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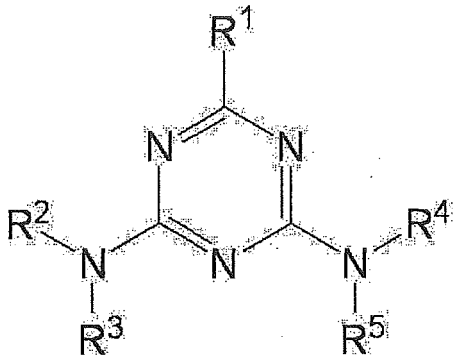
(54) FIBERS, COMPOSITION FOR PRODUCING FIBERS, AND BIOMATERIAL CONTAINING FIBERS

(57) An object to the present invention is to provide a fiber which is superior in safety, can be conveniently produced, and has organic solvent resistance, a starting material composition for producing the fiber and a biocompatible material containing the fiber.

A fiber produced by spinning a composition containing (A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1), and (B) an acid compound:



(1)

wherein each symbol is as defined in the DESCRIPTION.

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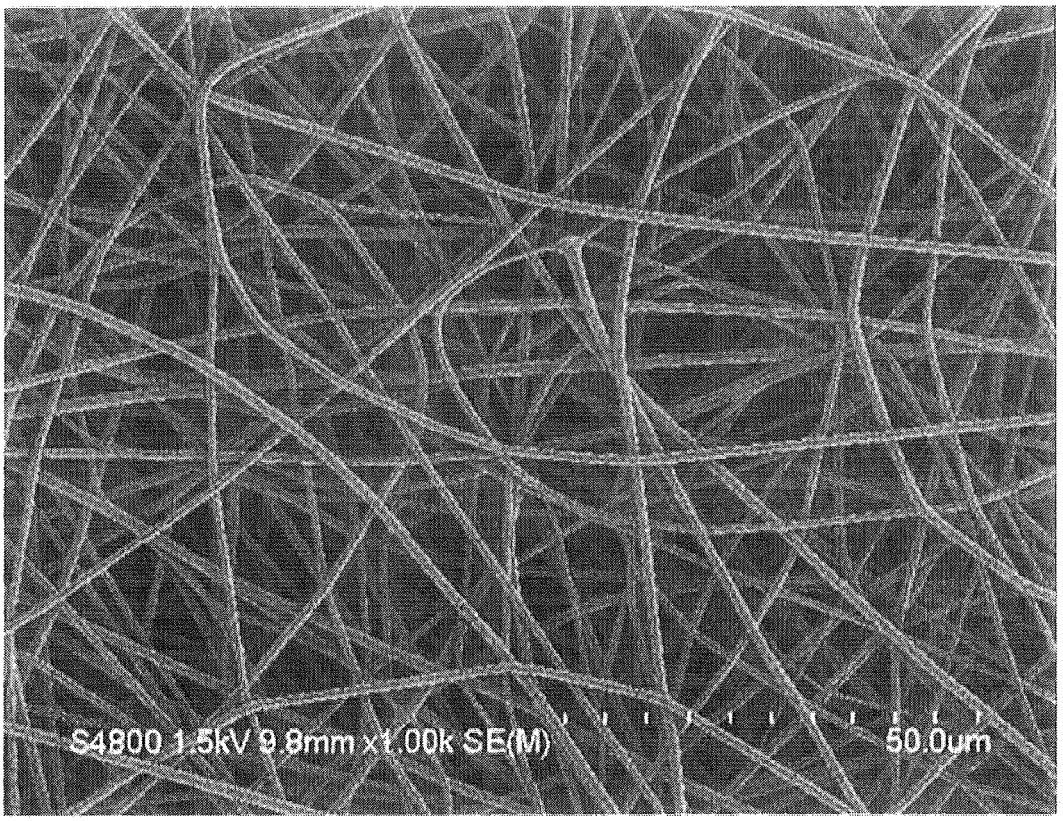
Fig. 1



Description

Technical Field

[0001] The present invention relates to a composition for producing a fiber, which contains an acid compound and a condensation product obtained by condensing a particular triazine compound, a fiber produced by spinning the composition, and a biocompatible material containing the fiber.

Background Art

[0002] In recent years, an ultrafine fiber having a diameter of a nano meter order to micro meter order has been attracting attention, and is expected to be utilizable in various fields of battery • information, environment • energy, medical care (e.g., biocompatible material etc.) • welfare.

[0003] As a material forming such ultrafine fiber, a wide variety of materials such as organic polymers (e.g., nylon and the like), inorganic substances (e.g., TiO_2, SiO_2 and the like), organism-derived polymers (e.g., cellulose, collagen and the like), and the like have been considered.

[0004] As a technique for spinning an ultrafine fiber having a diameter of a nano meter order to micro meter order, melt blow method, composite melt spinning method, electrospinning method and the like are known. Particularly, electrospinning method is attracting attention as a method capable of fibrosis of materials that could not be handled heretofore. For example, many medical polymers such as polylactic acid and the like, and water-soluble polymers such as polyvinyl alcohol and the like have been investigated in addition to the aforementioned organism-derived polymers such as cellulose, collagen and the like (patent documents 1 - 7, non-patent document 1).

[0005] On the other hand, as biocompatible materials such as cell culture scaffold material and the like, use of organism-derived materials (particularly, gelatin derived from bovine etc.) has been avoided in recent years due to safety problems, and production using non organism-derived materials (e.g., synthetic polymer etc.) has been desired.

[0006] Biocompatible materials such as cell culture scaffold material and the like require use of an organic solvent such as ethanol and the like for a sterilization treatment. When the above-mentioned ultrafine fiber is applied to the biocompatible materials, the fiber also needs to have resistance to organic solvents. In the above-mentioned patent documents and non-patent document, a method including crosslinking polymers by a crosslinking agent and the like are used as a means for improving durability of a fiber. However, when the kind of the polymer is different, crosslinking conditions vary, and a complicated treatment such as UV irradiation, hydrogen chloride gas treatment and the like is sometimes required (e.g., patent documents 3, 7 and non-patent document 1). Therefore, a method capable of producing a fiber having organic solvent resistance by a simple treatment alone (e.g., heat treatment alone, preferably, heat treatment at low temperature for short time alone) is desired.

[Document List]

Patent Documents

[0007]

patent document 1: US-A-2002/0192468
patent document 2: CN-A-101718004
patent document 3: JP-A-2013-49927
patent document 4: National Publication of International Patent Application No. 2008-514341
patent document 5: WO 2007/102606
patent document 6: JP-A-2009-100
patent document 7: US-A-2011/0275154
patent document 8: JP-A-2012-67432

[non-patent document]

[0008] non-patent document 1: Macromolecular Research (2010), 18(2), 137-143

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0009] An object of the present invention is to provide a fiber which is superior in safety, can be conveniently produced, and has organic solvent resistance, a starting material composition for producing the fiber (composition for producing a fiber) and a biocompatible material containing the fiber. Means of Solving the Problems

[0010] The present inventors have conducted intensive studies and found that a fiber produced by spinning a composition containing an acid compound and a condensation product obtained by condensing a particular triazine compound is useful as a biocompatible material, since it has sufficient organic solvent resistance, and further, superior biocompatibility, which is the function of a cell culture scaffold as a specific one embodiment, which resulted in the completion of the present invention.

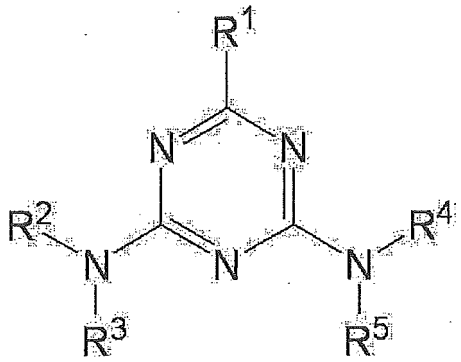
[0011] In addition, the present inventors have found that the fiber of the present invention expresses more superior organic solvent resistance and that the production efficiency is improved by applying a heat treatment.

[0012] Therefore, the present invention is as described below.

[0013]

[1] A fiber produced by spinning a composition comprising

(A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1), and
(B) an acid compound:



(1)

wherein

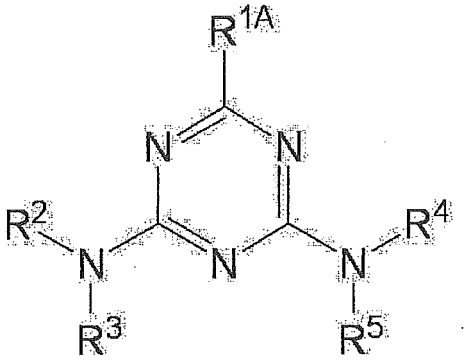
R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[2] The fiber of [1], wherein the above-mentioned composition further comprises (C) a solvent.

[3] The fiber of [1] or [2], wherein the above-mentioned R^1 is selected from an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group or a hydroxymethyl group, a vinyl group, a propenyl group, a butenyl group, a phenyl group and a naphthyl group, and
the above-mentioned R^2, R^3, R^4 and R^5 are the same or different and each is selected from a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group and a butyl group.

[4] The fiber of [1] or [2], wherein

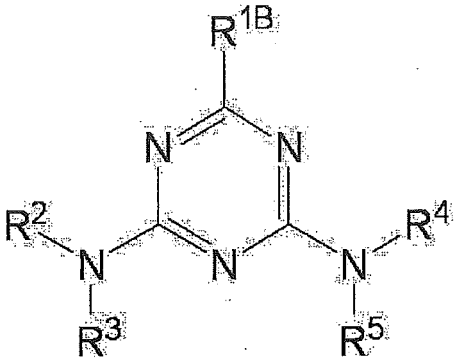
(A) the condensation product is a condensation product obtained by condensing a compound represented by the formula (1A):



(1A)

wherein

R^{1A} is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms, and/or
a compound represented by the formula (1B):



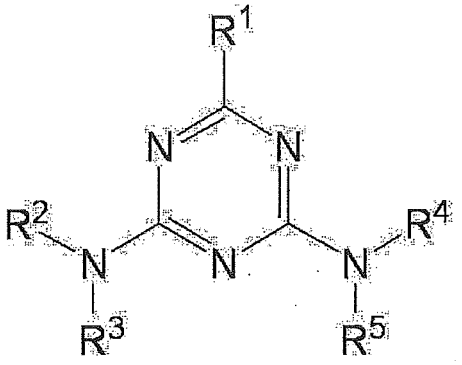
(1B)

wherein

R^{1B} is an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[5] The fiber of any one of [1] - [4], wherein (A) the condensation product has a weight average molecular weight of 1,000 - 1,000,000.
[6] The fiber of any one of [1] - [5], wherein the above-mentioned spinning is electrospinning.
[7] The fiber of any one of [1] - [6], which is a nanofiber and/or a microfiber.
[8] A composition for producing a fiber, comprising

(A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1), and
(B) an acid compound:



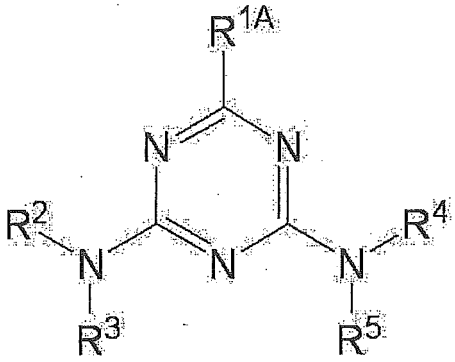
(1)

wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[9] The composition of [8], further comprising (C) a solvent.

