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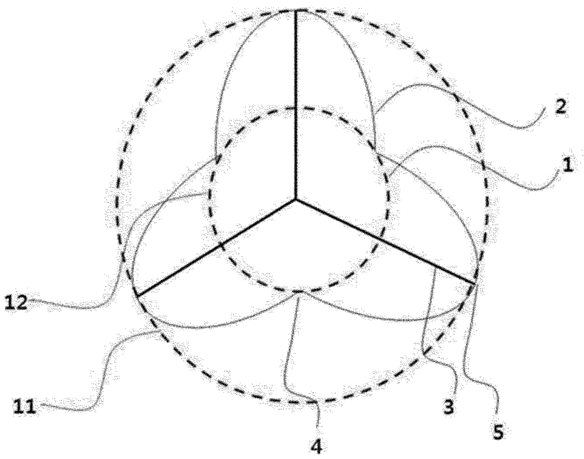
(54) **LYOCELL FIBER**

(57) This invention relates to a lyocell fiber and, more specifically, to a lyocell fiber exhibiting the same or improved physical properties even if used in a lesser amount, compared to a conventional lyocell fiber, by controlling the shape of the section of a monofilament included in the lyocell fiber to increase the specific surface area of the fiber.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a lyocell fiber.

Background Art

[0002] A fiber is a piece of natural or synthetic linear material that is flexible and thin and has a high ratio of length to thickness. Fibers are classified into long fibers, semi-long fibers, and staple fibers according to the type thereof, and into natural fibers and synthetic fibers according to the raw material thereof.

[0003] Fibers have had a close relationship with human life since old times, and natural fibers such as cotton, linen, wool, and silk have long been used as the main raw material for clothes. The use of fibers has extended beyond a material for clothes to industrial materials in accordance with the advancement of science and technology since the industrial revolution. In order to meet the rapidly growing demand for fibers due to cultural development and the increase in population, synthetic fibers have been developed as novel fiber materials.

[0004] Among synthetic fibers, regenerated fibers have an excellent tactile and wearing sensation and a very fast water-absorbing and discharging ability, compared to cotton, thus being frequently used as the raw material of clothes. In particular, rayon fibers, among regenerated fibers, have excellent gloss and color development and realize the same tactile sensation as natural fibers. Rayon fibers are considered to be a material that is harmless to the human body, and accordingly, have been used extensively in the past. However, rayon fibers easily shrink and wrinkle, the manufacturing process thereof is complicated, and a lot of chemicals are used during a process for melting wood pulp, which causes environmental pollution in work and during wastewater treatment.

[0005] Accordingly, a study has been made to find fibers that are not harmful to the environment and the human body and have excellent physical properties compared to other fibers. Recently, lyocell fibers manufactured using natural pulp and amine oxide hydrate have been proposed. Lyocell fibers have excellent physical fiber properties such as tensile strength and tactile sensation, compared to conventional regenerated fibers, and do not cause any contamination during the production process thereof, an amine oxide-based solvent used to form the lyocell fibers may be recycled, and the lyocell fibers are biodegradable when use thereof has been completed. Accordingly, lyocell fibers have been used as environment-friendly fibers in various fields.

[0006] However, current lyocell fibers can be produced only in the form of products having a circular section. Since it is expected that lyocell fibers may be imparted with various physical properties depending on the sectional shape thereof, there is a demand for a technology for manufacturing lyocell fibers having various types of sections.

Disclosure

Technical Problem

[0007] Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and an object of the present invention is to provide a lyocell fiber having a large specific surface area.

Technical Solution

[0008] In order to accomplish the above object, the present invention provides a lyocell fiber including a lyocell multifilament manufactured by spinning a lyocell spinning dope including a cellulose pulp and an N-methylmorpholine-N-oxide (NMMO) aqueous solution. The multifilament includes a monofilament having a multi-lobal section, the multi-lobal section includes a plurality of projections, and the plurality of projections comes into contact with a first virtual circle and a second virtual circle, included in the first virtual circle, is integrally formed with the second virtual circle serving as a core, and comes into contact with the first virtual circle at ends thereof.

[0009] The lyocell spinning dope may include 6 to 16 wt% of the cellulose pulp and 84 to 94 wt% of the N-methylmorpholine-N-oxide aqueous solution.

