lyocell multifilament may be reduced in the crimp imparting.

[0243] In some embodiments, the method of preparing a lyocell material may further include pressing the lyocell multifilament, and the pressing of the lyocell multifilament may be included between the washing and the crimp imparting. Although not particularly limited, the pressing of the lyocell multifilament may be performed at a pressure of 29.42 N/cm^2 to 34.33 N/cm^2 (3.0 kgf/cm^2 to 3.5 kgf/cm^2). The moisture regain of the lyocell multifilament may be reduced by pressing the lyocell multifilament. For example, the pressing of the lyocell multifilament may be performed by rolls, in particular, nip rolls.

[0244] Although not particularly limited, the above-described spinning, coagulation, washing, and/or emulsion treatment may be controlled so that the above-described crimp factor and CEI may be secured.

<Crimp imparting (e)>

[0245] The crimp imparting is an operation of applying pressure to a lyocell multifilament treated with an emulsion through steam and/or a press roller to obtain a crimped multifilament, for example, crimped tow. The crimp imparting may be referred to as crimping.

[0246] Through crimping, waves may be imparted to the lyocell multifilament, and fibers may have bulky properties. The crimping may be performed by using known crimp machines, such as a stuffer box and/or a steam box, and available crimp machines are not particularly limited as long as the crimp machines are devices capable of applying one or more of pressures which will be described below.

[0247] In some embodiments, in the method of preparing a lyocell material, steam may not be used before the crimp imparting, during the crimp imparting, or before and during the crimp imparting. Due to the use of steam, the moisture regain and temperature of the lyocell material may excessively increase, and thus a lyocell material with deteriorated blooming properties may be prepared. In addition, the preparing of a filter for a smoking article including the lyocell material may be limited due to the deterioration of the blooming properties.

[0248] For example, the crimp imparting may be performed by pressing the lyocell multifilament with a press roller to form wrinkles in the lyocell multifilament. In addition, steam may not be supplied before pressing, steam may not be supplied simultaneously with pressing, or steam may not be supplied before pressing and simultaneously with pressing.

[0249] For example, the crimp imparting may be performed by applying a pressure of 14.71 N/cm^2 to 39.23 N/cm^2 (1.5 kgf/cm^2 to 4.0 kgf/cm^2) to the lyocell multifilament put into the crimp machine by using a press roller.

[0250] For example, a pressure of 15.69 N/cm^2 (1.6 kgf/cm^2) or more, 16.67 N/cm^2 (1.7 kgf/cm^2) or more, 17.65 N/cm^2 (1.8 kgf/cm^2) or more, 18.63 N/cm^2 (1.9 kgf/cm^2) or more, 19.61 N/cm^2 (2.0 kgf/cm^2) or more, 20.60 N/cm^2 (2.1 kgf/cm^2) or

more, 21.58 N/cm^2 (2.2 kgf/cm^2) or more, 22.56 N/cm^2 (2.3 kgf/cm^2) or more, 23.54 N/cm^2 (2.4 kgf/cm^2) or more, or 24.52 N/cm^2 (2.5 kgf/cm^2) or more may be applied to the lyocell multifilament through the press roller. In addition, a pressure of 38.25 N/cm^2 (3.9 kgf/cm^2) or less, 37.27 N/cm^2 (3.8 kgf/cm^2) or less, 36.29 N/cm^2 (3.7 kgf/cm^2) or less, 35.31 N/cm^2 (3.6 kgf/cm^2) or less, 34.33 N/cm^2 (3.5 kgf/cm^2) or less, 33.35 N/cm^2 (3.4 kgf/cm^2) or less, 32.37 N/cm^2 (3.3 kgf/cm^2) or less, 31.39 N/cm^2 (3.2 kgf/cm^2) or less, 30.41 N/cm^2 (3.1 kgf/cm^2) or less, 29.42 N/cm^2 (3.0 kgf/cm^2) or less, 28.44 N/cm^2 (2.9 kgf/cm^2) or less, 27.46 N/cm^2 (2.8 kgf/cm^2) or less, 26.48 N/cm^2 (2.7 kgf/cm^2) or less, 25.50 N/cm^2 (2.6 kgf/cm^2) or less, or 24.52 N/cm^2 (2.5 kgf/cm^2) or less may be applied through the press roller.

[0251] When the pressure of the press roller is less than the above range, the desired number of crimps may not be formed sufficiently. When the pressure of the press roller exceeds the above range, a pressing force may be too strong, and thus the filament may not be smoothly put into the crimp machine or may not pass through the crimp machine (for example, the stuffer box). Wrinkles may be formed in the lyocell multifilament by the press roller that provides the pressure.

