[0009]

To achieve the above-described object, in a first aspect, the present disclosure provides an electro-functional member comprising a fiber network and a conductive member. The fiber network comprises a first resin and a second resin, wherein the first resin and the second resin are mutually different in solubility in water such that the fiber network is partially dissolved in water and partially remains when immersed in water. The conductive member is formed on the fiber network. Each of the first resin and the second resin is a polyvinyl alcohol derivative.

[0010]

According to an embodiment of the electro-functional member of the invention, the fiber network includes a first resin and a second resin as the resin, and the first resin and the second resin are mutually different in solubility to water. In a preferred embodiment, the fiber network is configured by stacking a first fiber network including a fiber containing the first resin and a second fiber network including a fiber containing the second resin. In another preferred embodiment, the fiber network includes a fiber containing the first resin and a fiber containing the second resin. In further another preferred embodiment, the fiber network includes a fiber containing the first resin and the second resin.

[0010a]

In a second aspect, the present disclosure provides an electro-functional member comprising: a fiber network comprising a first resin and a second resin, wherein the fiber network is partially dissolved in water and partially remaining when immersed in water; and a conductive member formed on the fiber network, wherein the fiber network is formed by stacking: a first fiber network including a fiber containing

the first resin; and a second fiber network including a fiber containing the second resin, the first resin is a water-soluble resin, and the second resin is a water-insoluble resin.

[0010b]

In a third aspect, the present disclosure provides an electro-functional member comprising: a fiber network comprising a first resin and a second resin, wherein the fiber network is partially dissolved in water and partially remaining when immersed in water; and a conductive member formed on the fiber network, wherein the fiber network includes a fiber containing the first resin and a fiber containing the second resin, the first resin is a water-soluble resin, the second resin is a water-insoluble resin, and the second resin is disposed to cover an entire or a part of a surface of the fiber of the first resin.

[0011]

In the electro-functional member of the invention, an occupancy of the fiber in the fiber network is preferably 20% to 90%, and more preferably the occupancy is 30% to 70%.

[0012]

In a second aspect, the present disclosure provides a method for manufacturing an electro-functional member, the method comprises: a step of forming a first fiber network that includes a fiber containing a water-soluble first resin; a step of forming a second fiber network that includes a fiber containing a second resin that is water-soluble and changes to being

configuration including the resin dissolved in water and the resin that remains when the fiber network is immersed in water, the durability is improved compared with the conventional electro-functional member in which the fiber network of the nanofiber made of polyvinyl alcohol (PVA) is formed and gold is vapor-deposited thereon to form the electrode layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 includes schematic diagrams for describing a first electro-functional member.

Fig. 2 is a schematic diagram for describing a method for manufacturing the first electro-functional member.

Fig. 3 is a diagram illustrating a result of a water solubility test of resins.

Fig. 4 is a diagram indicating a difference of crystallinity depending on a heating temperature.

Fig. 5 includes schematic diagrams for describing a second electro-functional member.

Fig. 6 is a schematic diagram for describing a method for manufacturing the second electro-functional member.

Fig. 7 includes schematic diagrams for describing a third electro-functional member.

Fig. 8 is a schematic diagram for describing a method for manufacturing the third electro-functional member.

Fig. 9 includes diagrams illustrating results of an adhesion evaluation.

Fig. 10 includes photographs illustrating results of the adhesion evaluation.

network 12 and the second fiber network 14 are each formed. For the support body 58, the material and the like are not specifically limited insofar as the support body 58 functions to support the fiber network 10.

[0022]

When the fiber in the fiber network 10 is a flexible material like silicone and polyurethane, the fiber is easily stretched to be broken. In a case of a hard material like polycarbonate, the followability to the skin becomes poor. In view of this, the fiber in the fiber network is preferably a fiber with a Young's modulus in a range of 500 MPa to 8000 MPa, and more preferably a fiber in a range of 1000 MPa to 5000 MPa.