[0010] The cellulose pulp may have an alpha-cellulose content of 85 to 97 wt% and a degree of polymerization (DPw) of 600 to 1700.

[0011] In the lyocell fiber, a space occupancy ratio defined in the following Equation 1 may be 150 to 400%.

<Equation 1>

Space occupancy ratio (%) = (Area of first virtual circle/sectional area of monofilament included in lyocell fiber) × 100

[0012] The first virtual circle may have a radius of 8 to 30 μm.
[0013] The second virtual circle may have a radius of 3 to 12 μm.

Advantageous Effects

[0014] According to the present invention, a lyocell fiber having a large specific surface area is provided in a manner capable of exhibiting the same or improved physical properties even if used in a lesser amount, compared to a conventional lyocell fiber, when the lyocell fiber is applied to reinforcing materials in the clothing, construction, and vehicle fields.

Description of Drawings

[0015]

FIG. 1 shows a section of a monofilament included in a lyocell fiber according to an embodiment of the present invention; and
FIGS. 2a to 2c show the sections of lyocell fibers manufactured in Examples of the present invention, and FIGS. 2a, 2b, and 2c are pictures showing the sections of the lyocell fibers manufactured in Examples 1, 2, and 3, respectively.

<Description of the Reference Numerals in the Drawings>

[0016]

1: Core,
2: Projection,
3: Long axis of projection,
4: Recess of projection,
5: End of projection,
11: First virtual circle,
12: Second virtual circle

Best Mode

[0017] Hereinafter, the present invention will be described in greater detail.
[0018] The present invention relates to a lyocell fiber including a lyocell multifilament manufactured by spinning a lyocell spinning dope including a cellulose pulp and an N-methylmorpholine-N-oxide (NMMO) aqueous solution. The multifilament includes a monofilament having a multi-lobal section, and the multi-lobal section includes a plurality of projections. The plurality of projections comes into contact with a first virtual circle and a second virtual circle, included in the first virtual circle, is integrally formed with the second virtual circle, which serves as a core, and comes into contact with the first virtual circle at ends thereof.

[Multi-lobal section]

[0019] In the present invention, a multi-lobal section is a section including a plurality of projections. Specifically, as shown in FIG. 1, the multi-lobal section is a section including one core 1 and a plurality of projections formed around the core so as to be integrated with the core.
[0020] Specifically, the size and the shape of the multi-lobal section may be defined within the boundary of a first virtual circle 11 connecting the ends of the plurality of projections, and the boundary of a second virtual circle 12 included in the first virtual circle 11. The radius of the first virtual circle 11 is larger than that of the second virtual circle 12, and

the first virtual circle 11 and the second virtual circle 12 may be preferably concentric. However, the first virtual circle 11 and the second virtual circle 12 may not be concentric.

[0021] The multi-lobal section includes the plurality of projections. The plurality of projections is integrally formed with the core 1 overlapping the second virtual circle 12, ends 5 of the projections come into contact with the first virtual circle 11, and a recess 4 formed between the projections comes into contact with the second virtual circle 12.

[0022] In the present invention, the multi-lobal section may include three projections in order to maximize the specific surface area of the lyocell fiber.

[0023] The first virtual circle and the second virtual circle may have radii of 8 to 30 μm and 3 to 12 μm, respectively.

[0024] When the radius of the first virtual circle is 8 μm or more, the multi-lobal section may be embodied, and when the radius is 30 μm or less, a monofilament having a denier suitable as that of fiber products may be formed. Further, when the radius of the second virtual circle is 3 μm or more, the multi-lobal section may be embodied, and when the radius is 12 μm or less, a monofilament having a denier suitable as that of fiber products may be formed.

[0025] The monofilament included in the lyocell fiber according to the present invention may have the aforementioned multi-lobal section, and in the lyocell fiber, a space occupancy ratio, defined in the following Equation 1, may be 150 to 400%.

<Equation 1>

Space occupancy ratio (%) = (Area of first virtual circle/sectional area of monofilament included in lyocell fiber) × 100

[0026] The space occupancy ratio means the ratio of the substantial occupancy space of the monofilament in the fiber, depending on the projections of the multi-lobal section. That is, when the monofilament included in the lyocell fiber has a circular section, since the sectional area of the monofilament is the same as the area of the first virtual circle, the space occupancy ratio, defined above, becomes 100%. However, in the case of the fiber having the multi-lobal section including the projections, the actual occupancy area of the fiber is increased due to the projections. Therefore, it can be seen that the specific surface area of the fiber is increased as the space occupancy ratio is increased.

