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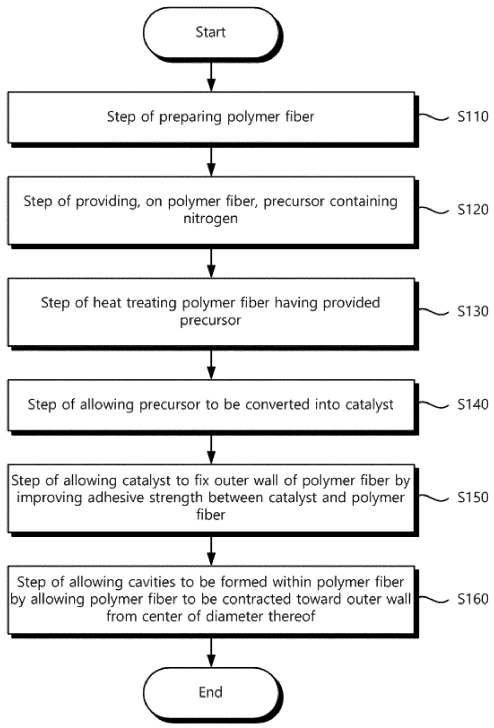
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(54) METHOD FOR PREPARING HOLLOW FIBER COMPOSITE

(57) A method for preparing a hollow fiber composite is disclosed. The method for preparing a hollow fiber composite comprises the steps of: preparing a polymer fiber; providing, on the polymer fiber, a precursor containing nitrogen; and heat treating the polymer fiber having the provided precursor, wherein the precursor is heat treated to be converted into a catalyst and the polymer fiber is heat treated to have cavities formed therein.

【FIG. 1】



EP 3 680 368 A1

Description

[Technical Field]

[0001] The present invention relates to a method for preparing a hollow fiber composite, and more particularly to a method for preparing a hollow fiber composite including heat-treating a polymer fiber provided with a precursor.

[Background Art]

[0002] In general, a nanofiber may be defined as a fibrous material having a diameter of less than 1 μm and may be prepared by various methods such as phase separation, self-assembly, chemical vapor disposition (CVD), electrospinning or the like. However, it is known that the electrospinning is most effective in terms of convenient preparation or mass production and applicability of final products.

[0003] The electrospinning is a method for preparing a fibrous material having a diameter of less than 1 μm into a web or three-dimensional non-woven fabric by applying a high-voltage electric field to a polymer solution. The nanofiber prepared as above may be used for purposes such as a filter material for air or water purification, a medical anti-adhesive agent, a dressing material, a wiping cloth, a carbon nanofiber for artificial leather and energy storage, an inorganic nanofiber by organic/inorganic mixed spinning, etc., and thus various nanofiber-related technologies have been developed.

[0004] For example, Korean Unexamined Patent Publication No. 10-2011-0110643 (Application No.: 10-2010-0030090 and applicant: University-Industry Cooperation Group of Kyung Hee University) discloses a method for preparing a metal-coated nanofiber, including a) preparing an electrospinning solution containing a polymer with a fiber forming ability and an electroless plating catalyst, b) preparing a nanofiber having a diameter of 10 nm to 5 μm by electrospinning the electrospinning solution, and c) electrolessly plating the nanofiber. Besides, various nanofiber-related technologies have been developed now.

[Disclosure]

[Technical Problem]

[0005] One technical object of the present invention is to provide a method for preparing a hollow fiber composite with an improved surface area.

[0006] Another technical object of the present invention is to provide a method for preparing a hollow fiber composite with an improved content of a catalyst.

[0007] Still another technical object of the present invention is to provide a method for preparing a hollow fiber composite, which may be applied to various applications.

[0008] The technical objects of the present invention are not limited to the above.

[Technical Solution]

[0009] To solve the above technical objects, the present invention provides a method for preparing a hollow fiber composite.

[0010] According to one embodiment, the method for preparing a hollow fiber composite includes preparing a polymer fiber, providing a precursor containing nitrogen onto the polymer fiber, and heat-treating the polymer fiber provided with the precursor, in which the precursor is heat-treated to be converted into a catalyst and the polymer fiber is heat-treated to have cavities formed therein.

[0011] According to one embodiment, in the method for preparing a hollow fiber composite, as the polymer fiber provided with the precursor is heat-treated, an adhesive strength between the catalyst and the polymer fiber may be enhanced so that the catalyst may be allowed to fix an outer wall of the polymer fiber, and the polymer fiber may be contracted toward the outer wall from a center of diameter of the polymer fiber so that cavities are formed within the polymer fiber, in which the adhesive strength between the catalyst and the polymer fiber may be stronger than a contraction force of the polymer fiber.

[0012] According to one embodiment, the providing of the precursor containing nitrogen onto the polymer fiber may be performed by a method of immersing the polymer fiber into a solution containing the precursor, and the catalyst may be provided onto the polymer fiber in a form of particle or layer depending on a ratio of a weight of the precursor to a weight of the polymer fiber.

[0013] According to one embodiment, the polymer fiber provided with the precursor may be heat-treated at a temperature of 580 °C or above and less than a temperature at which the polymer is carbonized. According to one embodiment,

in the method for preparing a hollow fiber composite, an amount of the precursor permeating into the polymer fiber may be increased as a thickness of the polymer fiber is decreased.

[0014] According to one embodiment, the polymer may include polyacrylo nitrile (PAN).

[0015] According to one embodiment, the precursor may include urea.

[0016] According to one embodiment, the catalyst may include g-C_3N_4.

[0017] According to another embodiment, the method for preparing a hollow fiber composite includes preparing a fiber composite including a precursor containing nitrogen and provided onto a surface of a polymer fiber, and heat-treating the fiber composite, in which, as the fiber composite is heat-treated, the precursor is converted into a catalyst, an adhesive strength between the catalyst and the polymer fiber is enhanced so that the catalyst is allowed to fix an outer wall of the polymer fiber, and the polymer fiber is contracted toward the outer wall from a center of diameter of the polymer fiber so that cavities are formed within the polymer fiber.

[0018] According to another embodiment, the adhesive strength between the polymer fiber and the catalyst may be stronger than a contraction force of the polymer fiber.

[0019] According to another embodiment, the catalyst may be provided onto the surface of the polymer fiber in a form of particle or layer.

[0020] According to another embodiment, the polymer may include polyacrylo nitrile (PAN) and the catalyst may include g-C_3N_4.

[0021] According to another embodiment, the catalyst may be formed prior to the cavities within the polymer fiber.

[Advantageous Effects]

[0022] The method for preparing a hollow fiber composite according to an embodiment of the present invention may include preparing a polymer fiber, providing a precursor containing nitrogen onto the polymer fiber, and heat-treating the polymer fiber provided with the precursor.

[0023] Further, as the polymer fiber provided with the precursor is heat-treated, the precursor may be converted into a catalyst, and an adhesive strength between the catalyst and the polymer fiber may be enhanced, so that the catalyst may be allowed to fix an outer wall of the polymer fiber. In this case, the polymer fiber may be contracted toward the outer wall from a center of diameter of the polymer fiber, so that cavities may be formed within the polymer fiber.