[0252] For example, by using a top plate, a pressure of 0.98 N/cm^2 to 19.61 N/cm^2 (0.1 kgf/cm^2 to 2 kgf/cm^2) may be applied to the lyocell multifilament. In addition, the upper plate may apply pressure to the lyocell multifilament when the lyocell multifilament has passed between the press rollers or while the lyocell multifilament is passing between the press rollers.

[0253] For example, the pressure applied by the upper plate may be 1.96 N/cm^2 (0.2 kgf/cm^2) or more, 2.94 N/cm^2 (0.3 kgf/cm^2) or more, 3.92 N/cm^2 (0.4 kgf/cm^2) or more, or 4.90 N/cm^2 (0.5 kgf/cm^2) or more. In addition, a pressure of 14.71 N/cm^2 (1.5 kgf/cm^2) or less, 13.73 N/cm^2 (1.4 kgf/cm^2) or less, 12.75 N/cm^2 (1.3 kgf/cm^2) or less, 11.77 N/cm^2 (1.2 kgf/cm^2) or less, 10.79 N/cm^2 (1.1 kgf/cm^2) or less, or 9.81 N/cm^2 (1.0 kgf/cm^2) or less may be applied by the upper plate.

[0254] Furthermore, when the pressure of the upper plate, which vertically moves to impart uniform crimps after the lyocell multifilament passes between the press rollers, is less than 0.98 N/cm^2 (0.1 kgf/cm^2), since the upper plate may not be fixed due to a pressure inside the crimp machine (for example, the stuffer box), while tow remains in the crimp machine (for example, the stuffer box) for a long time, the continuity of a process may not be maintained. When the pressure of the upper plate exceeds 19.61 N/cm^2 (2 kgf/cm^2), since steam inside the crimp machine (for example, the stuffer box) may not be smoothly discharged, a shape of a crimp may be irregular.

[0255] For example, in the crimp imparting, a doctor blade that applies a certain pressure to the lyocell multifilament may be applied. The doctor blade may adjust a residence time of a filament put into the crimp machine (for example, the stuffer box), thereby contributing to the control of the number of crimps. The doctor blade may be positioned, for example, on a movement path of the lyocell multifilament that is pressed by the above-described press roller and then discharged from a roller pressing point.

[0256] For example, the crimp imparting may be performed by applying a pressure of 0.98 N/cm^2 to 19.61 N/cm^2 (0.1 kgf/cm^{2}to 2.0 kgf/cm^2) to the lyocell multifilament, which has passed between the press rollers of the crimp machine, by using the doctor blade.

[0257] For example, the pressure applied by the doctor blade may be 1.96 N/cm^2 (0.2 kgf/cm^2) or more, 2.94 N/cm^2 (0.3 kgf/cm^2) or more, 3.92 N/cm^2 (0.4 kgf/cm^2) or more, or 4.90 N/cm^2 (0.5 kgf/cm^2) or more. In addition, a pressure of 14.71 N/cm^2 (1.5 kgf/cm^2) or less, 13.73 N/cm^2 (1.4 kgf/cm^2) or less, 12.75 N/cm^2 (1.3 kgf/cm^2) or less, 11.77 N/cm^2 (1.2 kgf/cm^2) or less, 10.79 N/cm^2 (1.1 kgf/cm^2) or less, or 9.81 N/cm^2 (1.0 kgf/cm^2) or less may be applied by the doctor blade.

[0258] For example, the crimp imparting may be performed at a temperature ranging from 120 °C to 250 °C. When the temperature is too low, the effect of stabilizing the shape of the crimp may not be good, and when the temperature is too high, a concentration of fat and oil inside the crimp machine (for example, the stuffer box) may be increased, which may make it difficult to form the crimp. Therefore, in consideration of the above-described pressure of the steam or the like, a temperature may be appropriately controlled in a range of 130°C or more, 140°C or more, or 150°C or higher, and 200 °C or less, 180 °C or less, or 160 °C or less.

<Binder treatment (f)>

[0259] In some embodiments, the method may further include an operation of treating the lyocell multifilament, which is treated with the emulsion, with a binder, or treating the lyocell multifilament, which is obtained through the crimp imparting, with a binder.

[0260] When a filter for a smoking article is prepared by using the lyocell material (for example, lyocell tow), a binder may be additionally used. The binder may increase the hardness of a filter for a smoking article including a lyocell material, thereby preventing problems such as filter jamming during a process of preparing a filter or a process of preparing a tobacco.

[0261] A method of treating (for example, coating) the lyocell material with the binder is not particularly limited. For example, binder treatment may be performed by immersing the lyocell multifilament in a bath filled with a binder and/or a binder solution such that the lyocell multifilament is completely immersed in the binder and/or the binder solution. Alternatively/additionally, binder treatment (for example, coating) of the lyocell multifilament may be performed by spraying and/or injecting a binder and/or a binder solution through a nozzle.

[0262] Types and components of available binders are as described above, and thus descriptions thereof are omitted.