[0027] The lyocell fiber of the present invention has excellent properties such as swelling, interface adhesion, and quick drying due to an increase in specific surface area, and has a space occupancy ratio, defined in Equation 1, of 150 to 400%, and preferably 300 to 400%.

[0028] Meanwhile, the present invention relates to a method of manufacturing a lyocell fiber. The method includes (S1) spinning a lyocell spinning dope including a cellulose pulp and an N-methylmorpholine-N-oxide (NMMO) aqueous solution, (S2) solidifying the lyocell spinning dope, spun during the step (S1), to obtain a lyocell multifilament, (S3) washing the lyocell multifilament obtained during the step (S2), and (S4) treating the lyocell multifilament, washed during the step (S3), using an emulsion. The multifilament includes a monofilament having a multi-lobal section, the multi-lobal section includes a plurality of projections, and the plurality of projections comes into contact with both a first virtual circle and a second virtual circle included in the first virtual circle, is integrally formed with the second virtual circle, which serves as a core, and comes into contact with the first virtual circle at ends thereof.

[Step (S1)]

[0029] During the step (S1), the lyocell spinning dope including the cellulose pulp and the N-methylmorpholine-N-oxide (NMMO) aqueous solution is spun.

[0030] The lyocell spinning dope may include 6 to 16 wt% of the cellulose pulp and 84 to 94 wt% of the N-methylmorpholine-N-oxide aqueous solution. The cellulose pulp may have an alpha-cellulose content of 85 to 97 wt% and a degree of polymerization (DPw) of 600 to 1700.

[0031] When the content of the cellulose pulp in the lyocell spinning dope is less than 6 wt%, it may be difficult to ensure fibrous characteristics, and when the content is more than 16 wt%, it may be difficult to dissolve the pulp in the aqueous solution.

[0032] Further, when the content of the N-methylmorpholine-N-oxide aqueous solution in the lyocell spinning dope is less than 84 wt%, the dissolution viscosity may be significantly increased, which is undesirable. When the content is more than 94 wt%, the spinning viscosity may be significantly reduced, making it difficult to ensure uniform fibers during the spinning step.

[0033] The weight ratio of N-methylmorpholine-N-oxide and water may be 93 : 7 to 85 : 15 in the N-methylmorpholine-

N-oxide aqueous solution. When the weight ratio of N-methylmorpholine-N-oxide is more than 93(%), the dissolution temperature may be increased, thus decomposing cellulose during the dissolution of the cellulose. When weight ratio of N-methylmorpholine-N-oxide is less than 85(%), the dissolution capability of the solvent may be reduced, making it difficult to dissolve cellulose.

[0034] The spinning dope is discharged through the spinning nozzle of a spinneret. The spinning dope on the filament is discharged through the air gap section of the spinneret into a solidifying solution in a solidifying bath. The spinning dope may be discharged from the spinneret at a spinning temperature of 80 to 130°C.

[0035] The spinneret may have a plurality of unit holes when one unit hole is set to include a plurality of holes. The number of holes included in the unit hole may be the same as the number of projections of the multi-lobal section. For example, the number of holes included in the unit hole may be three in order to manufacture a lyocell fiber that includes a monofilament having a multi-lobal section including three projections.

[Step (S2)]

[0036] During the step (S2), the lyocell spinning dope, spun during the step (S1), is solidified to obtain the lyocell multifilament. The solidification of the step (S2) may include a primary solidifying step of supplying cooled air to the spinning dope to solidify the spinning dope using air quenching (Q/A) and a secondary solidifying step of adding the primarily solidified spinning dope to the solidifying solution to solidify the spinning dope.

[0037] During the (S1) step, the spinning dope may be discharged through the spinneret and then pass through the air gap section between the spinneret and the solidifying bath. Cooled air is supplied from a donut-shaped air cooler, positioned in the spinneret, to the air gap section in the outward direction from the inside of the spinneret. Cooled air may be supplied to the spinning dope to primarily solidify the spinning dope using air quenching.

[0038] Factors affecting the physical properties of the lyocell multifilament obtained during the step (S2) are the temperature and the wind speed of cooled air in the air gap section. Cooled air may be supplied to the spinning dope at a temperature of 4 to 15°C and a wind speed of 5 to 50 m/s to thus solidify the spinning dope during the step (S2).