[0024] Accordingly, a surface area of the polymer fiber may be increased to enhance a content of the catalyst. Further, the hollow fiber composite may be used as an artificial photosynthetic material, a photocatalyst responding to light, etc., depending on a type of the catalyst, and may be also used as a material which carries out reduction of contaminants such as carbon dioxide. Furthermore, the hollow fiber composite may be also used as a composite material, a conductive polymer composite material, a photoelectrochemical water-splitting material, etc., which are used in an electrode material with an improved rate of ionic adsorption, a gas sensor with an improved rate of gas adsorption, an energy storage, and a radiator panel of aircrafts, cars, etc.

[Description of Drawings]

[0025]

FIG. 1 is a flowchart for explaining a method for preparing a hollow fiber composite according to an embodiment of the present invention.

FIGS. 2 to 4 are views showing a process of preparing a hollow fiber composite according to an embodiment of the present invention.

FIG. 5 is a view specifically showing a fiber composite formed in a process of preparing a hollow fiber composite according to an embodiment of the present invention.

FIG. 6 is a view for explaining that cavities are formed within a polymer fiber in a process of preparing a hollow fiber composite according to an embodiment of the present invention.

FIG. 7 is a view showing pictures of a hollow fiber composite according to an embodiment of the present invention.

FIG. 8 is a view showing pictures of a nanofiber composite according to Comparative Example 2 of the present invention.

FIGS. 9 to 11 are views showing pictures of hollow fiber composites according to embodiments of the present invention, which are prepared at mutually different temperatures.

FIG. 12 is a graph showing a change in properties of a hollow fiber composite according to an embodiment of the present invention depending on a concentration of urea.

[Mode for Invention]

[0026] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. However, the technical spirit of the present invention is not limited to the embodiments, but may be realized in different forms. The embodiments introduced herein are provided to sufficiently deliver the spirit of the present invention to those skilled in the art so that the disclosed contents may become thorough and complete.

[0027] When it is mentioned in the specification that one element is on another element, it means that the first element may be directly formed on the second element or a third element may be interposed between the first element and the second element. Further, in the drawings, the thicknesses of the membrane and areas are exaggerated for efficient description of the technical contents.

[0028] Further, in the various embodiments of the present invention, the terms such as first, second, and third are used to describe various elements, but the elements are not limited to the terms. The terms are used only to distinguish one element from another element. Accordingly, an element mentioned as a first element in one embodiment may be mentioned as a second element in another embodiment. The embodiments illustrated here include their complementary embodiments. Further, the term "and/or" in the specification is used to include at least one of the elements enumerated in the specification.

[0029] In the specification, the terms of a singular form may include plural forms unless otherwise specified. Further, the terms "including" and "having" are used to designate that the features, the numbers, the steps, the elements, or combination thereof described in the specification are present, and may be understood that one or more other features, numbers, step, elements, or combinations thereof may be added.

[0030] Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention unnecessarily unclear.

[0031] FIG. 1 is a flowchart for explaining a method for preparing a hollow fiber composite according to an embodiment of the present invention, and FIGS. 2 to 4 are views showing a process of preparing a hollow fiber composite according to an embodiment of the present invention.

[0032] Referring to FIGS. 1 and 2, a polymer fiber 100 may be prepared (S110). According to one embodiment, the polymer fiber 100 may be prepared by electrospinning a polymer solution. For example, the polymer may include polyacrylo nitrile (PAN). For example, the electrospinning process may be performed through a single nozzle. For example, the polymer fiber 100 may include a PAN nanofiber.

[0033] Referring to FIGS. 1 and 3, the precursor 200a may be provided onto the polymer fiber 100 to prepare a fiber composite 300 (S120). According to one embodiment, the precursor 200a may contain nitrogen. For example, the precursor 200a may include urea.

[0034] According to one embodiment, the fiber composite 300 may be prepared by a method of immersing the polymer fiber 100 into a solution containing the precursor 200a. For example, if the polymer fiber 100 includes PAN and the precursor 200a includes urea, the fiber composite 300 may be prepared by a method of immersing a PAN fiber having a weight of 50 mg into a solution containing urea having a weight of 3 g.

[0035] According to one embodiment, as a thickness of the polymer fiber 100 is decreased, an amount of the precursor 200a permeating into the polymer 100 may be increased. Specifically, if the polymer fiber 100 is immersed into the solution containing the precursor 200a, the precursor 200a may permeate into the polymer fiber 100. In this case, an amount of the precursor 200a permeating into the polymer fiber 100 having a small thickness may be more than an amount of the precursor 200a permeating into the polymer fiber 100 having a large thickness.

[0036] Referring to FIGS. 1 and 4, the polymer fiber 100 provided with the precursor 200a may be heat-treated (S130). In other words, the fiber composite 300 may be heat-treated. According to one embodiment, the fiber composite 300 may be disposed within a sintering device 400 and heat-treated. Accordingly, the fiber composite 300 may be subject to sintering.

[0037] Hereinafter, as the fiber composite 300 is heat-treated, a process of forming cavities within the polymer fiber 100 will be described with reference to FIGS. 1, 5 and 6.

[0038] FIG. 5 is a view specifically showing a fiber composite formed in a process of preparing a hollow fiber composite according to an embodiment of the present invention, and FIG. 6 is a view for explaining that cavities are formed within a polymer fiber in a process of preparing a hollow fiber composite according to an embodiment of the present invention.

[0039] Referring to FIGS. 1 and 5, as the fiber composite 300 is heat-treated, the precursor 200a may be converted into a catalyst 200b (S140). In other words, if the fiber composite 300 is heat-treated, the precursor 200a provided onto the polymer fiber 100 may be converted into the catalyst 200b. Accordingly, the catalyst 200b may be provided onto the polymer fiber 100. For example, as described above, if the precursor 200a includes urea, the catalyst 200b may include g-C_3N_4.

[0040] According to one embodiment, as shown in (a) of FIG. 5, the catalyst 200b may be provided onto the polymer fiber 100 in a form of particle. According to another embodiment, as shown in (b) of FIG. 5, the catalyst 200b may be

provided onto the polymer fiber 100 in a form of layer. Specifically, the catalyst 200b may be provided onto the polymer fiber 100 in a form of particle or layer depending on a ratio of a weight of the precursor 200a to a weight of the polymer fiber 100 in the preparing of the fiber composite 300. For example, the catalyst 200b may be provided onto the polymer fiber 100 in the form of layer, if the polymer fiber 100 includes a PAN fiber and the precursor 200a includes urea, and if a weight ratio between the PAN fiber and the urea exceeds 50 mg : 3 g.

[0041] Although (a) and (b) of FIG. 5 show the polymer fiber 100 in a form of cylinder for convenience of explanation, a surface of the polymer fiber 100 may have a concavo-convex shape including concave and convex portions. Accordingly, the catalyst 200b may be provided onto the plurality of concave and convex portions in a form of particle, or may be provided in a form of layer, which conformally covers the surface of the concave and convex portions.

[0042] According to one embodiment, the fiber composite 300 may be heat-treated at a temperature of 580 °C or above and less than a temperature at which the polymer is carbonized. The temperature at which the polymer is carbonized may vary depending on a type of the polymer. For example, if the polymer includes PAN, the fiber composite 300 may be heat-treated at a temperature of 580 °C.