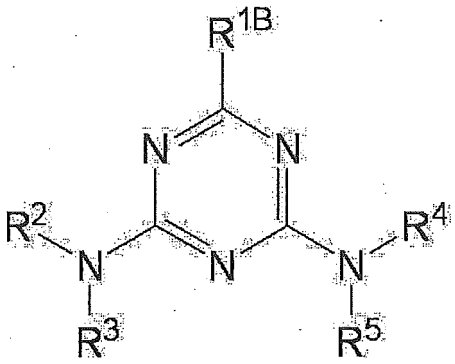
[10] The composition of [8] or [9], wherein (A) the condensation product is a condensation product obtained by condensing a compound represented by the formula (1A):



(1A)

wherein

R^{1A} is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms, and/or
a compound represented by the formula (1B):



(1B)

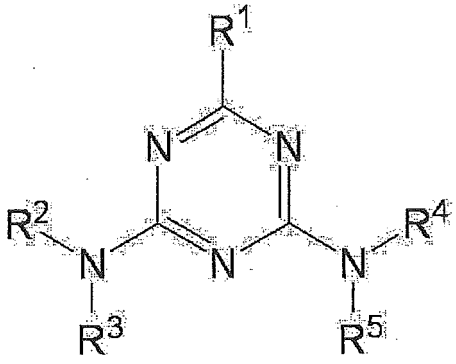
wherein

R^{1B} is an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[11] The composition of any one of [8] - [10], wherein

(A) the condensation product has a weight average molecular weight of 1,000 - 1,000,000.

[12] The composition of any one of [8] - [11], wherein
(A) the condensation product has a solid content of 1 - 90 wt%.
[13] A production method of a fiber, comprising (first step) a step of obtaining (A) a condensation product solution by condensing a monomer composition containing one or more kinds of a compound represented by the formula (1), (second step) a step of obtaining a composition for producing a fiber by adding (B) an acid compound and (C) a solvent to the aforementioned (A) the condensation product solution, and (third step) a step of spinning the aforementioned composition for producing a fiber:



(1)

wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[14] The method of [13], further comprising a step of heating the spun fiber at 50 - 300°C.
[15] The method of [13] or [14], wherein the above-mentioned spinning is electrospinning.
[16] A biocompatible material comprising the fiber of any one of [1] - [7].

[Effect of the Invention]

[0014] According to the present invention, a fiber which is superior in safety, can be conveniently produced, and has organic solvent resistance, a starting material composition for producing the fiber and a biocompatible material containing the fiber can be provided.

[Brief Description of the Drawings]

[0015]

Fig. 1 is an SEM photograph before heating of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 2 is an SEM photograph (enlarged view) before heating of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 3 is an SEM photograph after a heat treatment at 80°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 4 is an SEM photograph (enlarged view) after a heat treatment at 80°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 5 is an SEM photograph of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1, which is after a heat treatment at 80°C for 10 min and immersion in acetone.
Fig. 6 is an SEM photograph (enlarged view) of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1, which is after a heat treatment at 80°C for 10 min and immersion in acetone.
Fig. 7 is an SEM photograph after a heat treatment at 205°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 8 is an SEM photograph (enlarged view) after a heat treatment at 205°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1.
Fig. 9 is an SEM photograph of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1, which is after a heat treatment at 205°C for 10 min and immersion in acetone.
Fig. 10 is an SEM photograph (enlarged view) of a fiber obtained by an electrospinning method from the composition for producing a fiber of Example 1, which is after a heat treatment at 205°C for 10 min and immersion in acetone.
Fig. 11 is an SEM photograph before heating of a fiber obtained by an electrospinning method from the composition for producing a fiber of Comparative Example 1.
Fig. 12 is an SEM photograph (enlarged view) before heating of a fiber obtained by an electrospinning method from the composition for producing a fiber of Comparative Example 1.
Fig. 13 is an SEM photograph after a heat treatment at 80°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Comparative Example 1.
Fig. 14 is an SEM photograph (enlarged view) after a heat treatment at 80°C for 10 min of a fiber obtained by an electrospinning method from the composition for producing a fiber of Comparative Example 1.

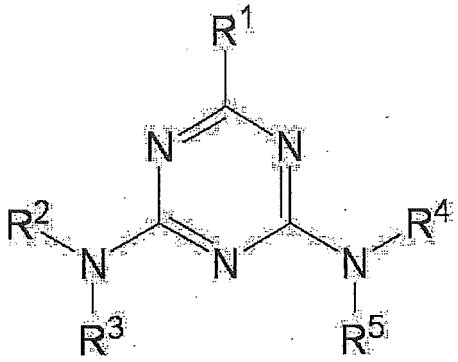
[Description of Embodiments]

[0016] The fiber of the present invention is mainly characterized in that it is produced by spinning (preferably electrospinning) a composition containing (A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1) (hereinafter to be also referred to as "the condensation product of component A" or simply as "component A"), and (B) an acid compound (hereinafter to be referred to as "the acid compound of component B" or simply as "component B").

[0017] The diameter of the fiber of the present invention can be appropriately adjusted according to the use of fiber and the like, and is not particularly limited. From the aspects of application to a substrate to be a cell scaffold and application to a medical material, a cosmetic material and the like, the fiber of the present invention is preferably a fiber having a diameter of a nano meter order (e.g., 1 - 1000 nm) (nanofiber) and/or a fiber having a diameter of a micro meter order (e.g., 1 - 1000 μm) (microfiber). In the present invention, the diameter of a fiber is measured by a scanning electron microscope (SEM).

[Component A]

[0018] Component A is a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1):



(1)

wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and

R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[0019] The definition of each group in the formula (1) is described in detail in the following.

[0020] R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms.

[0021] The "alkoxymethyl group having 2 - 6 carbon atoms" of the "amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group" for R^1 may be linear or branched chain, and concrete examples thereof include methoxymethyl group, ethoxymethyl group, propoxymethyl group, isopropoxymethyl group, butoxymethyl group, isobutoxymethyl group, sec-butoxymethyl group, tert-butoxymethyl group, pentoxymethyl group, isopentoxymethyl group, neopentoxymethyl group, tert-pentoxymethyl group, 1-ethylpropoxymethyl group, 2-methylbutoxymethyl group and the like. The carbon atom number of the alkoxymethyl group is preferably 2 - 5, more preferably 2 - 4.

[0022] The "alkyl group having 1 - 6 carbon atoms" for R^1 may be linear or branched chain, and concrete examples thereof include methyl group, ethyl group, propyl group, isopropyl group, butyl group, isobutyl group, sec-butyl group, tert-butyl group, pentyl group, isopentyl group, neopentyl group, tert-pentyl group, 1-ethylpropyl group, hexyl group, isohexyl group, 1,1-dimethylbutyl group, 2,2-dimethylbutyl group, 3,3-dimethylbutyl group, 2-ethylbutyl group and the like. The carbon atom number of the alkyl group is preferably 1 - 5, more preferably 1 - 4.

[0023] The "alkenyl group having 2 - 6 carbon atoms" for R^1 may be linear or branched chain, and concrete examples thereof include vinyl group, allyl group, propenyl group, butenyl group, pentenyl group, hexenyl group and the like. The carbon atom number of the alkenyl group is preferably 2 - 5, more preferably 2 - 4.

[0024] The "aryl group having 6 - 14 carbon atoms" for R^1 may be monocyclic or condensed polycyclic, and concrete examples thereof include phenyl group, naphthyl group, azulenyl group, indenyl group, indanyl group, anthryl group, phenanthryl group, acenaphthylenyl group and the like. The carbon atom number of the aryl group is preferably 6 - 12, more preferably 6 - 10.

[0025] From the aspect of the reactivity of the condensation reaction, R^1 is preferably an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms, more preferably an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group or a hydroxymethyl group, a vinyl group, a propenyl group, a butenyl group, a phenyl group or a naphthyl group, particularly preferably an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group or a hydroxymethyl group or a phenyl group.

[0026] R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

[0027] The "alkoxymethyl group having 2 - 6 carbon atoms", "alkenyl group having 2 - 6 carbon atoms" and "alkyl group having 1 - 6 carbon atoms" for R^2, R^3, R^4 or R^5 mean the same as the "alkoxymethyl group having 2 - 6 carbon atoms", "alkenyl group having 2 - 6 carbon atoms" and "alkyl group having 1 - 6 carbon atoms", respectively, for the above-mentioned R^1.

[0028] From the aspect of the reactivity of the condensation reaction with alkoxymethyl group and hydroxymethyl

group, R^2,

[0029] R^3, R^4 and R^5 are the same or different and each is preferably a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group or a butyl group, more preferably a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group or a hydroxymethyl group.

[0030] In a compound represented by the formula (1),

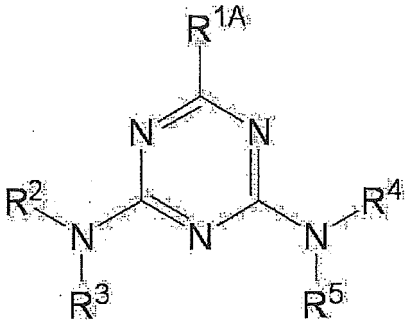
[0031] R^1 is selected from an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group or a hydroxymethyl group, a vinyl group, a propenyl group, a butenyl group, a phenyl group and a naphthyl group (more preferably an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group or a hydroxymethyl group or a phenyl group, particularly preferably an amino group optionally substituted by a methoxymethyl group, a butoxymethyl group or a hydroxymethyl group and a phenyl group); and

[0032] R^2, R^3, R^4 and R^5 are the same or different and each is preferably selected from a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group and a butyl group (more preferably a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group and a hydroxymethyl group, particularly preferably a methoxymethyl group, a butoxymethyl group and a hydroxymethyl group).

[0033] A compound represented by the formula (1) can be produced by a method known per se or a method analogous thereto. Also, a commercially available product can also be used.

[0034] The condensation product of component A may be obtained by condensing one kind of a compound represented by the formula (1), or two or more kinds of a compound represented by the formula (1). Preferred is a condensation product wherein not more than 4 kinds of a compound represented by the formula (1) are condensed, more preferred is a condensation product wherein not more than 3 kinds of a compound represented by the formula (1) are condensed, and particularly preferred is a condensation product wherein not more than 2 kinds of a compound represented by the formula (1) are condensed.

[0035] One embodiment of component A is a condensation product obtained by condensing a compound represented by the formula (1A) :

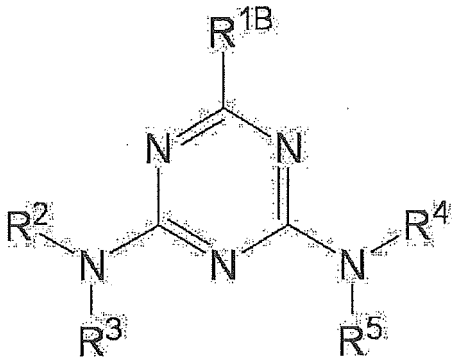


(1A)

wherein

R^{1A} is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group; and

R^2, R^3, R^4 and R^5 are as defined above, and/or a compound represented by the formula (1B):



(1B)

wherein

R^{1B} is an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are as defined above, and the like.

[0036] The "alkoxymethyl group having 2 - 6 carbon atoms" of the "amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group" for R^{1A}, and the "aryl group having 6 - 14 carbon atoms" for R^{1B} each mean the same as the "alkoxymethyl group having 2 - 6 carbon atoms" and "aryl group having 6 - 14 carbon atoms" for the above-mentioned R^1.

[0037] In the compound represented by the formula (1A),
R^{1A} is preferably selected from an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group or a hydroxymethyl group (more preferably an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group or a hydroxymethyl group, particularly preferably an amino group optionally substituted by a methoxymethyl group, a butoxymethyl group or a hydroxymethyl group); and
R^2, R^3, R^4 and R^5 are the same or different and each is preferably selected from a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group and a butyl group (more preferably a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group and a hydroxymethyl group, particularly preferably a methoxymethyl group, a butoxymethyl group and a hydroxymethyl group).