[0039] When the temperature of cooled air is lower than 4°C during primary solidification, the surface of the spinneret is cooled, the sections of the lyocell multifilaments become nonuniform, and spinning processability is reduced. When the temperature is higher than 15°C, primary solidification using cooled air is insufficiently performed, reducing spinning processability.

[0040] Further, when the wind speed of cooled air is less than 5 m/s during primary solidification, primary solidification using cooled air is insufficiently performed, reducing the spinning processability causing yarn breakage. When the wind speed is more than 50 m/s, spinning dope is discharged from the spinneret while being shaken due to the air, thus reducing spinning processability.

[0041] After primary solidification using air quenching, the spinning dope may be supplied to the solidifying bath containing the solidifying solution to thus perform secondary solidification. Meanwhile, the temperature of the solidifying solution may be 30°C or less in order to perform appropriate secondary solidification. With regard to this, since the secondary solidification temperature is not unnecessarily high, an appropriate solidifying speed is maintained. The solidifying solution may be manufactured so as to have a typical composition in the art to which the present invention belongs, and accordingly, the solidifying solution is not particularly limited.

[Step (S3)]

[0042] During the step (S3), the lyocell multifilament obtained during the step (S2) is washed.

[0043] Specifically, the lyocell multifilament obtained during the step (S2) may be transported to a pulling roller and then to a washing bath to thus be washed.

[0044] When the filament is washed, in consideration of ease of recovery and reuse of a solvent after washing, a washing solution having a temperature of 0 to 100°C may be used, and water may be used as the washing solution, and other additive components may be further included if necessary.

[Step (S4)]

[0045] During the step (S4), the lyocell multifilament washed during the step (S3) may be treated using an emulsion and then dried.

[0046] For treatment using the emulsion, the multifilament is completely immersed in the emulsion to be coated, and the amount of the emulsion applied on the filament is maintained using squeezing rollers attached to a feeding roll and a discharging roll of an emulsion-treatment apparatus. The emulsion serves to reduce friction caused when the filament comes into contact with a drying roller and a guide during a crimping step.

[0047] The lyocell fiber is biodegradable and thus environmentally friendly.

[0048] Further, in the lyocell fiber, since the monofilament has a multi-lobal section including a plurality of projections, the specific surface area thereof is increased. Accordingly, the manufactured lyocell fiber may exhibit the same or improved physical properties even if used in a lesser amount, compared to a conventional lyocell fiber having a circular section.

[0049] Particularly, the lyocell fiber according to the present invention has a large specific surface area, which exhibits the same or improved physical properties, compared to a conventional lyocell fiber, even if used in a lesser amount when the lyocell fiber is applied as a reinforcing material in the clothing, construction, and vehicle fields.

[0050] When the lyocell fiber according to the present invention is used for clothes, the lyocell fiber exhibits excellent properties such as hygroscopicity and quick drying due to the large specific surface area thereof. Accordingly, the lyocell fiber does not cling to the body, even a sweaty body, thereby always providing a pleasant state to the skin to thus reduce discomfort. Further, the lyocell fiber helps to quickly and continuously dry sweat. Specific examples of application of the lyocell fiber for use in clothes may include outdoor wear, sportswear, t-shirts, golf wear, men's and women's clothing, functional underwear, hats, sports socks, and underwear.

[0051] When the lyocell fiber according to the present invention is used as a reinforcing material, a reinforcing ability is increased as a contact area between the lyocell fiber and materials to be reinforced is increased. The lyocell fiber may be applied to MRG (mechanical rubber goods), such as tire cords and hose reinforcing materials, cement reinforcing materials, and interior materials of vehicles.

Mode for Invention

[0052] A better understanding of the present invention may be obtained through the following Examples. It will be apparent to those skilled in the art that the following Examples are intended to illustrate the present invention but are not to be construed to limit the scope of the present invention.

<u>Example 1</u>

[0053] Cellulose pulp having a degree of polymerization (DPw) of 820 and an alpha-cellulose content of 93.9% was mixed with an NMMO/H_2O mixture solvent (a weight ratio 90/10) having a propyl gallate content of 0.01 wt% to manufacture 12 wt% of a spinning dope for use in a lyocell fiber.