[0043] In contrast, if the fiber composite 300 is heat-treated at a temperature of less than 580 °C, a contraction of the polymer fiber 100, which will be described below, may not occur, so that cavities may not be easily formed within the polymer fiber 100. Further, if the fiber composite 300 is heat-treated at a temperature, at which the polymer is carbonized, or above, the precursor 200a may not be easily converted into the catalyst 200b, so that cavities may not be easily formed within the polymer fiber 100, which will be described below.

[0044] Referring to FIGS. 1 and 6, as the fiber composite 300 is heat-treated, the catalyst 200b may fix an outer wall 100b of the polymer fiber 100 (S150). Specifically, if the fiber composite 300 is heat-treated, adhesion between the catalyst 200b and the polymer fiber 100 may be enhanced, and thus the catalyst 200b may fix the outer wall 100b of the polymer fiber 100.

[0045] Further, as the fiber composite 300 is heat-treated, the polymer fiber 100 may be contracted to form cavities 100h within the polymer fiber 100. Specifically, the polymer fiber 100 may be contracted toward the outer wall 100b of the polymer fiber 100 from a center 100a of diameter of the polymer fiber 100. In this case, the adhesive strength between the polymer fiber 100 and the catalyst 200b may be stronger than a contraction force of the polymer fiber 100. Accordingly, the cavities 100h may be formed within the polymer fiber 100.

[0046] In other words, if the fiber composite 300 is heat-treated, the precursor 200a provided onto the polymer fiber 100 may be converted into the catalyst 200b and the adhesive strength between the catalyst 200b and the polymer fiber 100 may become strong. Further, as the polymer fiber 100 is heat-treated, a contraction phenomenon of the polymer fiber 100 may occur.

[0047] In this case, as the adhesive strength between the polymer fiber 100 and the catalyst 200b is stronger than the contraction force of the polymer fiber 100, the polymer fiber 100 may be contracted while the outer wall 100b of the polymer fiber 100 is fixed by the catalyst 200b. Accordingly, the polymer fiber 100 may be contracted toward the outer wall 100b of the polymer fiber 100 from a center 100a of diameter of the polymer fiber, and the cavities 100h may be formed within the polymer fiber 100.

[0048] If the cavities 100h are formed within the polymer fiber 100, the catalyst 200b may be provided not only onto a surface of the polymer fiber 100, but also within the cavities 100h of the polymer fiber 100. However, an amount of the catalyst 200b provided onto the surface of the polymer fiber 100 may be more than an amount of the catalyst 200b provided within the cavities 100h of the polymer fiber 100.

[0049] The method for preparing a hollow fiber composite according to an embodiment of the present invention as described above may include preparing the polymer fiber 100, providing the precursor 200a containing nitrogen onto the polymer fiber 100, and heat-treating the polymer fiber 100 provided with the precursor 200a.

[0050] Further, as the polymer fiber 100 provided with the precursor 200a is heat-treated, the precursor 200a may be converted into the catalyst 200b, and the adhesive strength between the catalyst 200b and the polymer fiber 100 may be enhanced, so that the catalyst 200b may fix the outer wall 100b of the polymer fiber 100. In this case, the polymer fiber 100 may be contracted toward the outer wall 100b from a center 100a of diameter of the polymer fiber 100, so that the cavities 100h may be formed within the polymer fiber 100.

[0051] Accordingly, a surface area of the polymer fiber 100 may be increased to enhance a content of the catalyst 200b. Further, the hollow fiber composite may be used as an artificial photosynthetic material, a photocatalyst responding to light, etc., depending on a type of the catalyst 200b, and may be also used as a material which carries out reduction of contaminants such as carbon dioxide. Furthermore, the hollow fiber composite may be also used as a composite material, a conductive polymer composite material, a photoelectrochemical water-splitting material, etc., which are used in an electrode material with an improved rate of ionic adsorption, a gas sensor with an improved rate of gas adsorption, an energy storage, and a radiator panel of aircrafts, cars, etc.

[0052] Hereinafter, specific experimental examples and the results of property evaluation will be described with regard to the hollow fiber composite prepared in accordance with the method for preparing the hollow fiber composite according to an embodiment of the present invention.

Preparing of hollow fiber composite according to Example

[0053] A PAN nanofiber was prepared by electrospinning a polyacrylonitrile (PAN) solution through a single nozzle. After that, a fiber composite was prepared by immersing the PAN nanofiber having a weight of 50 mg into a solution containing urea having a weight of 3 g, after which the fiber composite was heat-treated at a temperature of 580 °C under an atmosphere of argon (Ar) gas, so as to prepare a hollow fiber composite according to an embodiment, in which g-C_3N_4 was provided onto the PAN nanofiber.

Preparing of nanofiber according to Comparative Example 1

[0054] A PAN nanofiber was prepared by electrospinning a PAN solution.

Preparing of nanofiber composite according to Comparative Example 2

[0055] A carbonized PAN nanofiber was prepared by carbonizing a PAN nanofiber which was prepared by electrospinning a PAN solution through a single nozzle. After that, a fiber composite was prepared by immersing the carbonized PAN nanofiber into a solution containing urea and thiourea, after which the fiber composite was heat-treated at a temperature of 580 °C under an atmosphere of argon (Ar) gas, so as to prepare a hollow fiber composite according to an embodiment, in which g-C_3N_4 was provided onto the carbonized PAN nanofiber.

[0056] The hollow fiber composite according to the embodiment, the nanofiber according to Comparative Example 1, and the hollow fiber composite according to Comparative Example 2 are summarized in the following Table 1.

[Table 1]

Classification	Structure
Example	PAN/g-C_3N_4 hollow fiber composite
Comparative Example 1	PAN nanofiber
Comparative Example 2	Carbonized PAN/g-C_3N_4 nanofiber composite

[0057] FIG. 7 is a view showing pictures of a hollow fiber composite according to an embodiment of the present invention.

[0058] Referring to (a) and (b) of FIG. 7, the hollow fiber composite according to the embodiment was photographed through a scanning electron microscope (SEM) with magnification power of 500 nm and 5.00 um. As can be understood from (a) and (b) of FIG. 7, it might be confirmed that the hollow fiber composite according to the embodiment has cavities formed within the fiber composite. Further, the surface area (m^2/g) and total pore volume (cm^3/g) properties of the hollow fiber composite, which was photographed through the SEM with reference to (a) and (b) of FIG. 7, and the PAN nanofiber according to Comparative Example 1 are summarized in the following Table 2.

[Table 2]

Classification	Surface area (m^2/g) (R=coeffiecient)		Total pore volume (cm^3/g) (p/po=0.990)
	$a_{s,BET}$	$a_{s,Lang}$	
Experimental Example	65.9 (R=0.9999)	No. Lang fit	0.181
Comparative Example	19.1 (R=0.9965)	No. Lang fit	0.015

[0059] As can be understood from Table 2, it may be seen that the hollow fiber composite according to the embodiment has a surface area value about seven times more than that of the PAN nanofiber, and has a total pore volume value about 12 times more than that of the PAN nanofiber. In other words, it may be seen that the hollow fiber composite according to the embodiment, in which g-C_3N_4 is provided onto the PAN nanofiber, has excellent surface area and total pore volume properties.

[0060] FIG. 8 is a view showing pictures of a nanofiber composite according to Comparative Example 2 of the present invention.