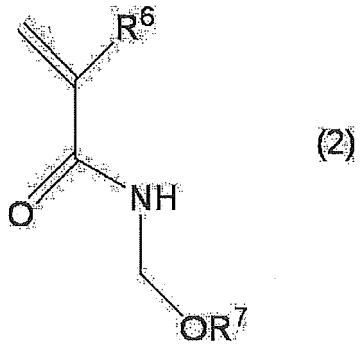
[0038] In a compound represented by the formula (1B),
R^{1B} is selected from a phenyl group and a naphthyl group (more preferably a phenyl group); and
R^2, R^3, R^4 and R^5 are the same or different and each is preferably selected from a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group and a butyl group (more preferably a methoxymethyl group, an ethoxymethyl group, a butoxymethyl group and a hydroxymethyl group, particularly preferably a methoxymethyl group, a butoxymethyl group and a hydroxymethyl group).

[0039] When a compound represented by the formula (1A) and a compound represented by the formula (1B) are condensed, the weight ratio of each compound to be used (1A:1B) is not particularly limited and, for example, 1:10 - 10:1.

[0040] Component A can be produced by a method known per se or a method analogous thereto. For example, it can be produced by polymerizing one or more kinds of a compound represented by the formula (1) in a suitable solvent (e.g., ethyl lactate etc.) by using a suitable condensation initiator (e.g., p-toluenesulfonic acid etc.) and the like, but the method is not limited thereto. Also, a commercially available product may be used.

[0041] When one or more kinds of a compound represented by the formula (1) is/are polymerized, other compound polymerizable with a compound represented by the formula (1) may be polymerized together as long as the object of the present invention is not impaired. Examples of other compound include, but are not limited to, known acrylic compound and known methacrylic compound. Such other compound may be used alone, or two or more kinds thereof may be used in combination. The ratio of a compound represented by the formula (1) to all compounds to be polymerized is generally not less than 10 mol%, preferably not less than 30 mol%, particularly preferably not less than 50 mol%.

[0042] As the above-mentioned known acrylic compound or known methacrylic compound, a compound represented by the following formula (2):



(2)

wherein

R^6 and R^7 are the same or different and each is a hydrogen atom or an alkyl group having 1 - 6 carbon atoms is

preferable.

[0043] The "alkyl group having 1 - 6 carbon atoms" for R^6 or R^7 is as defined above.

[0044] From the aspect of spinnability, the weight average molecular weight of component A is preferably 1,000 - 1,000,000, more preferably 5,000 - 500,000, particularly preferably 10,000 - 200,000, most preferably 10,000 - 100,000. In the present invention, the "weight average molecular weight" refers to a molecular weight based on polystyrene, which is measured by gel permeation chromatography (GPC).

[0045] Component A may be used alone or two or more kinds thereof may be used in combination. Not more than 4 kinds are preferably used, not more than 3 kinds are more preferably used, and not more than 2 kinds are particularly preferably used.

[Component B]

[0046] Component B is an acid compound and acts as a catalyst for a reaction of components A or a reaction of components A wherein a condensation product of a compound other than a compound represented by the formula (1) is further condensed as long as the object of the present invention is not impaired. A fiber containing such component B can maintain good fiber form even when a heat treatment is applied, and shows high organic solvent resistance. Component B may be in the form of a salt; that is, the term "acid compound" in the present invention is a concept encompassing even a salt.

[0047] Examples of the acid compound of component B include organic acid compounds such as sulfonic acid compound, carboxylic acid compound, phosphoric acid compound and the like; inorganic acid compounds such as hydrochloric acid, phosphoric acid, sulfuric acid, nitric acid, hydrobromic acid and the like, and the like.

[0048] Component B is preferably an organic acid compound, more preferably a sulfonic acid compound. Examples of the sulfonic acid compound include p-toluenesulfonic acid, pyridinium p-toluenesulfonate, trifluoromethanesulfonic acid and the like, with preference given to p-toluenesulfonic acid or pyridinium p-toluenesulfonate.

[0049] The acid compound of component B may be used alone, or two or more kinds thereof may be used in combination.

[0050] The acid compound of component B can be produced by a method known per se or a method analogous thereto. In addition, a commercially available product may also be used.

[0051] The fiber of the present invention is produced by preparing, preferably, a composition containing the condensation product of component A, the acid compound of component B, and further (C) a solvent (hereinafter to be also referred to as "the solvent of component C" or simply as "component C") (i.e., the composition for producing a fiber of the present invention (hereinafter to be also referred to simply to as "the composition of the present invention")), and spinning the composition.

[0052] More particularly, the fiber of the present invention is preferably produced by a production method, comprising (first step) a step of obtaining (A) a condensation product solution by condensing a monomer composition containing one or more kinds of a compound represented by the formula (1), (second step) a step of obtaining a composition for producing a fiber by adding (B) an acid compound and (C) a solvent to the aforementioned (A) the condensation product solution, and (third step) a step of spinning the aforementioned composition for producing a fiber.

[0053] The solvent of component C is not particularly limited as long as it can uniformly dissolve or disperse component A and component B, and does not react with each component. From the aspects of solubility of components A and B, a polar solvent is preferable.

[0054] Examples of the polar solvent include water, methanol, ethanol, 2-propanol, propylene glycol monomethyl ether, acetone, dimethylformamide, dimethylacetamide, N-methylpyrrolidone, ethyl lactate and the like. From the aspect of the solubility of components A and B, it is preferably ethyl lactate.

[0055] Component C may be used alone, or two or more kinds thereof may be used in combination.

[0056] The content ratio of the solid content of component A in the composition of the present invention is preferably 1 - 90 wt%, more preferably 1 - 70 wt%, from the aspects of spinnability. Here, the ratio of the solid content of component A is measured using Halogen Moisture Analyzer (HR83) manufactured by Mettler Toledo International Inc., as shown in the Examples described blow.

[0057] The content ratio of the solid content of component B in the composition of the present invention is preferably 1 - 10 wt%, more preferably 1 - 5 wt%, from the aspect of the reaction efficiency of the crosslinking reaction.

[0058] The weight ratio of the solid contents of component A and component B contained in the composition of the present invention (weight of solid content of component A/weight of component B) is preferably 5 - 40, more preferably 10 - 30, from the aspect of the reaction efficiency of the crosslinking reaction.

[0059] The content ratio of component C in the composition of the present invention is preferably 5 - 80, more preferably 10 - 50, from the aspect of the spinnability of the composition for producing a fiber.

[0060] Where necessary, the composition of the present invention may contain, besides components A - C, an additive conventionally used in the field of a composition for producing a fiber, as long as the object of the present invention is

not impaired. Examples of the additive include crosslinking agent, surfactant, rheology adjusting agent, chemical agent, fine particles, condensation product other than component A and the like.

[0061] In the above-mentioned (second step), the composition of the present invention is prepared by mixing component A with component B and component C, or further adding the above-mentioned additive thereto. The mixing method is not particularly limited, and a method known per se or a method analogous thereto can be used for mixing.

[0062] In the above-mentioned (third step), the spinning method of the composition of the present invention is not particularly limited as long as it can form a fiber. For example, melt blow method, composite melt spinning method, electrospinning method and the like can be mentioned, and electrospinning method is preferable from the aspect of the forming ability of ultrafine fiber (nanofiber, microfiber).

[0063] Electrospinning method is a known spinning method, and can be performed using a known electrospinning apparatus. Various conditions such as the speed of discharging the composition of the present invention from the tip of a nozzle (e.g., needle etc.) (discharge speed); application voltage; the distance between the tip of a nozzle discharging the composition of the present invention and a substrate for receiving same (discharge distance) and the like can be appropriately determined according to the diameter of the fiber to be produced and the like. The discharge speed is generally 0.1 - 100 μl/min, preferably 0.5 - 50 μl/min, more preferably 1 - 20 μl/min. The application voltage is generally 0.5 - 80 kV, preferably 1 - 60 kV, more preferably 3 - 40 kV. The discharge distance is generally 1 - 60 cm, preferably 2 - 40 cm, more preferably 3 - 30 cm.

[0064] The electrospinning method may be performed using a drum collector and the like. Using a drum collector and the like, the orientation of a fiber can be controlled. For example, when the drum is rotated at a low speed, a non-woven fabric and the like can be obtained and, when the drum is rotated at a high speed, an oriented fiber sheet and the like can be obtained.

[0065] The diameter of the fiber of the present invention produced by the electrospinning method can be made smaller than that of a fiber produced by other conventional spinning method, which is generally 1 nm - 3 μm, preferably 1 nm - 1 μm.

[0066] The production method of the fiber of the present invention may further include a step of heating a spun fiber at a particular temperature, in addition to the aforementioned spinning step.

[0067] The temperature for heating a spun fiber is generally 50 - 300°C. From the aspects of the heat resistance of the component A, it is preferably 80 - 250°C, more preferably 90 - 220°C. When the temperature is less than 50°C, the crosslinking reaction of components A becomes insufficient, and the produced fiber tends to show lower resistance to organic solvents. When it exceeds 300°C, component A itself undergoes decomposition or dissolution due to the heat and the like, and a fiber sometimes cannot be formed.

[0068] The heating method of the spun fiber is not particularly limited as long as heating at the above-mentioned heating temperature is possible, and a method known per se or a method analogous thereto can be appropriately used for heating. Specific examples of the heating method include a method using a hot plate, oven and the like under atmosphere, and the like.

[0069] While the heating time of the spun fiber can be appropriately determined according to the heating temperature and the like, it is preferably 1 min - 48 hr, more preferably 5 min - 36 hr, particularly preferably 5 min - 24 hr from the aspects of crosslinking reaction rate, and production efficiency.

[0070] While the use of the fiber of the present invention is not particularly limited, the fiber is suitable as a biocompatible material since it has superior resistance to organic solvents, as shown in the below-mentioned Examples. Although the fiber is a non-biological material, it is superior in the safety and suitable for a biocompatible material. In addition, the fiber of the present invention is suitable as a material of cell culture scaffold, since it has sufficient function as cell culture scaffold.

[0071] Therefore, the present invention also provides a biocompatible material containing the fiber of the present invention (hereinafter to be also simply referred to as "the biocompatible material of the present invention"). In the present invention, the "biocompatible material" refers to a material that does not exert an adverse influence on living organisms and can be utilized as a medical material, a cosmetic material and the like.

[0072] While the kind of the biocompatible material of the present invention is not particularly limited, for example, material of cell culture scaffold, wound coating material, face mask (for cosmetic, hygienic management) and the like can be mentioned. Of these, the material of cell culture scaffold is preferable since the fiber of the present invention has sufficient function as cell culture scaffold.

[0073] The biocompatible material of the present invention can be produced using the fiber of the present invention as one of the starting materials and according to a method known per se or a method analogous thereto.

[Examples]

[0074] While specific examples of the present invention are explained below, the present invention is not limited in any way by the examples.

<Preparation of condensation product solution>

[0075] A hexamethoxymethylmelamine compound (manufactured by Mitsui Cytec Ltd., trade name "Cymel303") (10.0 g) and a tetramethoxymethylbenzoguanamine compound (manufactured by Mitsui Cytec Ltd., trade name "Cymel1123") (10.0 g) were dissolved in ethyl lactate (100 g), p-toluenesulfonic acid (0.5 g) was added, and the mixture was stirred at 120°C for 24 hr to give a condensation product solution 1 containing a condensation product of these triazine compounds (condensation product 1).