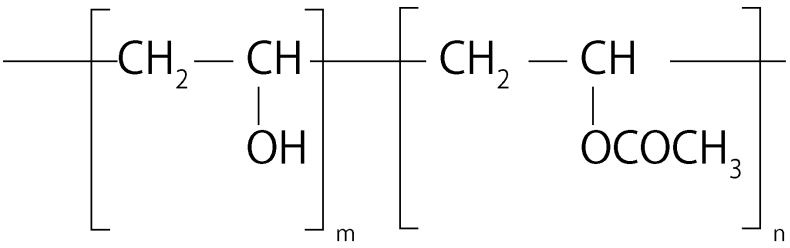
[0023]

As the resin constituting the fiber in the fiber network 10, for example, a polyvinyl alcohol (PVA) derivative with the Young's modulus of about 2000 to 4000 MPa is usable.

[0024]

The first fiber network 12 includes a first resin 32 dissolved in water when immersed in water. The first resin 32 is, for example, a water-soluble resin having a basic structure indicated by a formula (1) below. The first fiber network 12 includes a fiber containing the first resin 32.

[0025]



(1)

[0026]

Here, the first resin 32 only needs to be selected from a saponification degree of 75 or more [mol%] and a viscosity of 5.0 to 65.0 [mm^2/s], and a PVA derivative of the saponification degree of 86.5 to 89.0 [mol%] and the viscosity of 15.3 to 55.7 [mm^2/s] is preferably used. The saponification degree is obtained by $\{m/(m+n)\} \times 100$ [mol%]. The viscosity is measured under a condition of 4% of a water solution at 20℃ according to Japanese Pharmaceutical Excipients (JPE).

[0027]

As the PVA derivative having the above-described properties, EG-18P, 22P, 30P, 40P, and 48P of GOHSENOL EG series by Mitsubishi Chemical Corporation are available.

[0028]

The second fiber network 14 is configured to include a poorly water-soluble second resin 34 that is not dissolved in water and remains when immersed in water. The second resin 34 having the poor water solubility is obtained by heating and pressure-bonding the first resin 32 having the water solubility. For example, the second resin 34 is obtained by a thermocompression bonding of a PVA derivative that has the basic structure indicated by the above-described formula (1), the saponification degree of 86.5 to 89.0 [mol%], and the viscosity of 15.3 to 34.5 [mm^2/s]. As this PVA derivative, the above-described EG-18P, 22P, and 30P are used. While the condition of the thermocompression bonding can be appropriately set as necessary, for example, a condition in which the temperature is in a range of 90 to 180℃ and a press is performed for 1 to 5 minutes can be employed.

[0029]

When the thermocompression bonding is performed to the resin of the PVA derivative, changing the heating temperature and the heating period varies the solubility

to water. For example, a fiber containing a resin subjected to the thermocompression bonding at 180°C for three minutes is less likely to be dissolved in water compared with a fiber subjected to the thermocompression bonding at 120°C for one minute. Here, the point that a water-soluble resin changes to being poorly water-soluble is described in Non-patent Document 2 (Polymer Vol. 39, No. 18 pp. 4295-4302, 1998).

[0030]

Note that, while the poorly water-soluble resin is obtained using a thermocompression bonding apparatus here, the heating method is not limited thereto, and various kinds of apparatuses and methods are usable. The heating and the pressure bonding may be individually performed instead of simultaneously performing the heating and the pressure bonding.

[0031]

The first fiber network 12 and the second fiber network 14 are stacked and bonded by any appropriate means, thereby obtaining the fiber network 10.

[0032]

The fiber network 10 includes the first resin and the second resin mutually different in solubility to water as the resins. The first resin 32 is dissolved in water when immersed in water. Meanwhile, the second resin 34 is not immediately dissolved when immersed in water.

[0033]

Fig. 3 illustrates a result of examining the water solubility when the resin is immersed in water. Here, EG-48P as the first resin and EG-22P as the second resin are both subjected to the thermocompression bonding at 180°C for one minute. As illustrated in Fig. 3, it is seen that the first resin is entirely dissolved in water, and the second resin partially remains. Thus, it is obvious that the solubility is different

between the first resin and the second resin through the thermocompression bonding.

[0034]

Therefore, when the first electro-functional member is immersed in water for a predetermined period, while the first resin 32 constituting the first fiber network 12 is immediately almost entirely dissolved in water, the second resin 34 remains by a predetermined amount. The inventors involved in this application has found that this action improves the wear resistance as described below.