[0263] For example, the binder and/or the binder solution may further include a solvent in addition to components described above. Examples of the solvent may include water, ethanol, propylene glycol, and/or glycerin, but one or more embodiments are not limited thereto. When the binder and/or the binder solution includes a solvent, a content of the solvent may be, for example, in a range of about 20 wt% to about 80 wt% or about 40 wt% to about 60 wt% with respect to 100 wt% of the total weight of the binder and/or the binder solution.

[0264] Such binder treatment may be performed at a level that may achieve the purpose of the above-described binder treatment. For example, the binder treatment may be performed such that a content of the binder satisfies 20 wt% or less, for example, a range of 8 wt% o 15 wt%, with respect to 100 wt% of a lyocell multifilament treated with an emulsion and a binder. In this case, the above content may refer to a dry weight after a solvent or liquid component that may be included in the binder has evaporated.

[0265] After the binder is applied onto the lyocell multifilament, the binder may be dried. A drying temperature is not particularly limited, but, for example, drying may be performed at room temperature (about 10 °C to about 35 °C).

<Other operations (g)>

[0266] After the crimp imparting, appropriate post-treatment may be additionally performed.

[0267] In some embodiments, secondary emulsion treatment (g1) may be additionally performed. Flexibility may be further imparted to a lyocell multifilament (for example, lyocell tow) through the secondary emulsion treatment. The secondary emulsion treatment may be performed in the same manner as or in accordance with the emulsion treatment (d) described above.

[0268] In particular, the secondary emulsion treatment may be performed by treating a lyocell multifilament (for example, lyocell tow), which has undergone a process using a crimper, with an emulsion. The secondary emulsion treatment may function advantageously in various processes performed during the preparation of a filter for a smoking article. For example, the secondary emulsion treatment may allow fibers and filters to spread well even in air during a spreading process and also may restrict fibers from being cut during a stretching process.

[0269] The secondary emulsion treatment as described above may be performed before or after the binder treatment. Alternatively, the secondary emulsion treatment may be performed irrespective of whether the binder treatment is performed.

[0270] Even in a case in which the secondary emulsion treatment as described above is performed, a secondary emulsion treatment process may be performed such that a content or an OPU content of an emulsion in a material satisfies the range described above.

[0271] In some embodiments, drying treatment (g2) may be additionally performed. Drying may be performed, for example, at a temperature in a range of 100 °C to 130 °C. A drying treatment manner or method is not particularly limited, and known technologies may be used. For example, the drying may be performed by applying hot air to tow or allowing a lyocell multifilament (for example, lyocell tow) to pass through a temperature-controlled room or leaving the lyocell multifilament for a certain period of time.

[0272] A lyocell material according to the disclosure may be obtained through the above-described method of preparing a lyocell material.

[0273] The lyocell material according to the disclosure may be a material obtainable through the above-described method of preparing a lyocell material.

[Smoking article]

[0274] Although not particularly limited, a lyocell material prepared through the method may be included in a smoking article. The smoking article may be an aerosol-generating article. The aerosol-generating article may include an aerosol-generating material or an aerosol-forming substrate.

[0275] For example, the lyocell material may be included in a combustion-type cigarette. As another example, the lyocell material may be included in a heated cigarette, and the heated cigarette may be used together with an aerosol generating device.

[0276] For example, when used as a heated smoking article, the smoking article may be separately inserted into an aerosol generating device. Here, the aerosol generating device may include an accommodation groove in which an aerosol-generating article may be accommodated, and in addition, may include a heater for heating the aerosol-generating article to generate aerosol, a control unit for controlling the overall operation of the aerosol generating device, a battery for providing power used for operating the aerosol generating device, and a detector for recognizing that the aerosol-generating article has been inserted into the aerosol generating device.

[0277] The smoking article may include a tobacco medium portion, a filter for a smoking article, and a wrapper, wherein the filter for a smoking article may be positioned at one end portion of the tobacco medium portion, for example, a rear end

portion or a front end portion. The tobacco medium portion and the filter for a smoking article may each include a single segment or may each independently include a plurality of segments.

[0278] The tobacco medium portion may include a tobacco material, and the tobacco material may include nicotine. In addition, the tobacco medium portion may additionally include one or more excipients.

[0279] The excipients may include a binder, a filler, and other additives. For example, a tobacco medium included in the tobacco medium portion may be prepared in the form of granules including a tobacco material, an excipient, and the like.

[0280] For example, a filler may be additionally included to constantly maintain the shape, strength, and mass of the tobacco medium portion. For example, the lyocell material may be included in the tobacco medium portion. In addition, the lyocell material may be used as a filler.

[0281] The wrapper may be subdivided into cigarette paper for wrapping the tobacco medium portion, filter wrapping paper for wrapping the filter, and a tipping wrapper for coupling the tobacco medium portion and the filter.

