CLAIMS

1. A separation membrane element, comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions; wherein in the membrane-sealing portion, at least the surface at a side that is to be in contact with a liquid to be treated is formed of a thermosetting fluororesin.

2. The separation membrane element as defined by claim 1, wherein in the membrane-sealing portion, the surface at a side at which openings of the hollow-fiber-shaped porous separation membranes are located is further formed of a thermosetting fluororesin.

3. A method of producing a separation membrane element comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions, the method comprising the steps of:

(a) bundling end portions of the multiple hollow-fiber-shaped porous separation membranes together to set the end portions in a mold;

(b) casting a thermosetting resin, which is uncured, into the mold;

(c) after the casting, curing the thermosetting resin to seal the end portions of the hollow-fiber-shaped porous separation membranes;

(d) in the thermosetting resin, which has been cured, applying a thermosetting fluororesin, which is uncured, onto at least the surface at a side from which the hollow-fiber-shaped porous separation membranes extend;

(e) after the applying, curing the thermosetting fluororesin; and

(f) removing the thermosetting resin, which has been cured, from the mold and performing a cutting-away operation at the end-portion side of the hollow-fiber-shaped porous separation membranes to form openings of the hollow-fiber-shaped porous separation membranes.

4. The method of producing a separation membrane element as defined by claim 3, wherein after the openings of the hollow-fiber-shaped porous separation membranes are formed, a thermosetting fluororesin is further applied onto the cured thermosetting resin's surface at a side where the openings of the hollow-fiber-shaped porous separa-

tion membranes are located and the applied thermosetting fluororesin is cured.

5. A method of producing a separation membrane element comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions, the method comprising the steps of:

(a) bundling end portions of the multiple hollow-fiber-shaped porous separation membranes together to set the end portions in a mold;

(b) casting a thermosetting fluororesin, which is uncured, into the mold;

(c) after the casting, curing the thermosetting fluororesin to seal the end portions of the hollow-fiber-shaped porous separation membranes; and

(d) removing the thermosetting fluororesin, which has been cured, from the mold and performing a cutting-away operation at the end-portion side of the hollow-fiber-shaped porous separation membranes to form openings of the hollow-fiber-shaped porous separation membranes.

6. The method of producing a separation membrane element as defined by any one of claims 3 to 5, wherein the thermosetting fluororesin is a composite comprising:

(a) a perfluoropolyoxyalkane dicarboxylic acid expressed as the formula $HOOCCF_2[(OCF_2CF_2)p—(OCF_2)q]—OCF_2COOH$ (in the formula, p = 2 to 20, and q = 2 to 20) or its derivative; and

(b) a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dicarboxylic acid or its derivative.

7. The method of producing a separation membrane element as defined by any one of claims 3 to 5, wherein the thermosetting fluororesin comprises:

(a) a perfluoropolyoxyalkane dihydroxy expressed as the formula $HOCF_2—[(OCF_2CF_2)p—(OCF_2)q]—OCF_2OH$ (in the formula, p = 2 to 20, and q = 2 to 20) or its derivative; and

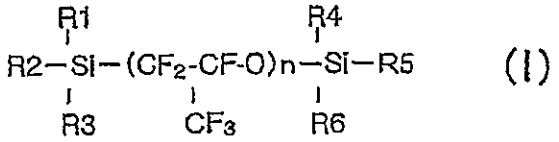
(b) a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dihydroxy or its derivative.

8. The method of producing a separation membrane element as defined by any one of claims 3 to 5, wherein the thermosetting fluororesin comprises a perfluoropolyoxyalkane having a silane functional group at the ends of the formula expressed as $XCF_2—[(OCF_2CF_2)p—(OCF_2)q]—OCF_2X$ (in the formula, X denotes a silane functional group, p

= 2 to 20, and q = 2 to 20).

9. The method of producing a separation membrane element as defined by any one of claims 3 to 5, wherein the thermosetting fluororesin comprises a silicone compound that has perfluoroalkyl ethers and that is expressed by formula (I) below:

[Chemistry 1]



(I)

(in the formula, n = 2 to 50; R1, R2, R3, R4, R5, and R6 are each an alkyl group or an alkenyl group; and at least one group among R1, R2, and R3 and at least one group among R4, R5, and R6 are each an alkenyl group).

10. A separation membrane element, comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions; wherein:

(a) the membrane-sealing portion is formed of a casting resin; and

(b) pores in the hollow-fiber-shaped porous separation membranes are filled with a pore-filling resin at portions where the hollow-fiber-shaped porous separation membranes are in contact with the membrane-sealing portion, so that the casting resin is bonded with the pore-filling resin.