[0035]

While the first fiber network 12 and the second fiber network 14, which is not subjected to the thermocompression bonding, are in an amorphous state, the second fiber network 14 is crystallized when the second fiber network 14 is subjected to the thermocompression bonding. Therefore, when a structural analysis by an X-ray diffraction is performed, for example, an X-ray diffraction angle, a half-value width, and an intensity vary depending on the crystallinity. Thus, the water-soluble resin and the poorly water-soluble resin can be discriminated also by the diffraction profile obtained from the X-ray diffraction.

[0036]

Fig. 4 illustrates a result of examining the difference in crystallinity between EG-22P and EG-48P depending on the heating temperature. In Fig. 4, the horizontal axis indicates the temperature (℃) and the vertical axis indicates the crystallinity (%). The crystallinity is obtained from the structural analysis by the X-ray diffraction. For both of EG-22P and EG-48P, the crystallinity increases with the heating at the temperature of 90℃ or more. Especially, at the temperatures about 90℃ and 180℃, the crystallinity is different between EG-22P and EG-48P, and the crystallinity of EG-22P is higher at both temperatures. Accordingly, for example, when EG-48P is used as

of a fiber network included in the second electro-functional member. Fig. 5(A) is a schematic cross-sectional view taken along a line similar to the line I-I of Fig. 1(A).

[0059]

In the second electro-functional member, a fiber network 110 is configured to include the first resin and the second resin which are water-soluble and different in solubility to water after the thermocompression bonding. The first resin 32 is, for example, EG-40P or EG-48P, and the second resin 34 is EG-18P to 30P.

[0060]

When the thermocompression bonding is performed to the fiber network 110 that includes the fiber containing the first resin 32 and the fiber containing the second resin 34, the solubility to water of the second resin 34 changes, and the second resin 34 becomes to be less likely to be dissolved in water compared with the first resin 32.

[0061]

For example, when EG-48P is used as the first resin 32 and EG-22P is used as the second resin 34, through the thermocompression bonding, while the first resin 32 indicates the water solubility, the second resin 34 indicates the poor water solubility.

[0062]

With reference to Fig. 6, a method for manufacturing the second electro-functional member will be described. The second electro-functional member is manufactured by an electrospinning method using two nozzles.

[0063]

A first solution 156 in a first syringe 152 is sprayed to the support body 58 from a first needle 154. Meanwhile, a second solution 157 in a second syringe 153 is sprayed to the support body 58 from a second needle 155. The first solution 156 is one in which the first resin 32 is dissolved in a solvent. The second solution 157 is one in

With reference to Fig. 8, a method for manufacturing the third electro-functional member will be described. In the third electro-functional member, as a solution, a solution 256 in which both of the first resin 32 and the second resin 34 are dissolved in a solvent is used. Consequently, a fiber containing both of the first resin 32 and the second resin 34 is formed through the needle 54. Because of the similarity to the method for manufacturing the first electro-functional member except that the solution in which the different two types of resins are dissolved is used, the description will be omitted.

[0071]

While the example in which the different two types of resins are used and one resin changes to being poorly water-soluble by the heating and the pressure bonding is described as the configuration of the fiber network in the second electro-functional member and the third electro-functional member described above, the second electro-functional member and the third electro-functional member are not limited to this. It is only necessary to achieve the object of the present invention, and another resin other than the two types of the resins may be included.

[0072]

The fiber network may be configured using one type of the resins. Even when the fiber network is configured using one type of the water-soluble resins, it becomes partially poorly water-soluble due to chemical or physical bonding force and/or cohesive force of its molecules in some cases. Also in this case, as a result, the fiber network that partially dissolved in water and partially remains is obtained.

[0073]

The wear resistance in the case of using one type of resins is indicated in Table 2 below. The measurement was performed similarly to the friction and wear test in the

[0078]

The PVA derivative B has the viscosity between those of the PVA derivative A and the PVA derivative C, and is less likely to be dissolved in water compared with the PVA derivative C while indicating the water-soluble property. Therefore, when immersed in water, some parts are dissolved and other parts remain. Consequently, the wear resistance is excellent.