[0076] Thereafter, using a hot-water bath at 50°C, the solvent was appropriately evaporated from the condensation product solution 1, and acid and ion in the condensation product solution 1 were further removed by ion exchange by cationic ion exchange resin known per se. The content ratio of the solid content of the condensation product 1 in the condensation product solution 1 after solvent evaporation was 79 wt%. The weight average molecular weight of the condensation product 1 was 16,000 based on polystyrene.

[0077] The measurement of the content ratio of the solid content of the condensation product 1 in the condensation product solution 1, and the measurement of the weight average molecular weight of the condensation product 1 were each performed as follows.

[Measurement of content ratio of solid content of condensation product 1 in condensation product solution 1]

[0078] The content ratio of solid content of condensation product 1 in condensation product solution 1 was measured using Halogen Moisture Analyzer (HR83) manufactured by Mettler Toledo International Inc. as a measuring apparatus and according to the following procedures.

(1) A Whatman (registered trade mark) glass fiber filter (GF/D, diameter 70 mm) is placed on an aluminum sample plate (HA-D90) manufactured by Mettler Toledo International Inc., and the plate is set inside the apparatus.
(2) The apparatus is calibrated to zero gram, and 1.0 g of the condensation product solution 1 is weighed and heated at 120°C.
(3) When the solvent in the condensation product solution 1 is completely evaporated, the measurement automatically ends, and the content ratio (unit: wt%) of the solid content of the condensation product 1 is indicated.

[Measurement of weight average molecular weight of condensation product 1]

[0079] The weight average molecular weight of the condensation product 1 was measured by gel permeation chromatography (GPC). The apparatus used for the measurement and measurement conditions are as follows.
apparatus: TOSOH HLC-8320GPC system
column: Shodex (registered trade mark) KF-803 L, KF-802 and KF-801
column temperature: 40°C
eluent: DMF
flow rate: 0.6 ml/min
detector: RI
standard sample: polystyrene

<Preparation of composition (solution) for producing fiber>

(Example 1)

[0080] A condensation product solution 1 (2.5 g) (solid content of condensation product 1: 2.0 g), p-toluenesulfonic acid (0.10 g) and ethyl lactate (0.44 g) were mixed, and the mixture was stirred by mix rotor VMR-5 (manufactured by AS ONE Corporation) at 80 rpm until dissolution to give the composition for producing a fiber of Example 1. The content ratio of the solid content of the condensation product 1 in the composition for producing a fiber of Example 1 is about 65 wt%.

(Comparative Example 1)

[0081] A condensation product solution 1 (2.5 g) (solid content of condensation product 1: 2.0 g) and ethyl lactate (0.54 g) were mixed, and the mixture was stirred by mix rotor VMR-5 (manufactured by AS ONE Corporation) at 80 rpm until dissolution to give the composition for producing a fiber of Comparative Example 1. The content ratio of the solid content of the condensation product 1 in the composition for producing a fiber of Comparative Example 1 is about 65 wt%.

<Experimental Example 1: heat treatment and solvent resistance test>

[0082] The compositions for producing a fiber of Example 1 and Comparative Example 1 were each spun on aluminum foil by the electrospinning method, each of the obtained fibers was heat treated (heating temperature: 80°C, 160°C, 205°C, heating time: each 10 min), and the fiber form after the heat treatment was confirmed.

[0083] The fiber that underwent the heat treatment was immersed in acetone for 10 seconds, the fiber form was confirmed, and the diameter of the fiber was measured.

[0084] The fiber production by the electrospinning method, confirmation of the fiber form and measurement of the fiber diameter were each performed as follows.

[Production of fiber by electrospinning method]

[0085] Fibers were produced by an electrospinning method by using Esprayer ES-2000 (manufactured by Fuence Co., Ltd.). The composition for producing a fiber was filled in a 1 ml lock-type glass syringe (manufactured by AS ONE Corporation), and a lock-type metallic needle 22G with needle length of 13 mm (manufactured by Musashi engineering) was attached. The distance from the needle tip to the substrate for receiving the fiber (discharge distance) was set to 20 cm. The applied voltage was 25 kV, and the discharge speed was 10 μl/min.

[Confirmation of fiber form]

[0086] The fiber form was confirmed by vapor depositing Pt-Pd on the fiber for 1 min by ion sputter (E-1030, manufactured by Hitachi High-Technologies Corporation), and observing same under a scanning electron microscope (SEM) (S-4800, manufactured by Hitachi High-Technologies Corporation) at magnification x10,000.

[Measurement of fiber diameter]

[0087] The fiber diameter (thickness of fiber) was measured using a scanning electron microscope (SEM), by preserving images at magnification x10,000 and measuring by the attached length measuring tool.

[0088] The results are shown in Table 1 (form after heat treatment), Table 2 (form and fiber diameter after acetone immersion) and Figs. 1 - 14 (SEM photographs before heat treatment, after heat treatment and after acetone immersion).

Table 1

after heat treatment	heating temperature	form
Example 1	80°C	good fiber
	160°C	good fiber
	205°C	good fiber
Comparative Example 1	80°C	net
	160°C	dissolved (film state)
	205°C	dissolved (film state)

Table 2

after acetone immersion	heating temperature	Form	fiber diameter (nm)
Example 1	80°C	good fiber	700 - 1000
	160°C	good fiber	700 - 1000
	205°C	good fiber	700 - 1000
Comparative Example 1	80°C	dissolved	not measured

[0089] The fiber obtained by electrospinning the composition for producing a fiber of Example 1 showed a good form under any condition of heating temperature of 80°C - 205°C. The fiber obtained by electrospinning the composition for producing a fiber of Comparative Example 1 barely maintained its form at a heating temperature of 80°C and became

a solidified net product. At 160°C and 205°C, it could not maintain its form and was dissolved to give a film-like coat (Table 1).

[0090] Furthermore, the fiber obtained by electrospinning the composition for producing a fiber of Example 1 maintained good organic solvent (acetone) resistance under any heating temperature conditions. However, the net solidified product obtained by electrospinning the composition for producing a fiber of Comparative Example 1 and a heat treatment at 80°C was dissolved in acetone and disappeared from the surface of the aluminum foil (Table 2).

<Experimental Example 2: Cell culture evaluation>

[0091] The composition of Example 1 for producing a fiber was spun by an electrospinning method, and cell culture on the obtained fiber was evaluated. In the following, the CO_2 concentration (%) of CO_2 incubator is shown in % by volume of CO_2 in the atmosphere. PBS means phosphate buffered saline (manufactured by Sigma-Aldrich Japan), FBS means fetal bovine serum (manufactured by Biological Industries).

[Preparation of cell]

[0092] As the cell, human embryonic kidney cell line Hek293 (manufactured by DS Pharma Biomedical Co., Ltd.) was used. The medium used for cell culture was EMEM medium (manufactured by Wako Pure Chemical Industries, Ltd.) containing 10%(v/v) FBS and 1% (v/v) NEAA (manufactured by GIBCO). The cells were subjected to standing culture using a diameter 10 cm petri dish (medium 10 mL) for 2 days or longer in a CO_2 incubator at 37°C while maintaining 5% carbon dioxide concentration. The cells were washed with PBS (10 mL), trypsin-EDTA solution (manufactured by Wako Pure Chemical Industries, Ltd.) (1 mL) was added to detach the cells, which were suspended in the above-mentioned medium (10 mL). The suspension was centrifuged (manufactured by TOMY SEIKO Co., Ltd., LC-200, 1000 rpm/for 3 min, room temperature), the supernatant was removed, and the above-mentioned medium was added to prepare a cell suspension.

[Production of fiber of Example 1]

[0093] The composition for producing a fiber of Example 1 was spun by the electrospinning method, spun in the same manner as in Experimental Example 1, blown against a glass substrate for 10 min, and heat-treated at 205°C for 30 min. As the glass substrate, TEMPAX Float (registered trade mark) (Φ12 mm, thickness 1 mm) was used. The obtained fiber was washed with ethanol, air-dried, and the fiber form was confirmed by a scanning electron microscope (SEM). The diameter of the fiber obtained from the composition of Example 1 for producing a fiber was about 1 μm.

[0094] In the following, the glass substrate on which the composition of Example 1 for producing a fiber was spun to form a fiber is conveniently referred to as "the fiber substrate of Example 1".

[Cell culture]

[0095] The fiber substrate of Example 1, and an untreated glass substrate as a control were set in a 24 well flat-bottom microplate (manufactured by Corning Incorporated), and the microplate was immersed in EMEM medium (manufactured by Wako Pure Chemical Industries, Ltd.) containing 1%(v/v) penicillin/streptomycin solution (manufactured by GIBCO) for 15 min. The medium was removed, and a cell suspension of Hek293 (human embryonic kidney cell) prepared to 1.0×10^5 cells/well was added at 1 mL each. Thereafter, the microplate was stood in a CO_2 incubator at 37°C for 24 hr while maintaining 5% carbon dioxide concentration.

[Cell number count using Trypan Blue]

[0096] After cell culture for 24 hr, the supernatant on the fiber substrate of Example 1 and the glass substrate used for the cell culture were removed, and the cells were washed with PBS (2 mL). PBS was removed, and trypsin-EDTA solution (manufactured by Wako Pure Chemical Industries, Ltd.) (300 μL) was added. After standing in a CO_2 incubator at 37°C for 5 min, 1 mL of EMEM medium containing 10%(v/v) FBS was added, and the cells were detached by pipetting. The detached cells were transferred into a 1.5 mL micro test tube (manufactured by Eppendorf), the same amount of Trypan Blue staining solution (manufactured by GIBCO) was added to a part of the culture medium, and the viable cell number was measured by a cell counter (manufactured by Bio-Rad, TC20).

[Cell number count using WST-8]

[0097] After cell culture for 24 hr, the supernatant on the fiber substrate of Example 1 and the glass substrate used

for the cell culture were removed, and the cells were washed with PBS (2 mL). PBS was removed, 1 mL of EMEM medium containing 10%(v/v) FBS and 1%(v/v) NEAA (manufactured by GIBCO) was added, and 100 μL of WST-8 reagent (manufactured by KISHIDA CHEMICAL Co., Ltd.) was added. After standing in a CO_2 incubator at 37°C for 100 min, the reaction solution (100 μL) was transferred to a 96 well flat-bottom microplate, and the absorbance at 450 nm was measured by an absorption spectrometer (manufactured by Molecular Devices, SpectraMax).

[0098] The results of each cell number measurement are shown Table 3 (mean of n=2).

Table 3

	cell number ($\times 10^4$ cells/mL) (Trypan Blue)	absorbance (450 nm) (WST-8)
fiber substrate of Example 1	9.3	0.21
glass substrate	7.6	0.16

[0099] It is clear from the results of Table 3 that cell proliferation occurs on the fiber substrate of Example 1, the fiber produced from the composition of Example 1 for producing a fiber is harmless to living organisms. Furthermore, when cultured on the fiber substrate of Example 1, the cell number increased as compared to that on a glass substrate. Particularly, in the cell number measurement by WST-8, 30% increase in the cell number was found. In the cell number measurement using Trypan Blue, about 20% increase in the cell number was found, even though not all cells were recovered to count the cell number.

[Industrial Applicability]

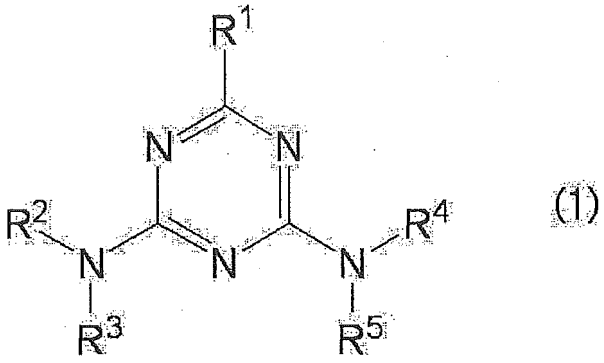
[0100] According to the present invention, a fiber which is superior in safety, can be conveniently produced, and has organic solvent resistance, a starting material composition for producing the fiber and a biocompatible material containing the fiber can be provided.