[0061] Referring to (a) and (b) of FIG. 8, a side and a surface of the nanofiber composite according to above Comparative Example 2 were photographed through a transmission electron microscope (TEM) with magnification power of 50 nm. As can be understood from (a) and (b) of FIG. 8, it may be confirmed that the nanofiber composite according to above Comparative Example 2 does not have cavities formed therein. Further, it may be confirmed that the nanofiber composite

according to above Comparative Example 2 has a carbonized PAN surface coated with g-C_3N_4.

[0062] FIGS. 9 to 11 are views showing pictures of hollow fiber composites according to embodiments of the present invention, which are prepared at mutually different temperatures.

[0063] Referring to FIGS. 9 to 11, the PAN nanofiber according to the embodiment, which was immersed in urea, was heat-treated at temperatures of 300 °C, 400 °C and 580 °C to prepare hollow fiber composites, which were then photographed through the SEM respectively.

[0064] As can be confirmed from FIGS. 9 and 10, the hollow fiber composites prepared by being heat-treated at temperatures of 300 °C and 400 °C do not have cavities formed in a part thereof. On the other hand, as can be confirmed from FIG. 11, it might be confirmed that the hollow fiber composite prepared by being heat-treated at a temperature of 580 °C has cavities easily formed therein. Accordingly, in case of preparing the hollow fiber composite according to the embodiment, it may be seen that it is easy to heat-treat the PAN nanofiber immersed in urea at a temperature of 580 °C or above.

[0065] FIG. 12 is a graph showing a change in properties of a hollow fiber composite according to an embodiment of the present invention depending on a concentration of urea.

[0066] Referring to FIG. 12, in a process of preparing a hollow fiber composite according to the embodiment, a concentration of urea was adjusted in a step of immersing a PAN fiber into a solution containing urea. Next, the hollow fiber composite was prepared when there is no urea (PAN@580) and when there are 2.4 g, 3 g, 4 g and 5 g of urea, after which a transmittance (%)depending on wavenumbers (cm^{-1}) was measured, and the results were shown in a graph of FT-IR (Fourier transform infrared spectroscopy).

[0067] As can be understood from FIG. 12, it might be confirmed that the hollow fiber composite (PAN@580) without urea does not show any peak and the hollow fiber composite prepared through immersion into the solution containing 2.4 g of urea shows one peak at 1200-1640 cm^{-1}. On the other hand, it might be confirmed that the hollow fiber composites prepared through immersion into the solutions containing 3 g, 4 g and 5 g of urea show two peaks at 1200-1640 cm^{-1} and 800-880 cm^{-1}.

[0068] In other words, in case of generally measuring FT-IR, a peak related to g-C_3N_4 may be confirmed at 1200-1640 cm^{-1} and 800-880 cm^{-1}. However, in case of the hollow fiber composites prepared through immersion into the solutions containing 3 g, 4 g and 5 g of urea, it is confirmed that a peak is shown in the range described above. Thus, it may be seen that the hollow fiber composite prepared through immersion into the solutions containing 3 g, 4 g and 5 g of urea have g-C_3N_4 easily formed therein. Accordingly, in case of preparing the hollow fiber composite according to the embodiment, it may be seen that g-C_3N_4 is easily formed by immersing the PAN fiber into the solution containing at least 3 g of urea.

[0069] Although the present invention has been described in detail with reference to exemplary embodiments, the scope of the present invention is not limited to a specific embodiment and should be interpreted by the attached claims. In addition, those skilled in the art should understand that many modifications and variations are possible without departing from the scope of the present invention.

[Industrial Applicability]

[0070] A hollow fiber composite according to an embodiment of the present invention and a method for preparing the same may be utilized in various fields of industry such as a photocatalyst, an artificial photosynthetic material, an electrode material, a gas sensor, an energy storage, a radiator panel, etc.

Claims

1. A method for preparing a hollow fiber composite, the method comprising:

preparing a polymer fiber;
providing a precursor containing nitrogen onto the polymer fiber; and
heat-treating the polymer fiber provided with the precursor,

wherein the precursor is heat-treated to be converted into a catalyst and the polymer fiber is heat-treated to have cavities formed therein.

2. The method of claim 1, wherein, as the polymer fiber provided with the precursor is heat-treated, an adhesive strength between the catalyst and the polymer fiber is enhanced so that the catalyst is allowed to fix an outer wall of the polymer fiber, and the polymer fiber is contracted toward the outer wall from a center of diameter of the polymer fiber so that cavities are formed within the polymer fiber, and wherein the adhesive strength between the catalyst

and the polymer fiber is stronger than a contraction force of the polymer fiber.

3. The method of claim 1, wherein the providing of the precursor containing nitrogen onto the polymer fiber is performed by immersing the polymer fiber into a solution containing the precursor, and the catalyst is provided onto the polymer fiber in a form of particle or layer depending on a ratio of a weight of the precursor to a weight of the polymer fiber.

4. The method of claim 1, wherein the polymer fiber provided with the precursor is heat-treated at a temperature of 580°C or above and less than a temperature at which the polymer is carbonized.

5. The method of claim 1, wherein an amount of the precursor permeating into the polymer fiber is increased as a thickness of the polymer fiber is decreased.

6. The method of claim 1, wherein the polymer includes polyacrylo nitrile (PAN).

7. The method of claim 1, wherein the precursor includes urea.

8. The method of claim 1, wherein the catalyst includes g-C_3N_4.

9. A method for preparing a hollow fiber composite, the method comprising:

preparing a fiber composite including a precursor containing nitrogen and provided onto a surface of a polymer fiber; and
heat-treating the fiber composite,

wherein, as the fiber composite is heat-treated, the precursor is converted into a catalyst, an adhesive strength between the catalyst and the polymer fiber is enhanced so that the catalyst is allowed to fix an outer wall of the polymer fiber, and
the polymer fiber is contracted toward the outer wall from a center of diameter of the polymer fiber so that cavities are formed within the polymer fiber.