[0079]

Note that the PVA derivative A has an initial resistance value of 110 Ω or more and the network rate α obtained by the formula (2) described above of less than 0.05, and the PVA derivative B has an initial resistance value of 34 to 45 Ω and the network rate of 0.1 or more.

[0080]

With reference to Fig. 9 and Fig. 10, an adhesion evaluation of the third electro-functional member will be described. Figs. 9(A) and 9(B) are drawings illustrating the results of the adhesion evaluation.

[0081]

In Fig. 9(A), the horizontal axis indicates a spinning time (minute) by an electrospinning apparatus, and the vertical axis indicates a normalized area remaining after a peeling test. In Fig. 9(A), an EG-22P single layer product without heating is indicated by outlined squares, an EG-22P single layer product heated at 130℃ is indicated by outlined triangles, a mixed product of EG-22P and EG-48P without heating is indicated by black squares, and a mixed product of EG-22P and EG-48P heated at 180℃ is indicated by black circles. Note that the vertical axis is normalized by the area after the peeling of the mixed product of EG-22P and EG-48P heated at 180℃ in the case of the spinning time of 20 minutes.

While it is indicated that the adhesion of the heated mixed product is high among the four types of the nanomeshes, especially, the adhesion is the highest in the heated mixed product with the spinning time of 20 minutes.

[0087]

(Fourth Electro-functional member)

With reference to Fig. 11, an electro-functional member according to a fourth embodiment of the invention (hereinafter referred to as a fourth electro-functional member) will be described. Fig. 11 includes schematic diagrams for describing the fourth electro-functional member. Fig. 11(A) is a schematic plan view, Fig. 11(B) is a schematic cross-sectional view taken along a line I-I of Fig. 11(A), and Fig. 11(C) is a schematic diagram illustrating a fiber network included in the fourth electro-functional member.

[0088]

The fourth electro-functional member is configured to include a fiber network 410 and a conductive member 420 formed on the fiber network 410. The fiber network 410 is configured by stacking a first fiber network 412 and a second fiber network 414. The conductive member 420 is disposed on the second fiber network 414 of the fiber network 410.

[0089]

While the first fiber network 412 and the second fiber network 414 are formed by any appropriate conventionally-known method, for example, similarly to the first electro-functional member, the first fiber network 412 and the second fiber network 414 are formed by injecting a resin composition by an electrospinning method.

[0090]

The first fiber network 412 includes a first resin 432 dissolved in water when

immersed in water. The first resin 432 is, for example, a water-soluble resin having a basic structure indicated by the formula (1) described above. As the first resin 432, EG-22P of GOHSENOL EG series by Mitsubishi Chemical Corporation is available.

[0091]

The second fiber network 414 is configured to include a water-insoluble second resin 434 that is not dissolved in water and remains when immersed in water. As the water-insoluble second resin 434, for example, polyurethane is used.

[0092]

The first fiber network 412 and the second fiber network 414 are stacked and bonded by any appropriate means, thereby obtaining the fiber network 410. As another example, by forming the first fiber network 412 by the electrospinning method and subsequently forming the second fiber network 414 by the electrospinning method, the fiber network 410 is obtained.

[0093]

Since the second resin 434 constituting the second fiber network 414 is not dissolved when immersed in water, the second resin 434 almost entirely remains while the first resin 432 constituting the first fiber network 412 is entirely or partially dissolved in water when immersed in water for a predetermined time.

[0094]

The conductive member 420 can be formed using, for example, an evaporation method, a sputtering method, a chemical vapor deposition method, an inkjet method, a screen-printing method, a gravure printing method, and a flexography method. While Fig. 11(A) illustrates an exemplary configuration of two strip shapes as the electrodes including the conductive members 20, an appropriate shape may be employed depending on the usage.

CLAIMS

1. An electro-functional member comprising:

a fiber network comprising a first resin and a second resin, wherein the first resin and the second resin are mutually different in solubility in water such that the fiber network is partially dissolved in water and partially remaining when immersed in water; and

a conductive member formed on the fiber network, wherein each of the first resin and the second resin is a polyvinyl alcohol derivative.

2. The electro-functional member according to claim 1, wherein

the first resin being water-soluble and remaining water-soluble after heating and pressure bonding, and the second resin being water-soluble and changing to being poorly water-soluble after the heating and the pressure bonding.