[Filter for smoking article]

[0282] A lyocell material may be used in a filter for a smoking article. The lyocell material may be lyocell tow. In some embodiments, the lyocell tow includes a lyocell multifilament imparted with crimps.

[0283] For example, the present application relates to a filter for a smoking article. The filter for a smoking article may include a lyocell material, and the lyocell material may be identical to that described above. In addition, the filter for a smoking article may include lyocell tow, and the lyocell tow may be identical to that described above.

[0284] In addition, the lyocell material may include an emulsion in a content of 0.1 wt% or more with respect to 100 wt% of the total weight of the lyocell material. In addition, an emulsion component and a content according to a specific example of the present application are as described above.

[0285] In some embodiments, a single fineness of a filament constituting the lyocell multifilament may be in a range of 1.67 dtex to 8.89 dtex (1.5 denier to 8.0 denier). A specific numerical value is as described above.

[0286] In some embodiments, the lyocell multifilament imparted with crimps may be lyocell tow having a total fineness of 1,667 tex to 6,111 tex (15,000 denier to 55,000 denier), and for example, the lyocell multifilament may be lyocell tow. A specific numerical value is as described above.

[0287] In some embodiments, the lyocell multifilament imparted with crimps may have 3.94 to 23.62 crimps per centimeter (10 to 60 crimps per inch). A specific numerical value is as described above.

[0288] In some embodiments, the filter for a smoking article may further include a binder on a surface of the lyocell multifilament imparted with crimps or between the lyocell multifilaments imparted with crimps. The binder may increase the hardness of a filter for a smoking article prepared from tow, thereby preventing problems such as filter jamming during a process of preparing a filter or a process of preparing a tobacco. Types, components, and contents of available binders are as described above.

[0289] In some embodiments, the filter for a smoking article may further include wrapping paper (which may be referred to as wrapper paper, filter paper, or filter wrapping paper). For example, the wrapping paper may be porous paper or non-porous paper that may wrap the above-described lyocell tow and may maintain a filter shape (for example, a cylinder or circular column).

[0290] In a specific embodiment of the present application, the filter for a smoking article may have a certain shape and a certain size.

[0291] For example, the filter may have a rod shape. In particular, the filter for a smoking article may have a shape such as a cylinder.

[0292] In addition, the filter may have a length of, for example, 10 nm to 50 mm. In particular, the length of the filter may have a lower limit of 15 mm or more, 20 mm or more, 25 mm or more, 30 mm or more, 35 mm or more, 40 mm or more, or 45 mm or more and an upper limit of 45 mm or less, 40 mm or less, 35 mm or less, 30 mm or less, 25 mm or less, 20 mm or less, or 15 mm or less.

[0293] In a specific example of the present application, the filter having the length may have a circular cross section, and a circumference of the circular cross section may be in a range of 10 mm to 40 mm. For example, the circumference of the filter may have a lower limit of 15 mm or more, 20 mm or more, 25 mm or more, 30 mm or more, or 35 mm or more, and an upper limit of 35 mm or less, 30 mm or less, 25 mm or less, 20 mm or less, or 15 mm or less.

[0294] In some embodiments, the filter for a smoking article may include lyocell tow and filter wrapping paper. The lyocell tow and the filter wrapping paper are as described above, and thus descriptions thereof are omitted.

[0295] The wrapping paper may be porous paper or non-porous paper that may wrap the above-described lyocell tow and may maintain a filter shape (for example, a cylinder or circular column).

[0296] For example, when porous wrapping paper is used, the wrapping paper may have a porosity of 10 coresta unit (CU) to 50,000 CU. A coresta unit may be defined as a volume flow rate (cm^3min^{-1}) of air passing through a 1 cm^2 substrate sample (that is, porous wrapping paper) at a pressure difference of 1 kPa. In particular, a lower limit of the porosity of the wrapping paper may be, for example, 1,000 CU or more, 5,000 CU or more, 10,000 CU or more, 15,000 CU or more,

20,.000 CU or more, 25,000 CU or more, 30,000 CU or more, 35,000 CU or more, 40,000 CU or more, or 45,000 CU or more, and an upper limit thereof may be, for example, 45,000 CU or less, 40,000 CU or less, 35,000 CU or less, 30,000 CU or less, 25,000 CU or less, or 20,000 CU or less. In a specific example of the present application, the wrapping paper may have a porosity in a range of 22,000 CU to 26,000 CU or 23,000 CU to 25,000 CU.