[0054] The spinning dope was maintained at a spinning temperature of 110°C in a spinning nozzle of a spinneret having a plurality of unit holes each including three holes. The spinning dope was spun while the discharge amount and the spinning speed of the spinning dope were controlled so that the monodenier of the filament was 3.37 denier. The spinning dope, discharged from the spinning nozzle, on the filament was supplied through an air gap section to a solidifying solution in a solidifying bath. The spinning dope was primarily solidified in the air gap section using cooled air at a temperature of 8°C and a wind speed of 10 m/s.

[0055] The solidifying solution included 85 wt% of water and 15 wt% of NMMO at 25°C.

[0056] The concentration of the solidifying solution was continuously monitored using a sensor and a refractometer.

[0057] The filament elongated in an air layer using a pulling roller was washed using a sprayed washing solution in a washing apparatus to remove remaining NMMO. After an emulsion was uniformly applied on the filament, the resultant filament was squeezed so that the content of the emulsion in the filament was maintained at 0.2%, and dried using a drying roller at 150°C to manufacture a lyocell fiber including a multifilament. The multifilament included a monofilament having a multi-lobal section including three projections.

<u>Example 2</u>

[0058] The same procedure as Example 1 was repeated to manufacture a lyocell fiber, which included a multifilament including a monofilament having a multi-lobal section including three projections, except that the monodenier of the filament was 3.58 denier.

<u>Example 3</u>

[0059] The same procedure as Example 1 was repeated to manufacture a lyocell fiber, which included a multifilament including a monofilament having a multi-lobal section including three projections, except that the monodenier of the filament was 14.82 denier.

<u>Comparative Example 1</u>

[0060] The same procedure as Example 1 was repeated to manufacture a lyocell fiber, which included a multifilament including a monofilament having a circular section, except that the spinneret that was used had a plurality of unit holes each including one hole having a circular section, and that the monodenier of the filament was 1.73 denier.

Comparative Example 2

[0061] The same procedure as Comparative Example 1 was repeated to manufacture a lyocell fiber, which included a multifilament including a monofilament having a circular section, except that the monodenier of the filament was 2.97 denier.

[0062] The shape of the section, the denier, and the space occupancy ratio of the monofilament that was included in the lyocell fiber manufactured in the Examples and the Comparative Examples were measured and calculated using the following methods, and the results are set forth in the following Table 1.

(1) Sectional shape of the monofilament included in the lyocell fiber

[0063] A few bundles of fibers were sampled and then rolled together with black cotton. The resultant fiber was processed to be thin and then inserted into a hole in a plate that was used to transversely cut the fiber. Subsequently, the fiber was cut using a razor blade in a way such that the shape of the section thereof was not changed.

[0064] The cut section of the fiber was magnified (× 200) and observed using an optical microscope (BX51, products manufactured by Olympus Corporation), and the image of the section was stored using a digital camera. The desired section was selected and the radius and the area of the section were analyzed using an image of the section of the fiber according to the Olympus soft imaging solution program.

(2) Denier

[0065] The denier of the lyocell fiber was calculated from the sectional area of the monofilament of the real lyocell fiber, which was obtained from the section analysis, and the density of the lyocell fiber using the following Equation 2.

$$\text{Density of lyocell fiber} = 1.49\ \text{g/cm}^3$$

<Equation 2>

$$\text{Denier (De)} = [\text{Sectional area of monofilament of lyocell fiber } (\mu\text{m}^2) \times \text{Density of lyocell fiber } (\text{g/cm}^3) \times 9000\ (\text{m})]/1000000$$

(3) Space occupancy ratio

[0066] The space occupancy ratio of the lyocell fiber was calculated using the following Equation 1.

<Equation 1>

$$\text{Space occupancy ratio } (\%) = (\text{Area of first virtual circle/sectional area of monofilament included in lyocell fiber}) \times 100$$

[Table 1]

	Shape of section of monofilament included in lyocell fiber				Denier (De)	L1/L2	Space occupancy ratio (%)
	Radius of first virtual circle (L1, μm)	Radius of second virtual circle (L2, μm)	Area of first virtual circle (μm^2)	Sectional area of monofilament of actual lyocell fiber (μm^2)			
Example 1	16.75	3.87	881	251.6	3.37	4.33	350
Example 2	11.44	6.16	411	266.6	3.58	1.86	154
Example 3	27.78	11.61	2423	1105	14.82	2.40	219
Comparative Example 1	6.4	6.4	129	129	1.73	1	100
Comparative Example 2	8.4	8.4	222	222	2.97	1	100

[0067] As shown in Table 1, the lyocell fiber including the monofilament having the multi-lobal section of Examples 1 to 3 exhibited a space occupancy ratio larger than that of the lyocell fiber including the monofilament having the circular section of Comparative Examples 1 and 2. The section of the lyocell fiber of Examples 1 to 3 is shown in FIGS. 2a to 2c.