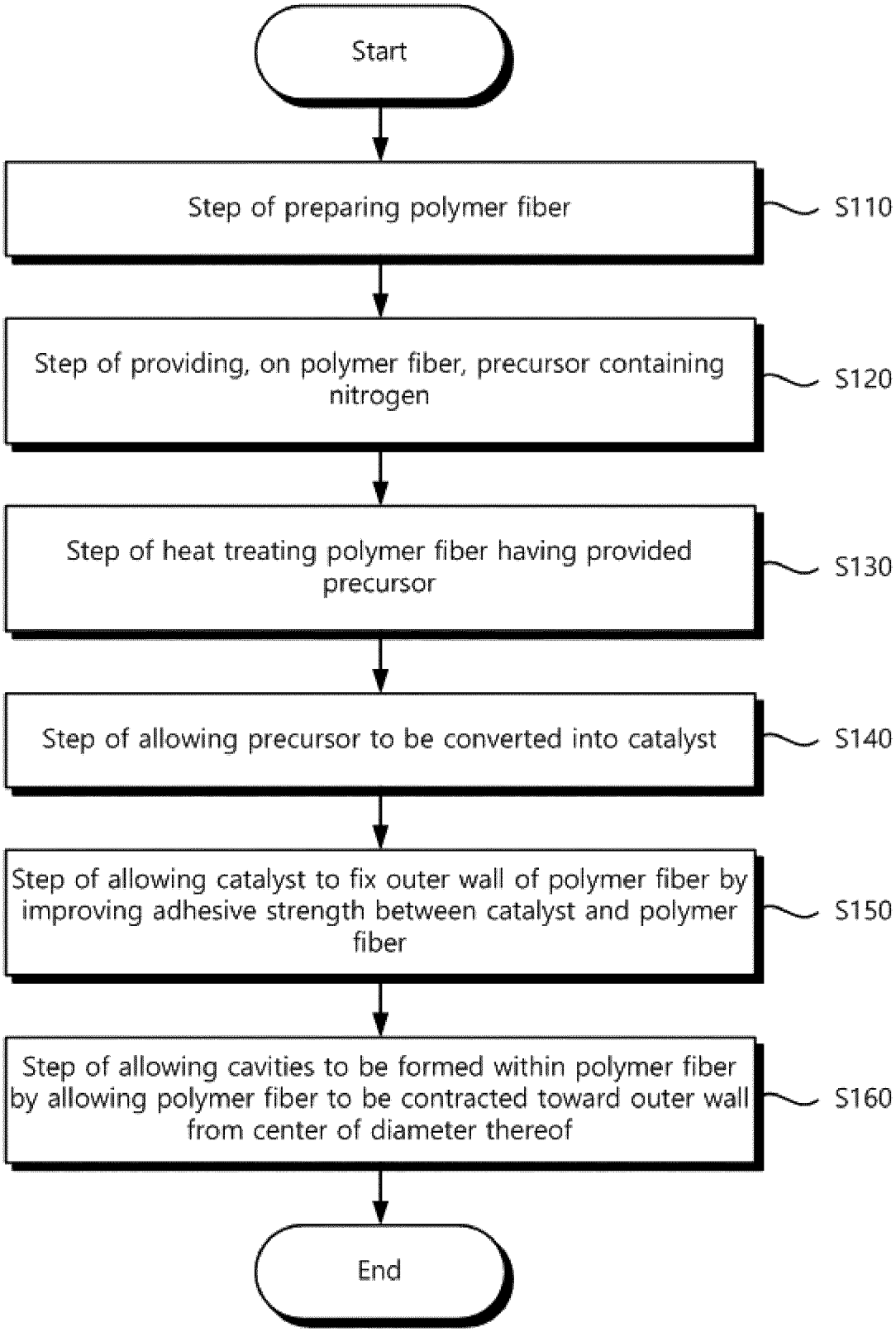
10. The method of claim 9, wherein the adhesive strength between the polymer fiber and the catalyst is stronger than a contraction force of the polymer fiber.

11. The method of claim 9, wherein the catalyst is provided onto the surface of the polymer fiber in a form of particle or layer.

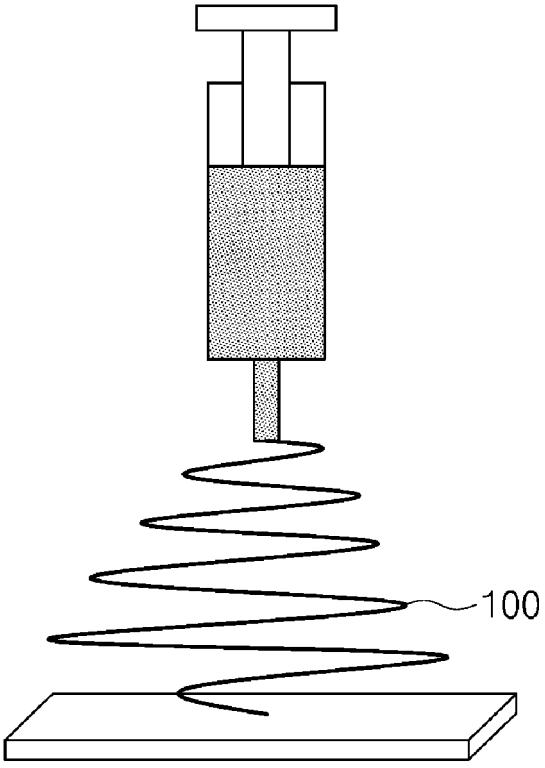
12. The method of claim 9, wherein the polymer includes polyacrylo nitrile (PAN), and the catalyst includes g-C_3N_4.

13. The method of claim 9, wherein the catalyst is formed prior to the cavities within the polymer fiber.

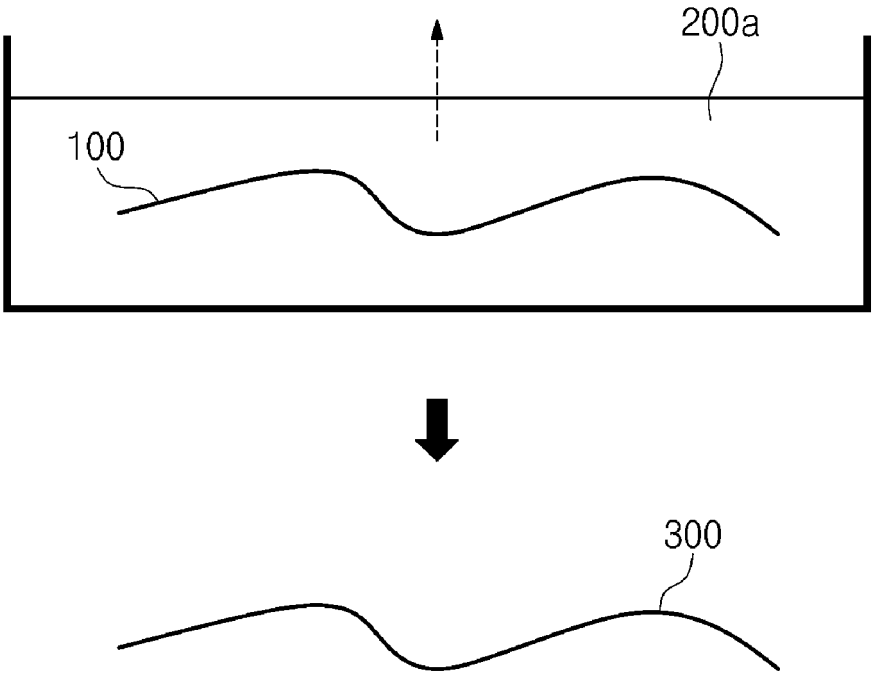
【FIG. 1】


Start
Step of preparing polymer fiber
S110
Step of providing, on polymer fiber, precursor containing nitrogen
S120
Step of heat treating polymer fiber having provided precursor
S130
Step of allowing precursor to be converted into catalyst
S140
Step of allowing catalyst to fix outer wall of polymer fiber by improving adhesive strength between catalyst and polymer fiber
S150
Step of allowing cavities to be formed within polymer fiber by allowing polymer fiber to be contracted toward outer wall from center of diameter thereof
S160
End