3. The electro-functional member according to claim 1 or 2, wherein

the fiber network is formed by stacking:

a first fiber network including a fiber containing the first resin; and

a second fiber network including a fiber containing the second resin.

4. The electro-functional member according to claim 1 or 2, wherein

the fiber network includes a fiber containing the first resin and a fiber containing the second resin.

5. The electro-functional member according to claim 1 or 2, wherein

the fiber network includes a fiber containing the first resin and the second

resin.

6. An electro-functional member comprising:

a fiber network comprising a first resin and a second resin, wherein the fiber network is partially dissolved in water and partially remaining when immersed in water; and

a conductive member formed on the fiber network, wherein

the fiber network is formed by stacking:

a first fiber network including a fiber containing the first resin; and

a second fiber network including a fiber containing the second resin,

the first resin is a water-soluble resin, and

the second resin is a water-insoluble resin.

7. The electro-functional member according to claim 6, wherein

the first resin is a polyvinyl alcohol derivative, and

the second resin is polyurethane.

8. An electro-functional member comprising:

a fiber network comprising a first resin and a second resin, wherein the fiber network is partially dissolved in water and partially remaining when immersed in water; and

a conductive member formed on the fiber network, wherein

the fiber network includes a fiber containing the first resin and a fiber containing the second resin,

the first resin is a water-soluble resin,

the second resin is a water-insoluble resin, and

the second resin is disposed to cover an entire or a part of a surface of the fiber of the first resin.

9. The electro-functional member according to claim 8, wherein

the first resin is a polyvinyl alcohol derivative, and

the second resin is polyparaxylene.

10. The electro-functional member according to any one of claims 1 to 9, wherein

an occupancy of the fiber in the fiber network is 20% to 90%.

11. The electro-functional member according to any one of claims 1 to 10, wherein

the occupancy of the fiber in the fiber network is 30% to 70%.

12. A method for manufacturing an electro-functional member, comprising:

a step of forming a first fiber network that includes a fiber containing a water-soluble first resin;

a step of forming a second fiber network that includes a fiber containing a second resin that is water-soluble and changes to being poorly water-soluble after heating and pressure bonding;

a step of changing the second resin to being poorly water-soluble by heating and pressure bonding the second fiber network; and

a step of stacking the first fiber network, the second fiber network, and a conductive member.

13. A method for manufacturing an electro-functional member, comprising:

a step of forming a fiber network that includes a fiber containing a first resin and a fiber containing a second resin, the first resin being water-soluble and remaining water-soluble after heating and pressure bonding, and the second resin being water-soluble and changing to being poorly water-soluble after the heating and the pressure bonding;

a step of heating and pressure bonding the fiber network; and

a step of disposing a conductive member on the fiber network.

14. A method for manufacturing an electro-functional member, comprising:

a step of forming a fiber network that includes a fiber containing a first resin and a second resin, the first resin being water-soluble and remaining water-soluble after heating and pressure bonding, and the second resin being water-soluble and changing to being poorly water-soluble after the heating and the pressure bonding; and

a step of heating and pressure bonding the fiber network and further disposing a conductive member on the fiber network.

15. A method for manufacturing an electro-functional member, comprising:

a step of forming a first fiber network that includes a fiber containing a water-soluble first resin;

a step of forming a second fiber network that includes a fiber containing a water-insoluble second resin; and

a step of stacking the first fiber network, the second fiber network, and a conductive member.

16. A method for manufacturing an electro-functional member, comprising:

a step of forming a fiber network by disposing a water-insoluble second resin on a surface of a fiber that includes a water-soluble first resin; and

a step of stacking a conductive member on the fiber network.

17. A biometric sensor comprising:

one or a plurality of nanomesh electrodes;

a measurement module;

an air permeable electrode disposed between the measurement module and the nanomesh electrode; and

an air permeable member, wherein

the nanomesh electrode, the air permeable electrode, and the air permeable member are disposed in an identical side with respect to the measurement module,

the nanomesh electrode and the air permeable member are attached to contact a measurement target, and

the nanomesh electrode is the electro-functional member according to any one of claims 1 to 11.