[0101] This application is based on a patent application No. 2013-264435 filed in Japan (filing date: December 20, 2013), the contents of which are incorporated in full herein.

Claims

1. A fiber produced by spinning a composition comprising

(A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1), and
(B) an acid compound:



(1)

wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl

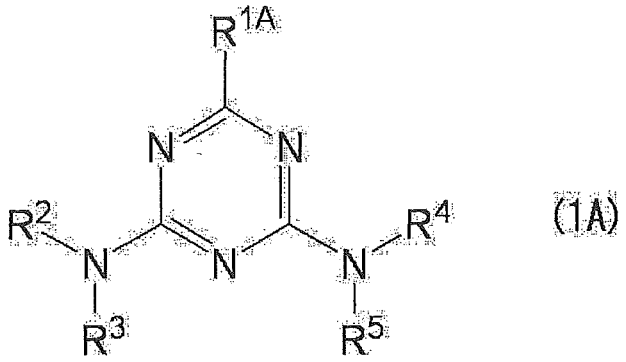
group having 1 - 6 carbon atoms.

2. The fiber according to claim 1, wherein the above-mentioned composition further comprises (C) a solvent.

3. The fiber according to claim 1 or 2, wherein the above-mentioned R^1 is selected from an amino group optionally substituted by a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group or a hydroxymethyl group, a vinyl group, a propenyl group, a butenyl group, a phenyl group and a naphthyl group, and the above-mentioned R^2, R^3, R^4 and R^5 are the same or different and each is selected from a hydrogen atom, a hydroxymethyl group, a methoxymethyl group, an ethoxymethyl group, a propoxymethyl group, a butoxymethyl group, a vinyl group, a propenyl group, a butenyl group, a methyl group, an ethyl group, a propyl group and a butyl group.

4. The fiber according to claim 1 or 2, wherein

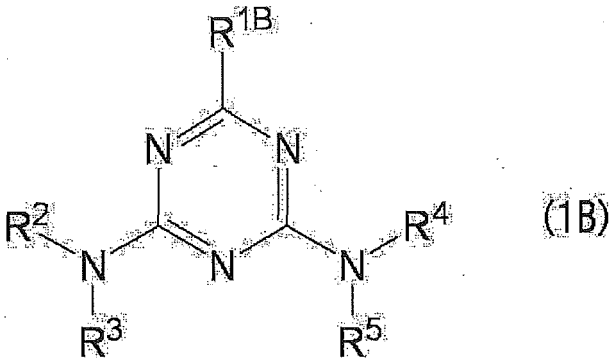
(A) the condensation product is a condensation product obtained by condensing a compound represented by the formula (1A):



(1A)

wherein

R^{1A} is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms, and/or
a compound represented by the formula (1B):



(1B)

wherein

R^{1B} is an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

5. The fiber according to any one of claims 1 to 4, wherein

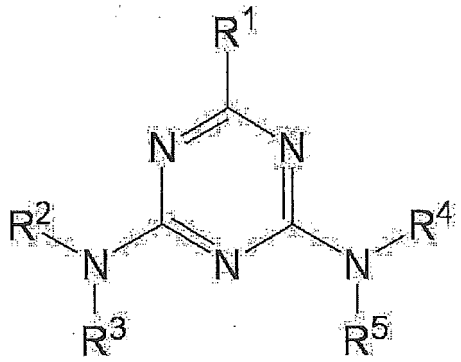
(A) the condensation product has a weight average molecular weight of 1,000 - 1,000,000.

6. The fiber according to any one of claims 1 to 5, wherein the above-mentioned spinning is electrospinning.

7. The fiber according to any one of claims 1 to 6, which is a nanofiber and/or a microfiber.

8. A composition for producing a fiber, comprising

(A) a condensation product obtained by condensing one or more kinds of a compound represented by the formula (1), and
(B) an acid compound:



(1)

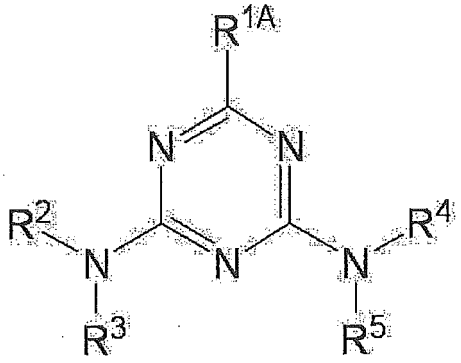
wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

9. The composition according to claim 8, further comprising (C) a solvent.

10. The composition according to claim 8 or 9, wherein

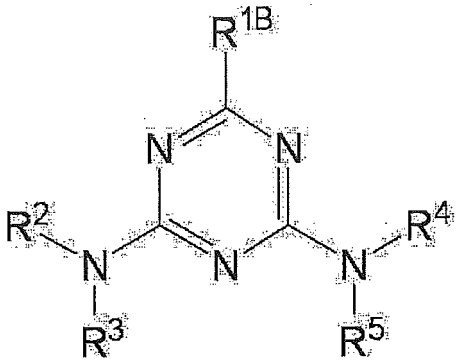
(A) the condensation product is a condensation product obtained by condensing a compound represented by the formula (1A) :



(1A)

wherein

R^{1A} is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms, and/or
a compound represented by the formula (1B):



(1B)

wherein

R^{1B} is an aryl group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

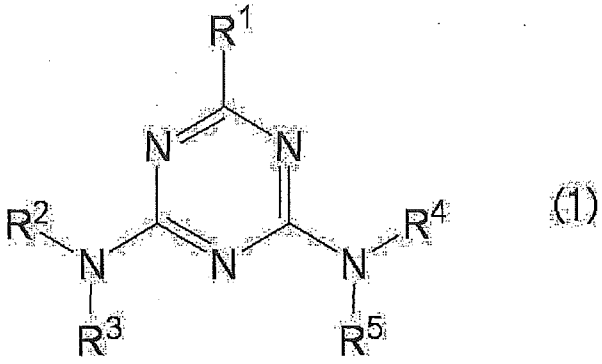
11. The composition according to any one of claims 8 to 10, wherein

(A) the condensation product has a weight average molecular weight of 1,000 - 1,000,000.

12. The composition according to any one of claims 8 to 11, wherein

(A) the condensation product has a solid content of 1 - 90 wt%.

13. A production method of a fiber, comprising (first step) a step of obtaining (A) a condensation product solution by condensing a monomer composition containing one or more kinds of a compound represented by the formula (1), (second step) a step of obtaining a composition for producing a fiber by adding (B) an acid compound and (C) a solvent to the aforementioned (A) the condensation product solution, and (third step) a step of spinning the aforementioned composition for producing a fiber:



(1)

wherein

R^1 is an amino group optionally substituted by an alkoxymethyl group having 2 - 6 carbon atoms or a hydroxymethyl group, an alkyl group having 1 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an aryl

group having 6 - 14 carbon atoms; and
R^2, R^3, R^4 and R^5 are the same or different and each is a hydrogen atom, a hydroxymethyl group, an alkoxymethyl group having 2 - 6 carbon atoms, an alkenyl group having 2 - 6 carbon atoms or an alkyl group having 1 - 6 carbon atoms.

14. The method according to claim 13, further comprising a step of heating the spun fiber at 50 - 300°C.

15. The method according to claim 13 or 14, wherein the above-mentioned spinning is electrospinning.

16. A biocompatible material comprising the fiber according to any one of claims 1 to 7.

Fig. 1

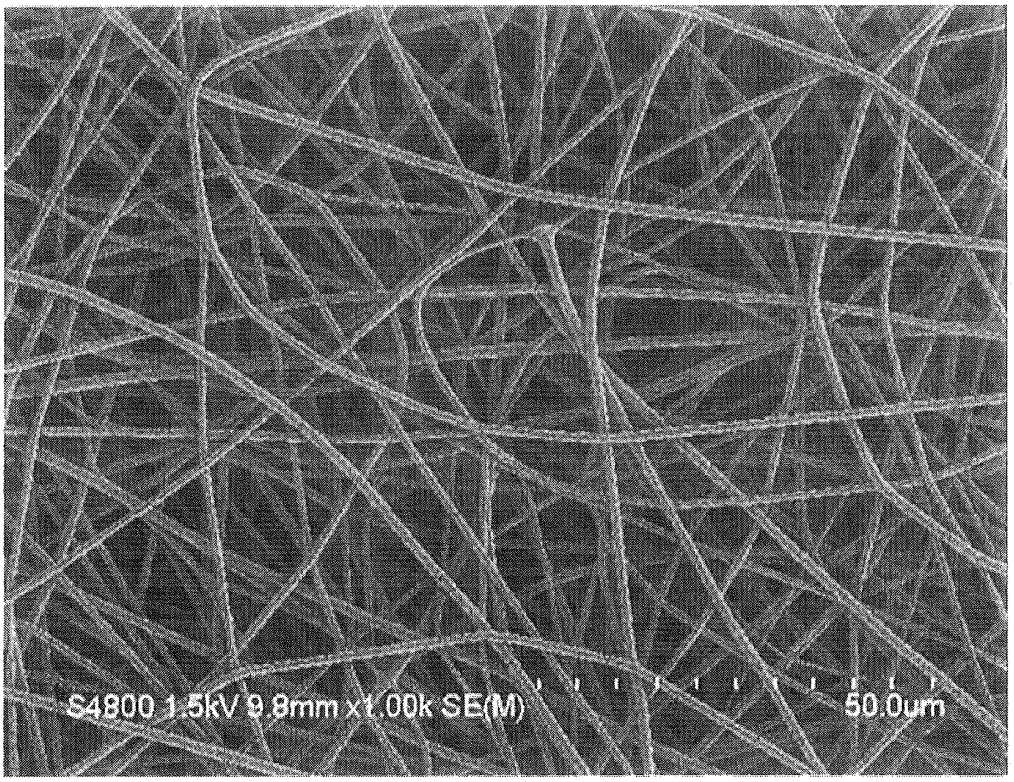

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Fig. 2

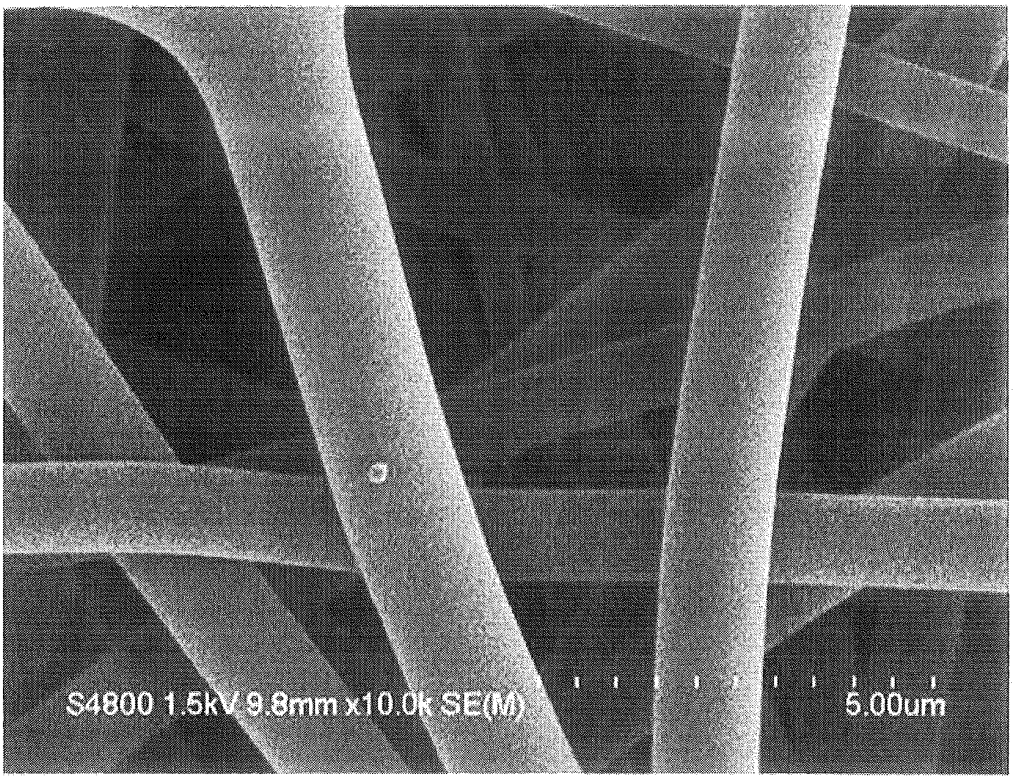
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Fig. 3