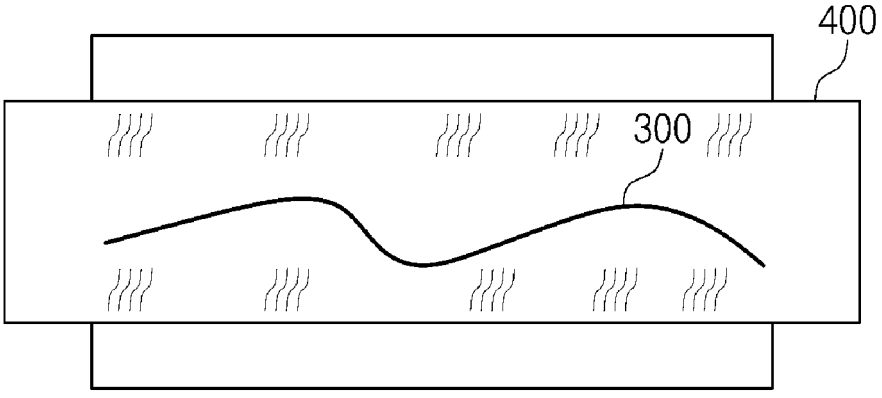
【FIG. 2】



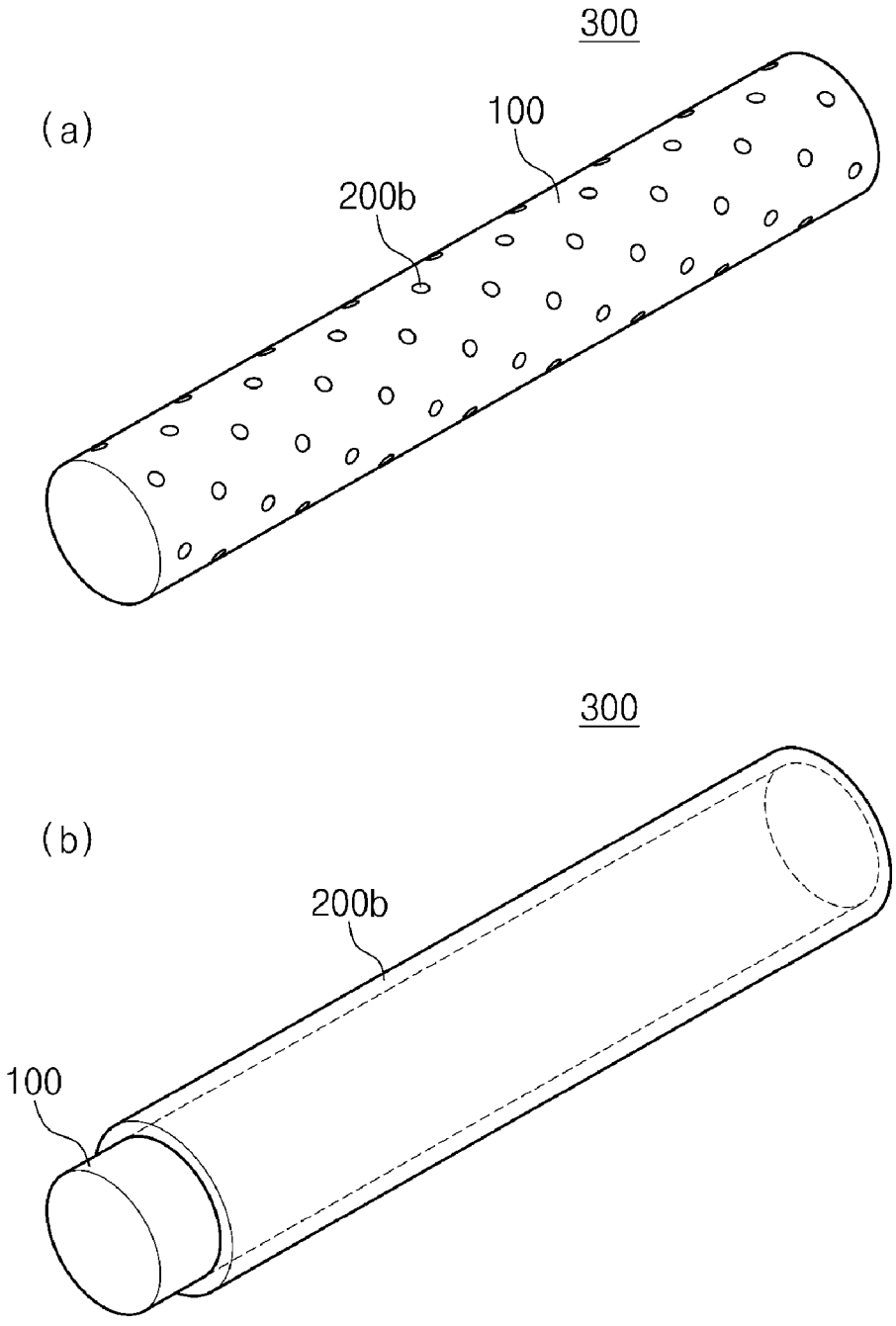
【FIG. 3】



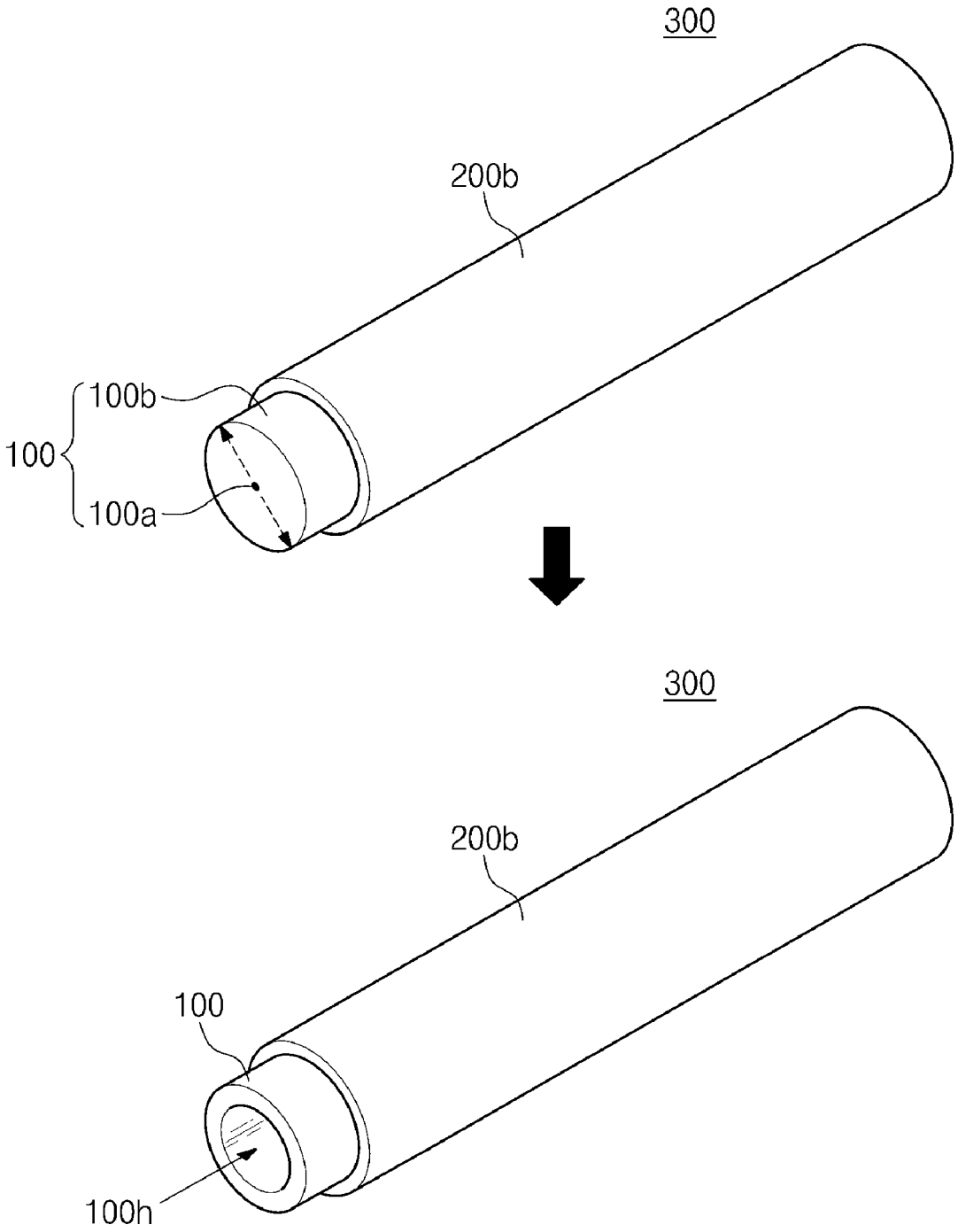
【FIG. 4】



【FIG. 5】

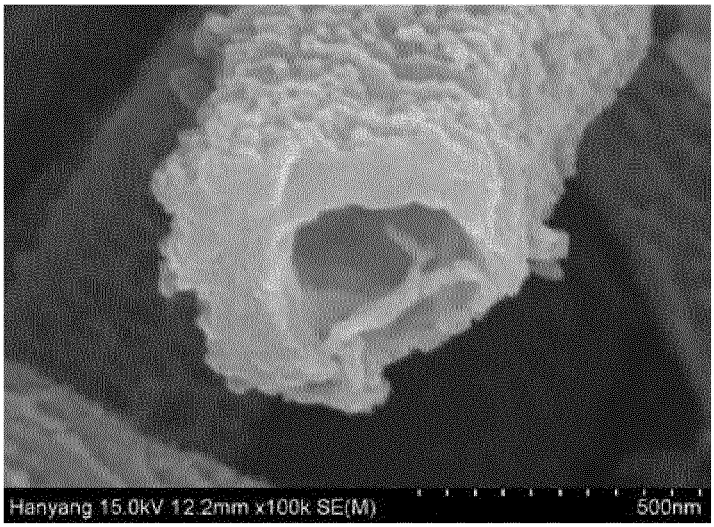


【FIG. 6】

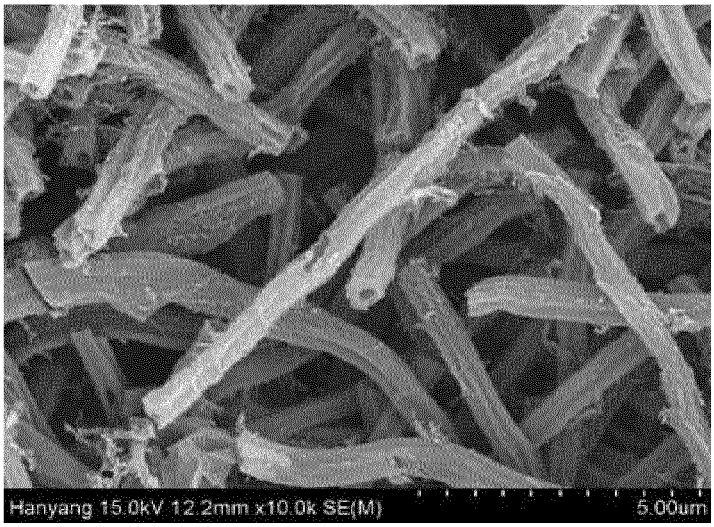