Industrial Applicability

[0068] From the aforementioned results, it can be seen that the lyocell fiber of Examples 1 to 3 has a large specific surface area and may be extensively applied in fields requiring a fiber having a large specific surface area.

[0069] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

1. A lyocell fiber comprising:

a lyocell multifilament manufactured by spinning a lyocell spinning dope including a cellulose pulp and an N-methylmorpholine-N-oxide (NMMO) aqueous solution,
wherein the multifilament includes a monofilament having a multi-lobal section, the multi-lobal section includes a plurality of projections, and the plurality of projections comes into contact with a first virtual circle and a second virtual circle, included in the first virtual circle, is integrally formed with the second virtual circle, serving as a core, and comes into contact with the first virtual circle at ends thereof.

2. The lyocell fiber of claim 1, wherein the lyocell spinning dope includes 6 to 16 wt% of the cellulose pulp and 84 to 94 wt% of the N-methylmorpholine-N-oxide aqueous solution.

3. The lyocell fiber of claim 2, wherein the cellulose pulp has an alpha-cellulose content of 85 to 97 wt% and a degree of polymerization (DPw) of 600 to 1700.

4. The lyocell fiber of claim 1, wherein a space occupancy ratio defined in a following Equation 1 is 150 to 400%:

<Equation 1>

Space occupancy ratio (%) = (Area of first virtual circle/sectional area of monofilament included in lyocell fiber) × 100.