[0297] For example, a basis weight of the wrapping paper may be in a range of 15 g/cm^2 to 60 g/cm^2. In particular, a lower limit of the basis weight of the wrapping paper may be, for example, 20 g/cm^2 or more, 25 g/cm^2 or more, 30 g/cm^2 or more, 35 g/cm^2 or more, 40 g/cm^2 or more, 45 g/cm^2 or more, 50 g/cm^2 or more, or 55 g/cm^2 or more, and an upper limit thereof may be, for example, 55 g/cm^2 or less, 50 g/cm^2 or less, 45 g/cm^2 or less, 40 g/cm^2 or less, 35 g/cm^2 or less, 30 g/cm^2 or less, 25 g/cm^2 or less, or 20 g/cm^2 or less. For example, the wrapping paper may have a basis weight of 16 g/cm^2 or more, 17 g/cm^2 or more, 18 g/cm^2 or more, 19 g/cm^2 or more, 20 g/cm^2 or more, or 21 g/cm^2 or more, and 25 g/cm^2 or less, 24 g/cm^2 or less, 23 g/cm^2 or less, 22 g/cm^2 or less, or 21 g/cm^2 or less.

[0298] Although not particularly limited, a weight of a filter having a rod shape may be 50 mg or more. In particular, the weight of the filter may have, for example, a lower limit of 100 mg or more, 150 mg or more, or 200 mg or more, and an upper limit of 500 mg or less, 450 mg or less, 400 mg or less, 350 mg or less, 300 mg or less, 250 mg or less, or 200 mg or less.

[0299] Other filters for a smoking article and materials included therein are as described above, and thus descriptions thereof are omitted.

[Method of preparing filter for smoking article]

[0300] For example, the present application relates to a method of preparing a filter for a smoking article. The method may be a method of preparing a filter for a lyocell smoking article as described above and may be a method including the above-described method of preparing a lyocell material.

[0301] Regarding the method of preparing a filter for a smoking article, the remaining processes excluding preparing of a filter are the same as processes described in the lyocell material described above, and thus descriptions thereof are omitted. In addition, descriptions overlapping the above descriptions are also omitted.

[0302] The preparing of the filter may be appropriately performed by a person skilled in the art according to a known method. For example, the filter may be prepared by forming wrapping paper filled with a lyocell material into a rod shape. Alternatively, the filter may be prepared by cutting filter paper filled with a lyocell material with a rod shape into an appropriate length. The wrapping paper is as described above.

[0303] Although not particularly limited, before the filter paper is filled with the lyocell material, the lyocell material may be further subjected to opening or plasticizer treatment. A surface area of the lyocell material may be increased by opening the lyocell material. For example, the lyocell material may be opened by applying an external force in a length direction, a width direction, and/or a thickness direction.

[0304] For example, the lyocell material used in preparing a filter for a smoking article may be lyocell tow.

[0305] Although not particularly limited, the filter for a smoking article may additionally include known cellulose acetate multifilaments at a level that does not impede the purpose of the disclosure. The cellulose acetate multifilament may be mixed with a lyocell multifilament. The cellulose acetate multifilament may be included in a segment distinguished from a segment including the lyocell multifilament.

Advantageous Effects of Invention

[0306] According to the present application, there may be provided a lyocell material for a smoking article filter, which is capable of replacing commercialized cellulose acetate (CA), and a filter for a smoking article including the same. In particular, the uniformity of crimps may be improved, and as a result, a lyocell material suitable for use in a filter for a smoking article may be prepared.

Mode for the Invention

[0307] Hereinafter, the operations and effects of the disclosure will be described in more detail through specific examples of the disclosure. However, this is presented as an example of the disclosure, and the scope of the disclosure is not limited thereby.

[0308] A lyocell material was prepared through processes as described in Preparation Example below. Conditions not specifically described are within the scope of the above description.

[Preparation Example]

[0309] Cellulose pulp having an alpha-cellulose content of 93.9 % and a DPw of 820 was mixed with an NMMO/H_2O solvent having a propyl gallate content of 0.01 wt% to prepare a spinning dope for preparing a lyocell multifilament (for

example, lyocell tow) having a cellulose pulp concentration of 11 wt% with respect to 100 wt% of the total weight of the mixture. Then, while a spinning temperature of a spinning nozzle was maintained at 110 °C, a discharge amount and a spinning speed were appropriately adjusted, and the spinning dope was spun.

[0310] The spinning dope with a filament phase discharged from the spinning nozzle was supplied to a coagulating solution (a coagulating solution having a concentration of 75 wt% water and 25 wt% NMMO with respect to 100 wt% of the total weight of the coagulating solution and a temperature of about 25 °C) in a coagulating tank through an air gap section. In this case, cooling air in the air gap section primarily solidifies the spinning dope at a temperature of 8 °C and an air flow rate of 120 Nm^3/h. In addition, the concentration of the coagulating solution was continuously monitored by using a sensor and a refractometer.

[0311] A coagulated lyocell filament was washed. In particular, the filament was introduced into a traction roller, and NMMO remaining in the filament was removed by using a washing solution sprayed from a washing device. Then, the washed filament was immersed inside a bath including a certain emulsion solution.