【FIG. 7】

(a)

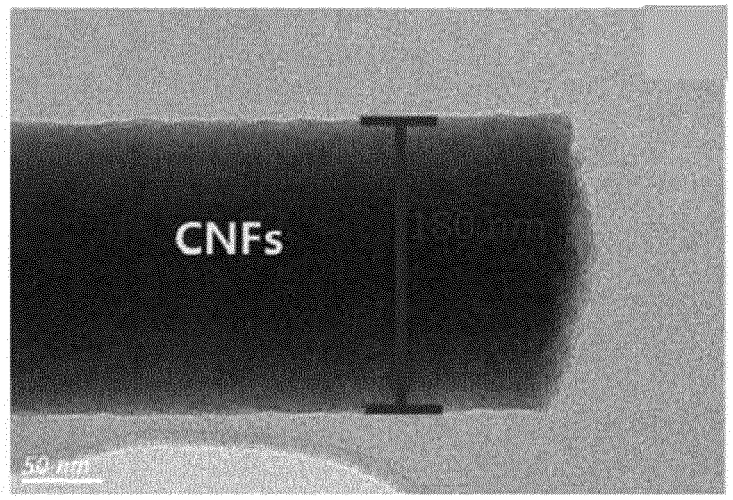

Hanyang 15.0kV 12.2mm x100k SE(M)
500nm

(b)

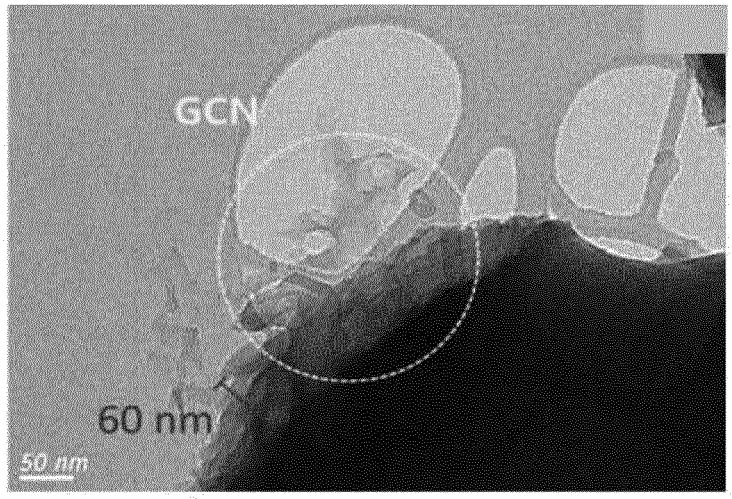

Hanyang 15.0kV 12.2mm x10.0k SE(M)
5.00um

【FIG. 8】

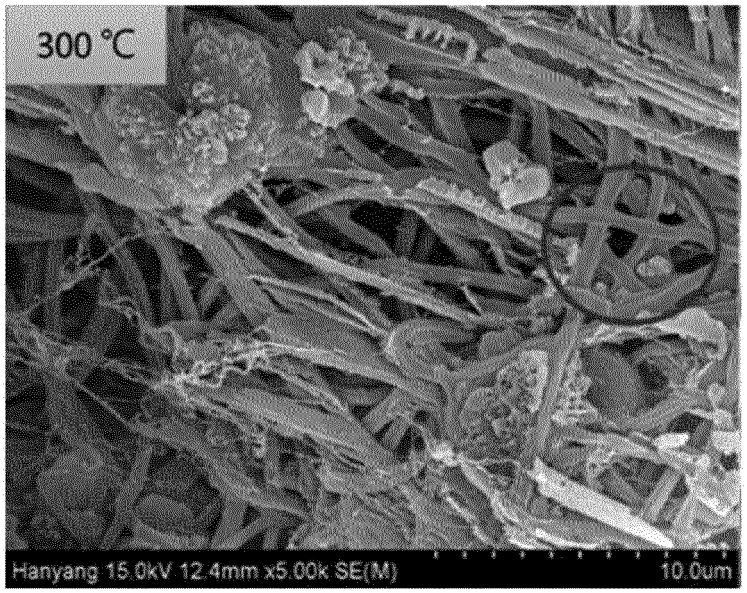
(a)