5. The lyocell fiber of claim 1, wherein the first virtual circle has a radius of 8 to 30 μm.

6. The lyocell fiber of claim 1, wherein the second virtual circle has a radius of 3 to 12 μm.

7. The lyocell fiber of claim 1, wherein the first virtual circle and the second virtual circle are concentric.

FIG. 1

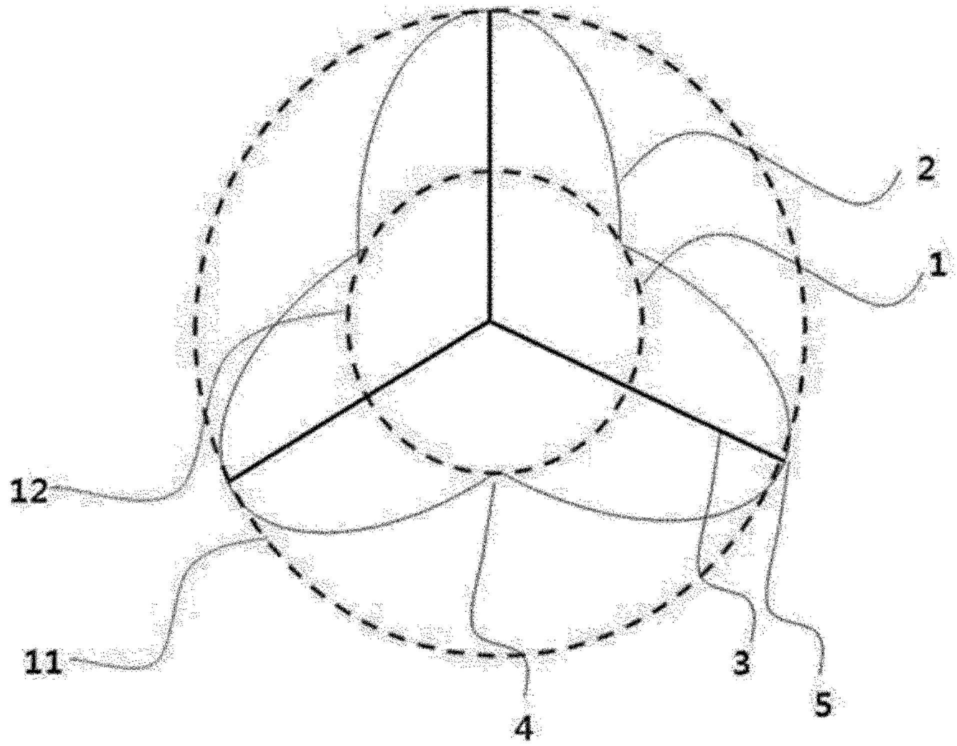


FIG. 2a

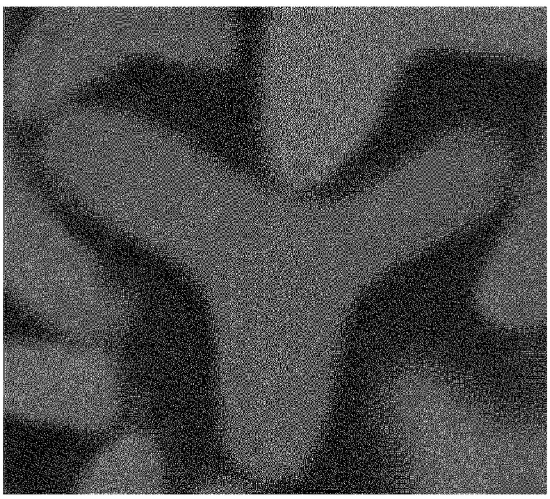


FIG. 2b

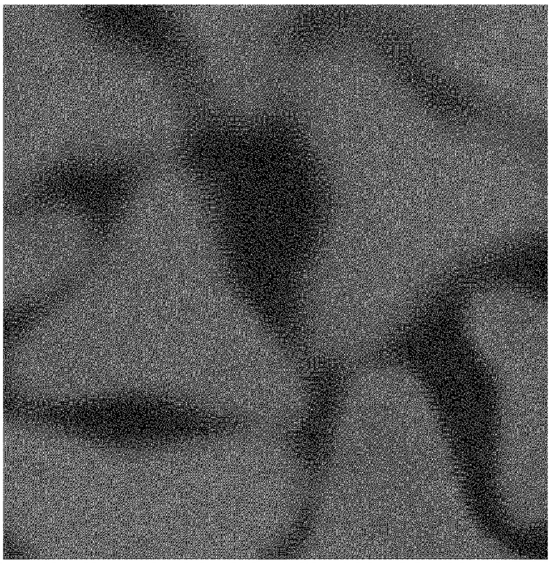
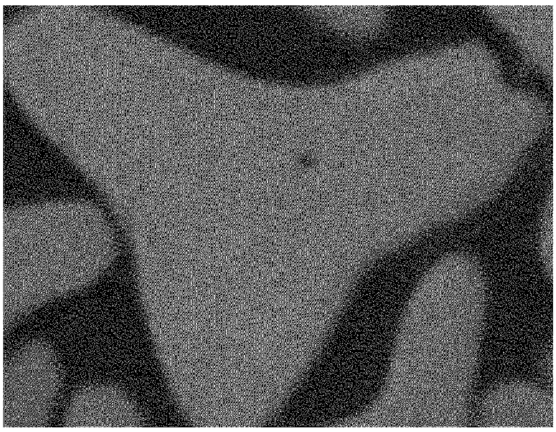


FIG. 2c



INTERNATIONAL SEARCH REPORT	International application No. PCT/KR2015/003140

A. CLASSIFICATION OF SUBJECT MATTER

D01F 2/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D01F 2/02; D01D 5/253; D01D 4/02; D02G 3/00; B32B 1/00; D01F 2/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: cellulose, N-methylmorpholine-N-oxide(NMMO), NMMO, lyocell, projection

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010-0021711 A1 (SCHREMPF, C. et al.) 28 January 2010 See abstract; paragraphs [0103], [0108]; claim 1; and figure 2B.	1-7
A	US 2008-0090076 A1 ((KRONER, G. et al.) 17 April 2008 See abstract; claims 1, 21; and figure 1.	1-7
A	JP 2001-316936 A (TOYOBO CO., LTD.) 16 November 2001 See abstract; claims 1, 3; and figure 3.	1-7
A	US 5108838 A (TUNG, W. H.) 28 April 1992 See abstract; claim 1; and figures 1-9.	1-7
A	KR 10-0769974 B1 (HYOSUNG CORPORATION) 25 October 2007 See abstract; claim 1; and figure 1.	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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