[0312] The filament was treated at a pressure of 29.42 N/cm^2 (3 kgf/cm^2) by using a nip roll installed in a bath discharge portion and put into a crimp machine to impart wrinkles.

[0313] In particular, an interval between an upper press roller and a lower press roller included in the crimp machine was 0.3 mm, a pressure of the upper press roller was set to 24.52 N/cm^2 (2.5 kgf/cm2), and a pressure of a doctor blade was set to 9.81 N/cm^2 (1 kgf/cm2) to prepare tow.

[0314] In order to prevent static electricity and impart flexibility to the prepared tow, secondary emulsion treatment was performed, and immediately after treatment, a tow product, which was dried while passing through a continuous drying device set at a temperature of 120 °C, was obtained.

[0315] The prepared tow may have a single fineness of 2.22 dtex to 4.44 dtex (2.0 denier to 4.0 denier), a total fineness of 3,333 tex to 5,000 tex (30,000 denier to 45,000 denier), and the number of crimps of 5.91 ea/cm to 15.75 ea/cm (15 ea/inch to 40 ea/inch).

[Examples]

Examples 1 to 6

[0316] Lyocell materials were prepared according to Preparation Example, and a concentration of an emulsion solution, a temperature of the emulsion solution, and a moisture regain of a lyocell multifilament were each adjusted as shown in Table 1 below. The moisture regain of the lyocell multifilament is a value measured immediately before the lyocell multifilament is put into a crimper.

Comparative Example 1

[0317] A lyocell material was prepared according to Preparation Example, and emulsion treatment was omitted. As a result, the lyocell material was not prepared.

[0318] A moisture regain was adjusted as shown in Table 1 below. A moisture regain of a lyocell multifilament is a value measured immediately before the lyocell multifilament is put into a crimper.

Comparative Examples 2 to 6

[0319] Lyocell materials were prepared according to Preparation Example, and a concentration of an emulsion solution (that is, a content (wt%) of an emulsion with respect to 100 wt% of the total weight of the emulsion solution), a temperature of the emulsion solution, and a moisture regain of a lyocell multifilament were each adjusted as shown in Table 1 below. The moisture regain of the lyocell multifilament is a value measured immediately before the lyocell multifilament is put into a crimper.

[Table 1]

		Emulsion content (wt%)	Temperature (°C) of emulsion solution	Moisture regain (wt%)
Examples	1	7.00	40.0	318.0
	2	7.00	80.0	276.0
	3	7.00	20.0	355.0
	4	7.00	60.0	181.0
	5	10.00	60.0	277.0
	6	2.00	60.0	281.0
Comparative Examples	1	-	-	272.0
	2	20.00	40.0	242.0
	3	15.00	60.0	358.0
	4	7.00	60.0	51.0
	5	7.00	110.0	258.0
	6	1.00	20.0	418.0

[Evaluation Example]

<Experiment 1: Evaluation of crimp factor and CEI>

[0320] For the lyocell material obtained in each of Examples 1 to 6 and Comparative Examples 1 to 6, a crimp factor and a CEI were each evaluated. The crimp factor was calculated according to Equation 1 below, and the CEI was calculated according to Equation 2 below. Each value used in calculating the crimp factor and CEI was measured as shown in Table 2 below.

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

Equation 2

$$\text{CEI} = \text{crimp energy} \times \text{crimp factor}$$

[0321] Before the crimp factor and the CEI were calculated, each lyocell material was stabilized for 24 hours under constant temperature and constant humidity conditions. The constant temperature condition was 20±2 °C, and the constant humidity condition was 65±4 %RH. It was confirmed that, after the stabilization, in each lyocell material, a mass change of 0.25 % or more did not occur for 2 hours.

[0322] The number of crimps, a height of the crimp, and a length of the crimp were measured by using monofilament physical property evaluation equipment (FAVIMAT+ manufactured by Textechno H. Stein GmbH & Co. KG). In particular, a monofilament unwound from the lyocell material was mounted on a jig with a certain length. An initial load was 0.44 cN/tex (0.05 g/d), and crimp sensitivity was 0.01 mm.

[0323] By using the height of the crimp and the length of the crimp measured for each lyocell material, a radian of the crimp was calculated according to Equation 1-1 below. Results thereof are shown in Table 2 below.

Equation 1-1

$$\text{Radian of crimp} = \arctan(\text{length of crimp}/(2 \times \text{height of crimp}))$$

[0324] Crimp energy of each lyocell material was measured by using a universal testing machine (UTM) (model name: 5566 manufactured by Instron).

[0325] In particular, samples collected from each lyocell material were each mounted on a dedicated jig with a length of

20 cm. An initial load was 0.98 N (100 gf), and each multifilament was weighted until a crimp was not identified from each sample. An average value of crimp energy measured from each sample is shown in Table 2 below.