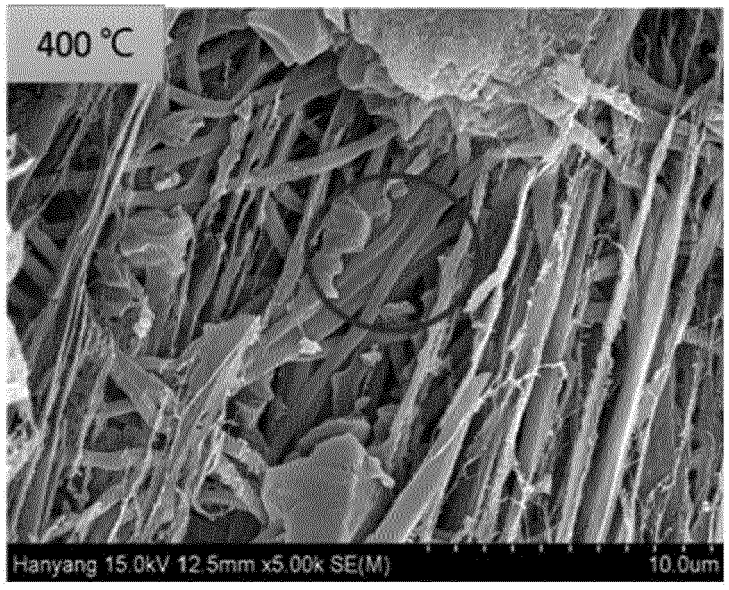
(b)



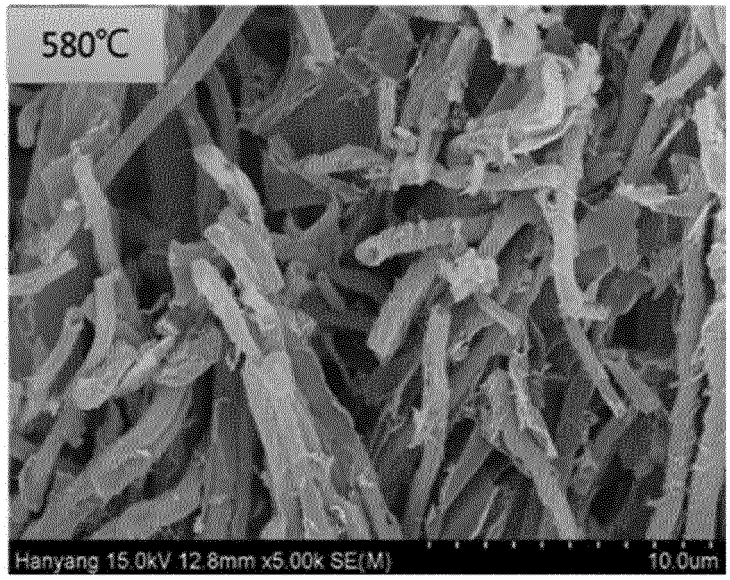
【FIG. 9】


300 ℃
Hanyang 15.0kV 12.4mm x5.00k SE(M)
10.0um

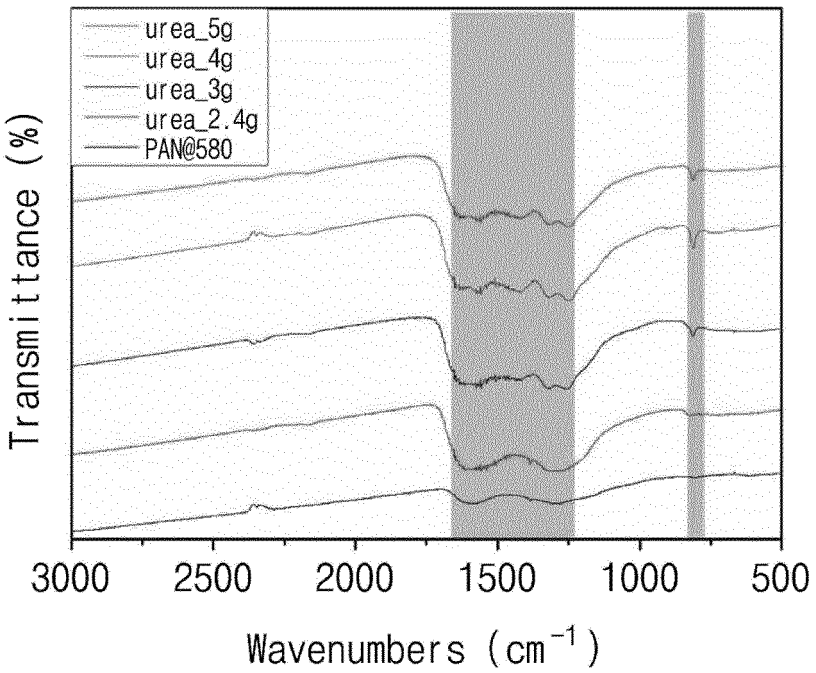
【FIG. 10】


400 ℃
Hanyang 15.0kV 12.5mm x5.00k SE(M)
10.0um

【FIG. 11】


580℃
Hanyang 15.0kV 12.8mm x5.00k SE(M)
10.0um

【FIG. 12】


urea_5g
urea_4g
urea_3g
urea_2.4g
PAN@580
Transmittance (%)
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2018/001148

A. CLASSIFICATION OF SUBJECT MATTER

D01D 5/24(2006.01)i, D01D 5/00(2006.01)i, D02J 13/00(2006.01)i, D06M 13/432(2006.01)i, D06M 101/28(2006.01)n

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)
D01D 5/24; B01J 27/051; D01D 5/00; B82B 1/00; D06M 11/42; D01F 9/12; B01J 23/00; B01J 35/00; D02J 13/00; D06M 13/432; D06M 101/28

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: hollow, nanofiber, thermal treatment, catalyst, precursor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2017-0042157 A (KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY) 18 April 2017 See paragraphs [0011]-[0068]; claims 1-15.	1-13
A	KR 10-2016-0078203 A (KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY) 04 July 2016 See the entire document.	1-13
A	KR 10-2015-0111548 A (DAEGU GYEONGBUK INSTITUTE OF SCIENCE AND TECHNOLOGY) 06 October 2015 See the entire document.	1-13
A	KR 10-2016-0050926 A (THE INDUSTRY & ACADEMIC COOPERATION IN CHUNGNAM NATIONAL UNIVERSITY) 11 May 2016 See the entire document.	1-13
A	US 2005-0112052 A1 (GU, Gang et al.) 26 May 2005 See the entire document.	1-13

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

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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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 JUNE 2018 (04.06.2018)	**04 JUNE 2018 (04.06.2018)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2018/001148

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		WO 2005-025734 A2	24/03/2005
		WO 2005-025734 A3	29/06/2006

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REFERENCES CITED IN THE DESCRIPTION

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- KR 1020110110643 **[0004]**
- WO 1020100030090 A **[0004]**