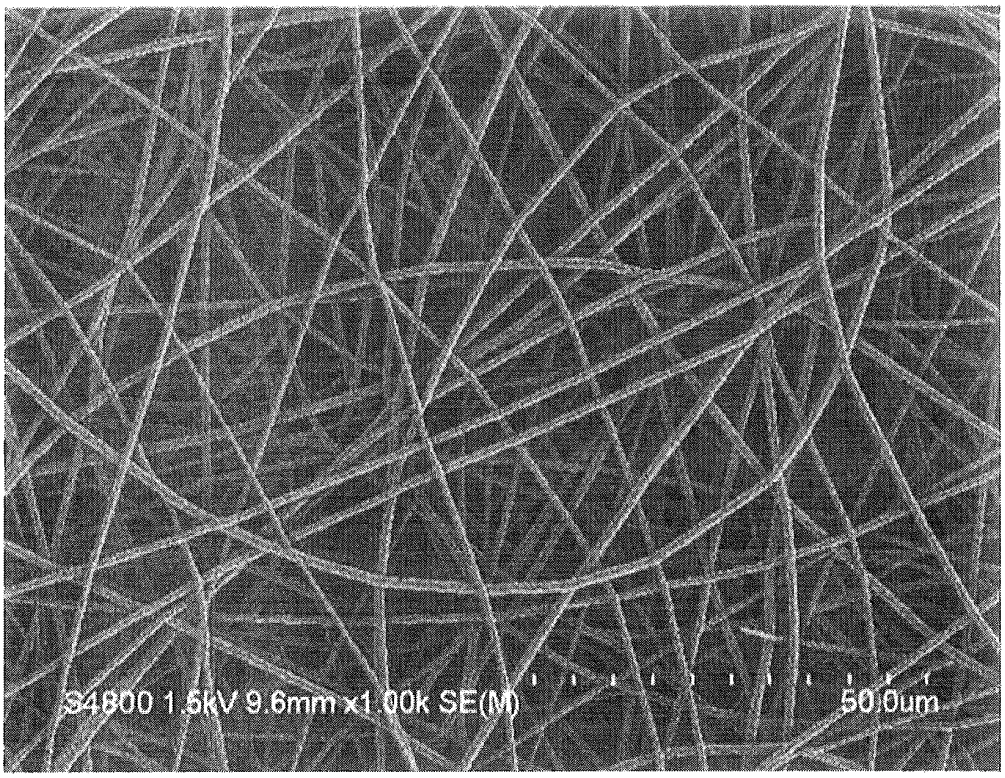
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Fig. 4

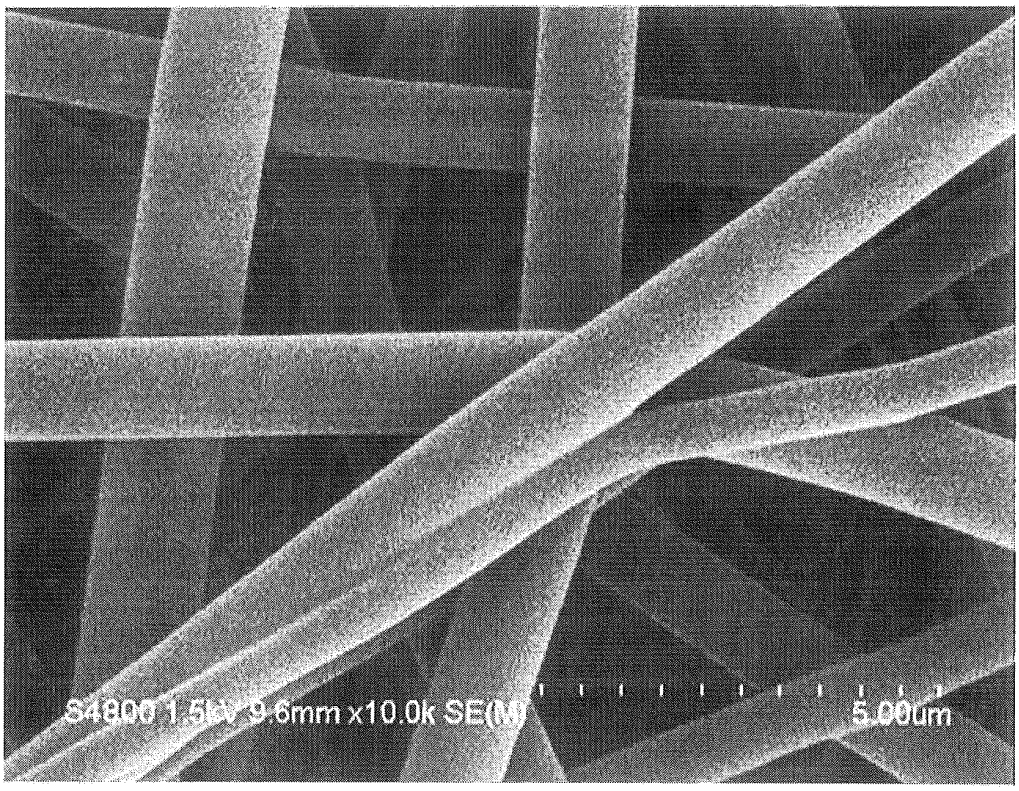
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Fig. 5

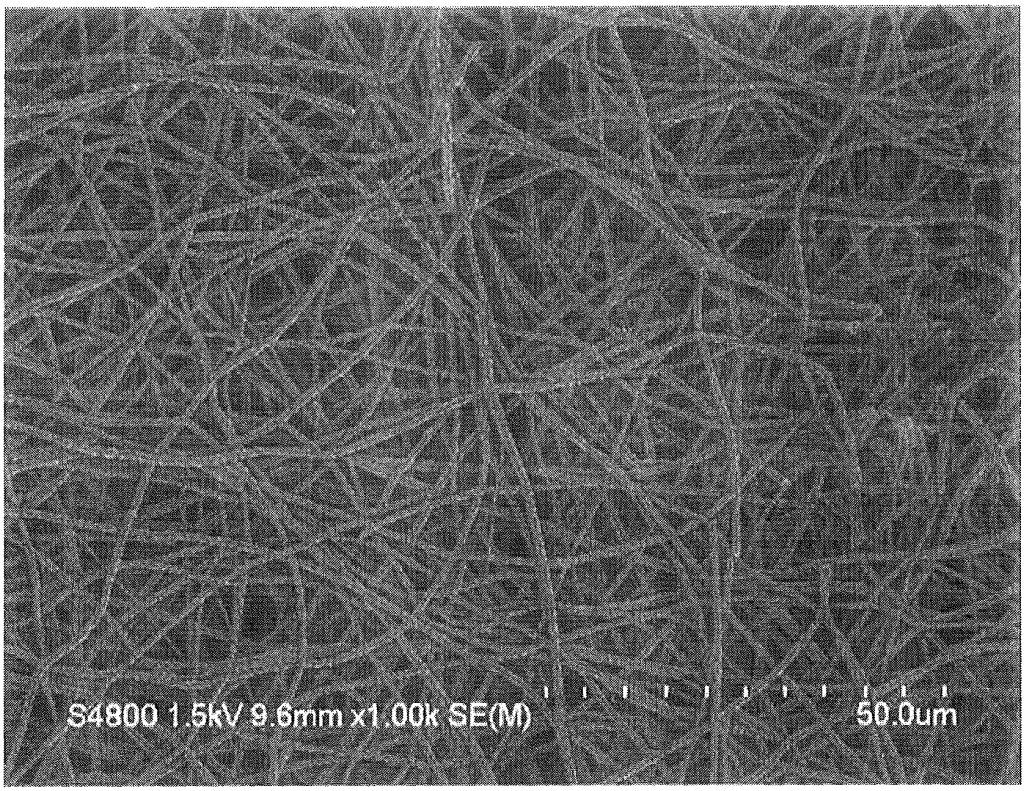
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Fig. 6

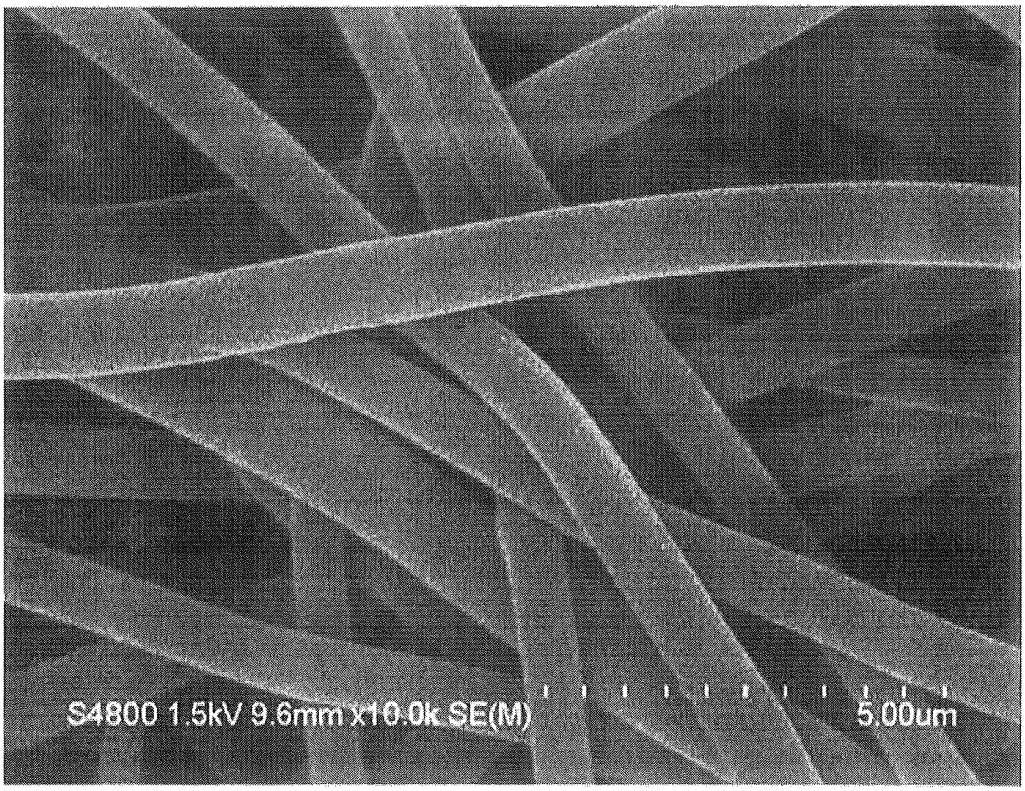
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Fig. 7