[Table 2]

		Crimp energy (J)	Number of crimps (ea/cm (ea/inch))	Height of crimp (mm)	Length of crimp (mm)	Radian of crimp	Crimp factor (rad·ea/cm (rad·ea/inch))	CEI (J·rad·ea/cm (J·rad·ea/inch))
Examples	1	1.566	15.35 (39)	0.05	0.33	1.28	19.75 (50.17)	12.60 (32)
	2	1.495	11.02 (28)	0.06	0.38	1.26	13.94 (35.42)	9.45 (24)
	3	1.512	16.93 (43)	0.04	0.29	1.30	22.04 (55.97)	14.57 (37)
	4	0.976	13.39 (34)	0.07	0.37	1.21	16.14 (40.99)	16.54 (42)
	5	1.120	9.84 (25)	0.10	0.35	1.05	10.35 (26.29)	9.06 (23)
	6	0.910	18.90 (48)	0.04	0.31	1.32	25.02 (63.54)	27.56 (70)
Comparison Examples	1	Unpreparable						
	2	0.650	3.15 (8)	0.45	0.44	0.45	1.38 (3.50)	1.97 (5)
	3	0.882	5.12 (13)	0.25	0.37	0.64	3.13 (7.96)	3.54 (9)
	4	1.245	6.30 (16)	0.33	0.41	0.56	3.45 (8.78)	2.75 (7)
	5	1.210	9.45 (24)	0.11	0.35	1.01	9.54 (24.23)	7.87 (20)
	6	0.750	21.65 (55)	0.02	0.20	1.37	29.74 (75.54)	39.76 (101)

[0326] Referring to Table 2, it is confirmed that the lyocell materials of Examples 1 to 6 have a crimp factor of 9.84 rad·ea/cm to 29.53 rad·ea/cm (25 rad·ea/inch to 75 rad·ea/inch), and it is confirmed that the lyocell materials of Comparative Examples 1 to 6 do not satisfy a range of the crimp factor.

[0327] In particular, it is confirmed that the lyocell materials of Examples 1 to 6 satisfy a radian of a crimp of 1.05 to 1.35. In particular, it is confirmed that the lyocell materials of Examples 1 to 6 satisfy a height of a crimp of 0.04 mm to 0.10 mm. Thus, it may be evaluated that the lyocell materials of Examples 1 to 6 have a more stable crimp shape than the lyocell materials of Comparative Examples 1 to 6.

[0328] In addition, referring to Table 2, it is confirmed that the lyocell materials of Examples 1 to 6 have a CEI of 8.27 J·rad·ea/cm to 39.37 J·rad·ea/cm (21 J·rad·ea/inch to 100 J·rad·ea/inch), and it is confirmed that the lyocell materials of Comparative Examples 1 to 6 do not satisfy the CEI.

[0329] In particular, it was confirmed that the lyocell materials of Examples 1 to 6 had a crimp energy of 0.91 J or more while having the number of crimps of 9.84 ea/cm (25 ea/inch) or more. On the other hand, Comparative Example 2 and Comparative Example 3 had the number of crimps of less than 5.91 ea/cm (15 ea/inch), Comparative Example 4 and Comparative Example 5 had a crimp energy of 1.2 J or more while having the number of crimps of less than 9.84 ea/cm (25 ea/inch), and Comparative Example 6 had a crimp energy of 0.75 J while having the number of crimps of 21.65 ea/cm (55 ea/inch).

[0330] In addition, considering that the lyocell materials of Examples 1 to 6 have a crimp factor of 23 rad·ea/inch or more, it may be evaluated that relatively high crimp energy is uniformly dispersed in more crimps.

[0331] On the other hand, the lyocell materials of Comparative Examples 2 and 3 had an insufficient number of crimps. In addition, considering that the lyocell material of Comparative Example 3 has a crimp factor of 3.45 rad·ea/cm (8.78 rad·ea/inch), it is evaluated that a crimp energy of 1.245 J is not effectively dispersed.

<Experiment 2: Blooming index of lyocell material>

[0332] For the lyocell materials of Examples 1 to 6 and the lyocell materials of Comparative Examples 2 to 6, a blooming index was evaluated. The blooming index measured for each lyocell material is shown in Table 3 below.

[0333] The blooming index was calculated by multiplying a blooming factor by the number of crimps. The blooming factor was calculated by dividing a change in fiber width before and after permanent deformation of the lyocell material by a change in fiber length before and after permanent deformation of the lyocell material, and a unit thereof was %.

[Table 3]

		Blooming index (%·ea/cm (%·ea/inch))
Examples	1	546.06 (1387)
	2	410.24 (1042)
	3	578.35 (1469)
	4	491.34 (1248)
	5	374.41 (951)
	6	627.17 (1593)
Comparative Examples	1	-
	2	8.27 (21)
	3	27.95 (71)
	4	45.67 (116)
	5	177.95 (452)
	6	Unmeasurable (breakage)

[0334] Referring to Table 3, it was evaluated that the lyocell materials of Examples 1 to 6 had a high blooming index of 354.33 %·ea/cm (900 %·ea/inch) or more. On the other hand, it was evaluated that the lyocell materials of Comparative Examples 2 to 5 had a blooming index of at least less than 50 % as compared to the lyocell materials of Examples 1 to 5.