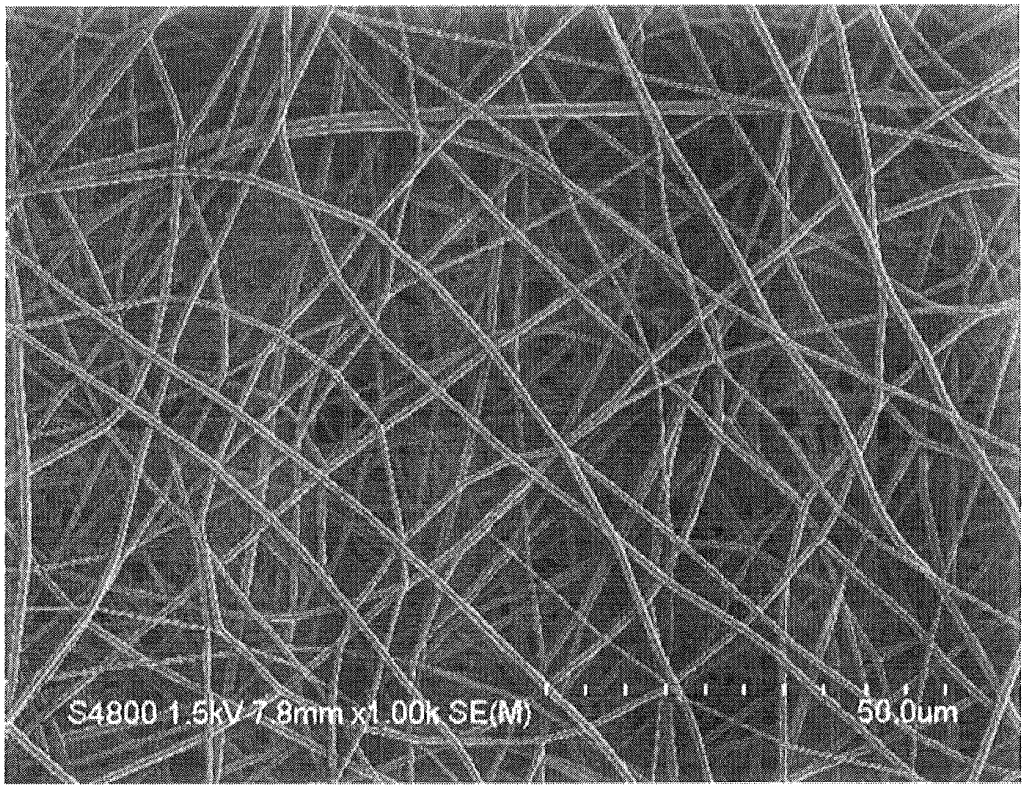
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Fig. 8

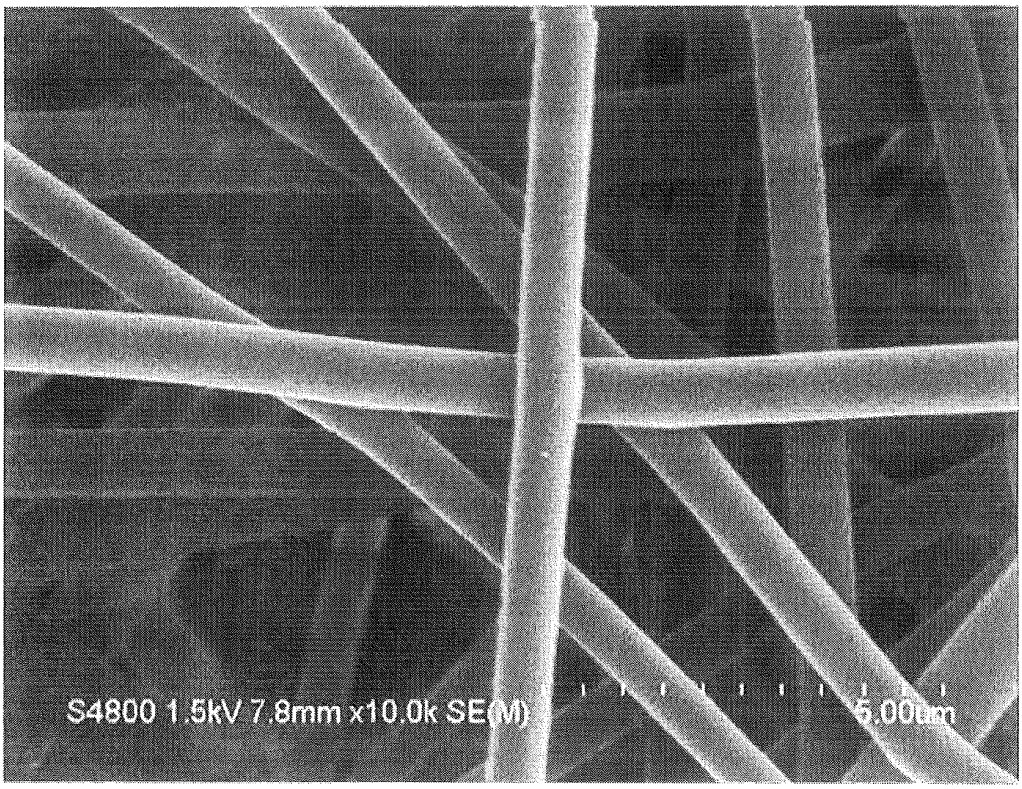
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Fig. 9

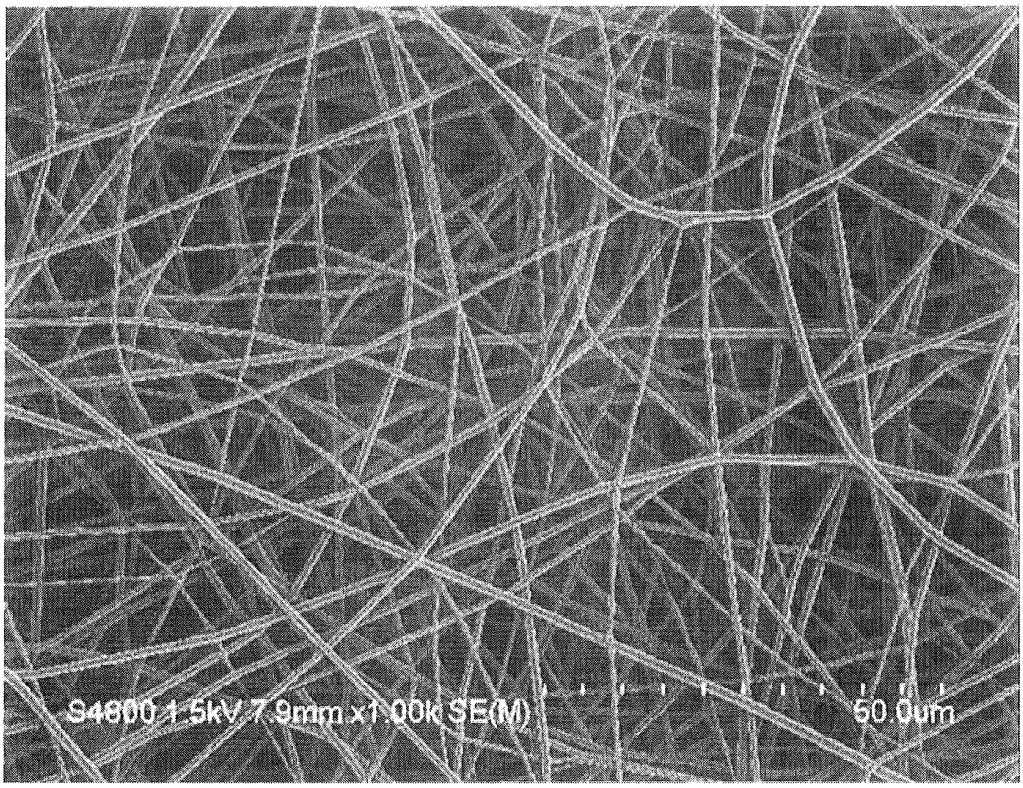
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Fig. 10

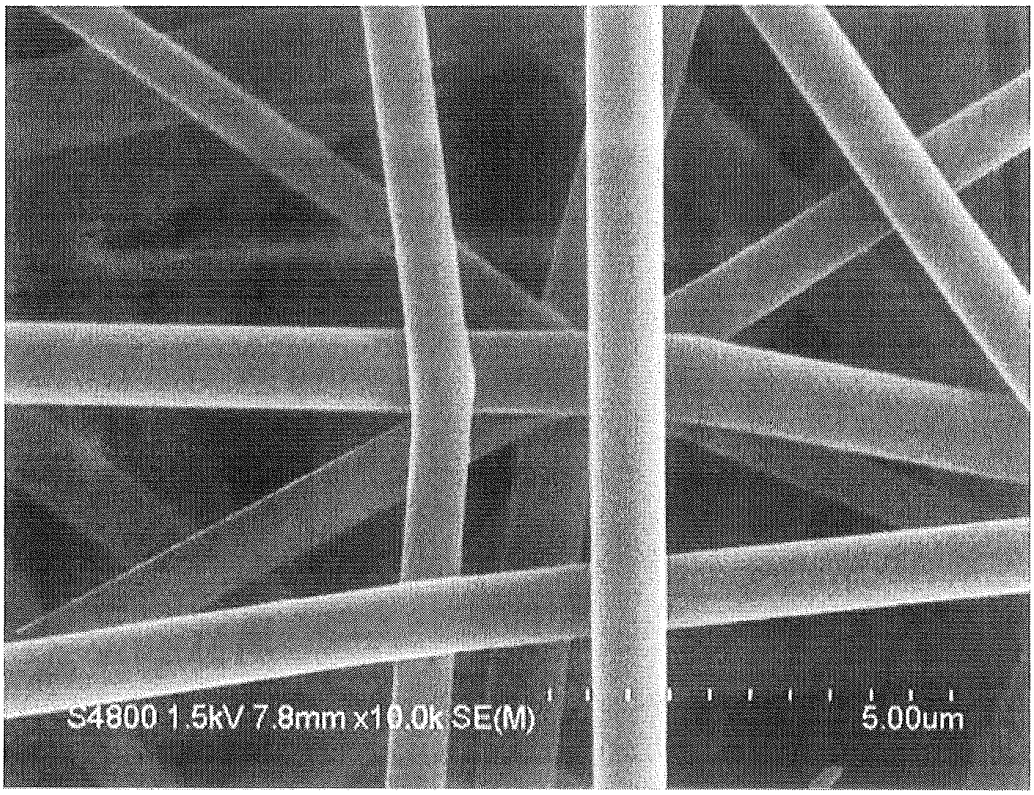
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Fig. 11