[0335] As a result, due to a significantly low blooming index, the lyocell materials of Comparative Examples 2 to 5 were evaluated to have a significantly smaller specific surface area than the lyocell materials of Examples 1 to 6 and were found to be unsuitable for use in a filter for a smoking article. In other words, it was found that the lyocell materials of Examples 1 to 6 could provide a specific surface area that was improved by at least 50 % as compared to the lyocell materials of Comparative Examples.

[0336] Meanwhile, the lyocell material of Comparative Example 6 was unable to bloom, and it was found that the lyocell material was broken when stretched for blooming. Thus, it was evaluated that it was impossible to prepare a filter for a smoking article by using the lyocell material of Comparative Example 6.

Claims

1. A lyocell material comprising a lyocell multifilament imparted with crimps,

wherein the lyocell material has a crimp factor calculated according to Equation 1 below in a range of 25 rad·ea/inch to 75 rad·ea/inch:

Equation 1

$$\text{Crimp factor} = \text{number of crimps} \times \text{radian of crimp}$$

wherein, in Equation 1,
the radian of the crimp is calculated according to Equation 1-1 below:

Equation 1-1

$$\text{Radian of crimp} = \arctan(\text{length of crimp}/(2 \times \text{height of crimp})).$$

2. The lyocell material of claim 1, wherein the number of the crimps is in a range of 10 ea/inch to 60 ea/inch, the radian of the crimp is in a range of 1.02 to 1.50, a height of the crimp is in a range of 0.01 mm to 0.10 mm, and/or a length of the crimp is in a range of 0.25 mm to 0.40 mm.

3. The lyocell material of claim 1, having a crimp efficiency index represented by Equation 2 below in a range of 21 to 100 J·rad·ea/inch:

Equation 2

$$\text{Crimp efficiency index} = \text{crimp energy} \times \text{crimp factor}$$

wherein, in Equation 2,
the crimp energy refers to energy required to straighten the crimps, and a unit of the crimp energy is joules (J).

4. The lyocell material of claim 3, wherein the crimp energy is in a range of 0.9 J to 1.6 J.

5. The lyocell material of claim 1, wherein the lyocell multifilament has a single fineness of 1.5 denier to 8.0 denier, and/or the lyocell material has a total fineness of 15,000 denier to 55,000 denier.

6. The lyocell material of claim 3, wherein the lyocell material satisfies [condition i] below and further satisfies at least one of [condition ii] and [condition iii] below:

[condition i] the crimp efficiency index is in a range of 23 to 70 J·rad·ea/inch;
[condition ii] the number of the crimps is in a range of 25 ea/inch to 50 ea/inch; and
[condition iii] the radian of the crimp is in a range of 1.02 to 1.50.

7. The lyocell material of claim 6, wherein the lyocell material satisfies [condition i] below and further satisfies at least one of [condition iv] and [condition v] below:

[condition i] the crimp efficiency index is in a range of 23 to 70 J·rad·ea/inch;
[condition iv] a height of the crimp is in a range of 0.01 mm to 0.10 mm; and
[condition v] a length of the crimp is in a range of 0.25 mm to 0.40 mm.

8. The lyocell material of claim 1, wherein the lyocell multifilament comprises one or more monofilaments, and at least one of the one or more monofilaments has a multi-lobal cross section.

9. The lyocell material of claim 1, wherein the lyocell material is lyocell tow.

10. The lyocell material of claim 1, wherein the lyocell material is used for a filter for a smoking article, and/or the lyocell material is not used for a tire cord or a garment.

11. A filter for a smoking article, comprising the lyocell material of any one of claims 1 to 10.

12. A smoking article comprising the filter for a smoking article of claim 11.

13. A method of preparing a lyocell material, the method comprising:

lyocell dope spinning;
coagulation and lycocell multifilament obtainment;
washing;
emulsion treatment; and
crimp imparting,
wherein the emulsion treatment is performed by using an emulsion solution having a concentration of 2 % to 10 % with respect to 100 % of the total weight of the emulsion solution,
wherein a temperature of the emulsion solution is in a range of 20 °C to 80 °C, and
a moisture regain of the lyocell multifilament is adjusted before the crimp imparting.

14. The method of claim 13, wherein the moisture regain of the lyocell multifilament is adjusted to within a range of 180 % to 360 %.

15. The method of claim 14, wherein steam is not used before the crimp imparting, during the crimp imparting, or before

and during the crimp imparting.

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Application Number
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