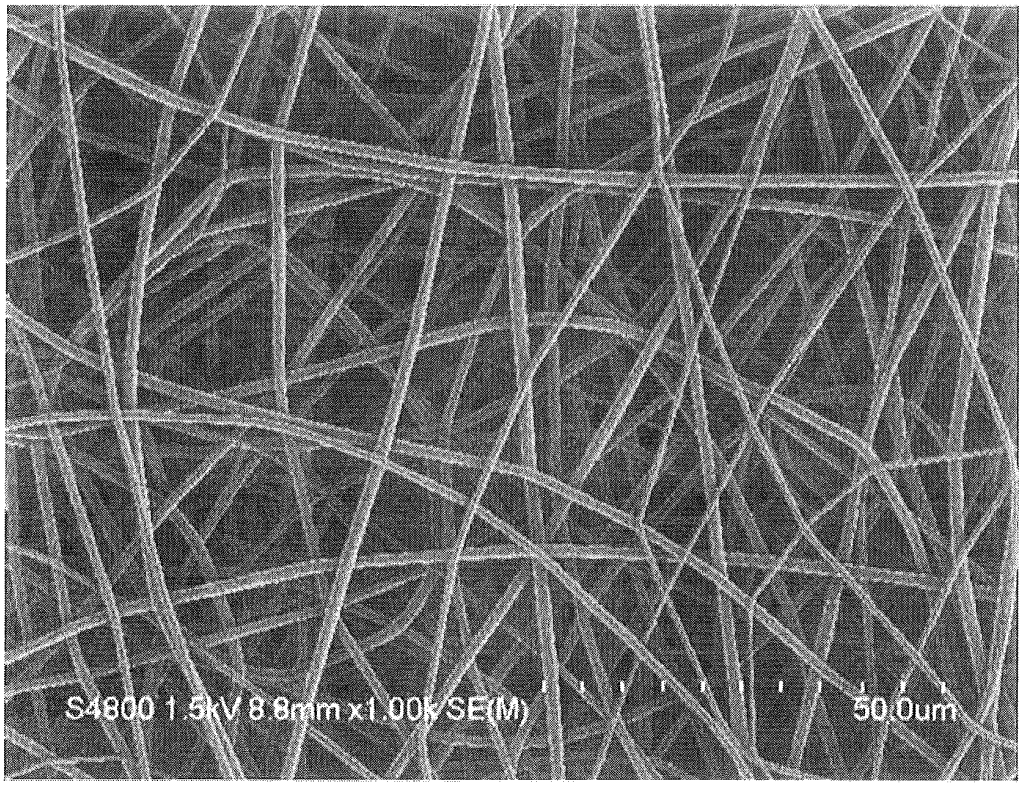
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Fig. 12

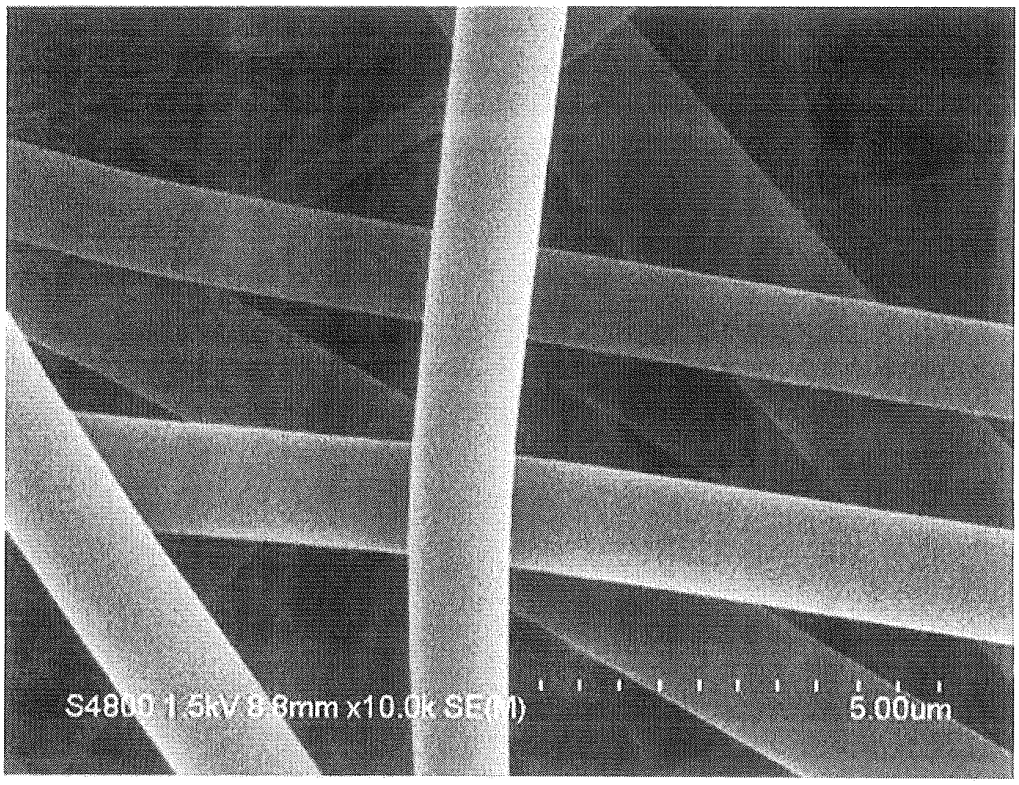
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Fig. 13

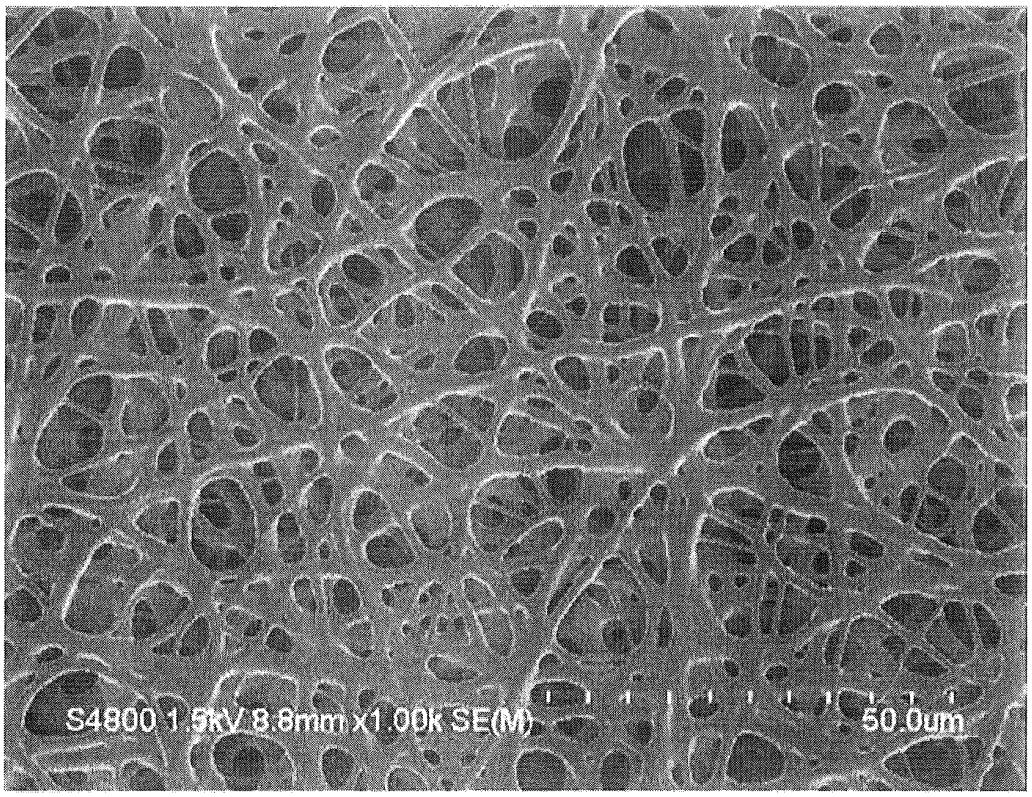
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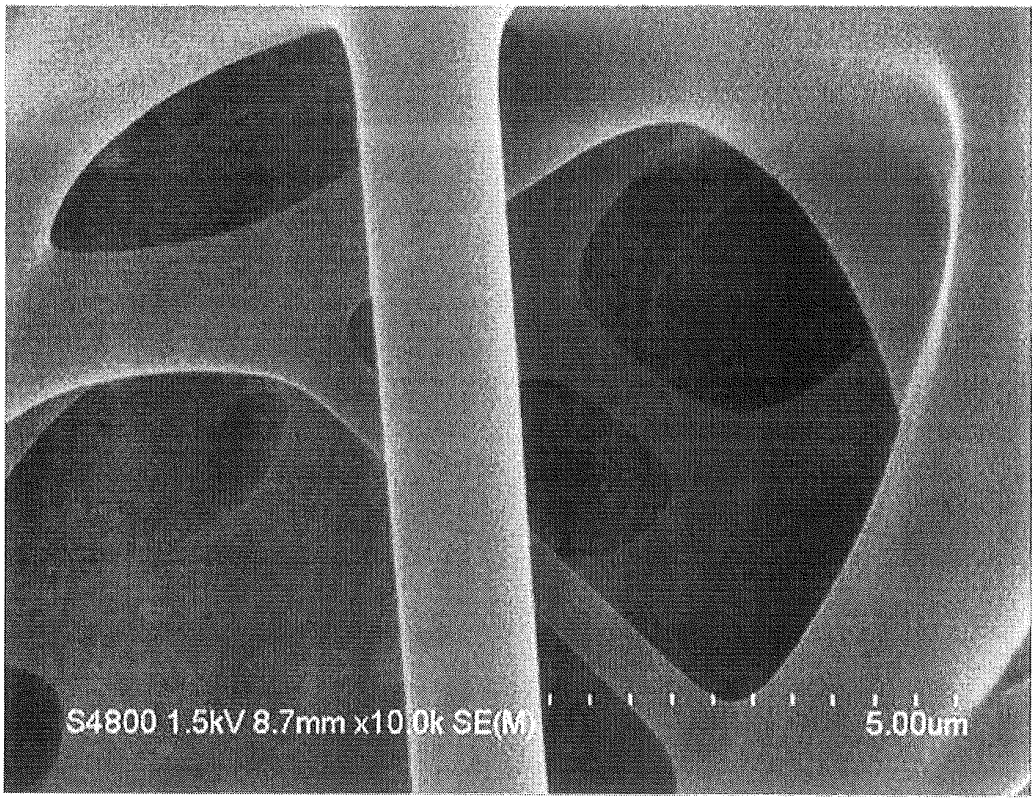
Fig. 14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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/083658

A. CLASSIFICATION OF SUBJECT MATTER
D01F6/76(2006.01)i, *D01D5/04*(2006.01)i, *D04H1/4326*(2012.01)i, *D04H1/728*(2012.01)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)
D01F1/00-6/96, 9/00-9/04, D04H1/00-18/04, D01D1/00-13/02, C08K3/00-13/08, C08L1/00-101/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 53-019425 A (Asahi Chemical Industry Co., Ltd.), 22 February 1978 (22.02.1978), claim 1; page 4, upper left column, line 12 to lower left column, line 20; page 5, upper left column, line 12 to lower left column, line 9; page 6, upper left column, line 14 to upper right column, line 4; page 6, lower left column, lines 3 to 6; page 6, lower right column, lines 19 to 20; page 7, upper right column, lines 4 to 8; examples (Family: none)	1-5,7-14,16 6,15
Y A	CN 102800490 A (Heilongjiang University), 28 November 2012 (28.11.2012), Summary (Family: none)	6,15 1-5,7-14,16

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* Special categories of cited documents:
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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
06 March 2015 (06.03.15)	24 March 2015 (24.03.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/083658

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-504084 A (BASF AG.), 06 April 1999 (06.04.1999), claims & US 5916999 A & EP 0822997 A1 & WO 1996/034133 A1 & CN 1182461 A	1-16
A	JP 2005-534730 A (AMI - Agrolinz Melamine International GmbH), 17 November 2005 (17.11.2005), claims & US 2005/0250896 A1 & EP 1519972 A1 & WO 2003/106524 A1 & CN 1662571 A	1-16
A	JP 49-087819 A (Kuraray Co., Ltd.), 22 August 1974 (22.08.1974), examples & GB 1452629 A & DE 2364091 A & FR 2217440 A & FR 2224562 A & FR 2234393 A	1-16
A	JP 03-231957 A (BASF AG.), 15 October 1991 (15.10.1991), examples & US 5084488 A & US 5162487 A & EP 0408947 A2	1-16
A	JP 2011-030487 A (Nisshin Pharma Inc. et al.), 17 February 2011 (17.02.2011), paragraph [0021] & US 2011/0027844 A1	1-16

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2012067432 A **[0007]**
- JP 2013264435 A **[0101]**

Non-patent literature cited in the description

- *Macromolecular Research,* 2010, vol. 18 (2), 137-143 **[0008]**