11. The separation membrane element as defined by claim 10, wherein the casting resin and the pore-filling resin are each a cured body of a thermosetting resin.

12. The separation membrane element as defined by claim 10 or 11, wherein the casting resin and the pore-filling resin are the same type of resins.

13. A method of producing a separation membrane element comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions, the method comprising the steps of:

(a) forming resin-impregnated portions by impregnating the end portions of the multiple hollow-fiber-shaped porous separation membranes with a solution of a thermosetting resin "b" and subsequently by drying the solution;

(b) casting a thermosetting resin "a," which is uncured, into a mold and immersing the resin-impregnated portions in the thermosetting resin "a," which has been cast; and

(c) curing the thermosetting resin "a" and the thermosetting resin "b" to seal the end portions of the hollow-fiber-shaped porous separation membranes.

14. The separation membrane element as defined by any one of claims 1, 2, and 10 to 12, wherein the hollow-fiber-shaped porous separation membranes are formed of a fluororesin.

15. A separation membrane module, comprising the separation membrane element as defined by any one of claims 1, 2, 10 to 12 and 14, and a housing that houses the separation membrane element;

wherein the separation membrane element is united with the housing.

CLAIMS

1. A separation membrane element, comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions;
wherein in the membrane-sealing portion, the surface at a side at which openings of the hollow-fiber-shaped porous separation membranes are located is further formed of a thermosetting fluororesin,

wherein the thermosetting fluororesin is any one of composites comprising:

(1) a perfluoropolyoxyalkane dicarboxylic acid or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dicarboxylic acid or its derivative;

(2) a perfluoropolyoxyalkane dihydroxy or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dihydroxy or its derivative;

(3) a perfluoropolyoxyalkane having a silane functional group at the ends; and

(4) a silicone compound that has perfluoroalkyl ethers.

2. A method of producing a separation membrane element comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions, the method comprising the steps of:

bundling end portions of the multiple hollow-fiber-shaped porous separation membranes together to set the end portions in a mold;

casting a thermosetting resin, which is uncured, into the mold;

after the casting, curing the thermosetting resin to seal the end portions of the hollow-fiber-shaped porous separation membranes;

in the thermosetting resin, which has been cured, applying a thermosetting fluororesin, which is uncured, onto at least the surface at a side from which the hollow-fiber-shaped porous separation membranes extend;

after the applying, curing the thermosetting fluororesin; and

removing the thermosetting resin, which has been cured, from the mold and performing a cutting-away operation at the end-portion side of the hollow-fiber-shaped porous separation

membranes to form openings of the hollow-fiber-shaped porous separation membranes,

wherein the thermosetting fluororesin is any one of composites comprising:

(1) a perfluoropolyoxyalkane dicarboxylic acid or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dicarboxylic acid or its derivative;

(2) a perfluoropolyoxyalkane dihydroxy or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dihydroxy or its derivative;

(3) a perfluoropolyoxyalkane having a silane functional group at the ends; and

(4) a silicone compound that has perfluoroalkyl ethers.

3. The method of producing a separation membrane element as defined by claim 2, wherein after the openings of the hollow-fiber-shaped porous separation membranes are formed, a thermosetting fluororesin is further applied onto the cured thermosetting resin's surface at a side where the openings of the hollow-fiber-shaped porous separation membranes are located and the applied thermosetting fluororesin is cured.

4. A method of producing a separation membrane element comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions, the method comprising the steps of:

bundling end portions of the multiple hollow-fiber-shaped porous separation membranes together to set the end portions in a mold;

casting a thermosetting fluororesin, which is uncured, into the mold;

after the casting, curing the thermosetting fluororesin to seal the end portions of the hollow-fiber-shaped porous separation membranes; and

removing the thermosetting fluororesin, which has been cured, from the mold and performing a cutting-away operation at the end-portion side of the hollow-fiber-shaped porous separation membranes to form openings of the hollow-fiber-shaped porous separation membranes,

wherein the thermosetting fluororesin is any one of composites comprising:

(1) a perfluoropolyoxyalkane dicarboxylic acid or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dicarboxylic

acid or its derivative;

(2) a perfluoropolyoxyalkane dihydroxy or its derivative, and a multifunctional compound that condensation-polymerizes with the perfluoropolyoxyalkane dihydroxy or its derivative;

(3) a perfluoropolyoxyalkane having a silane functional group at the ends; and

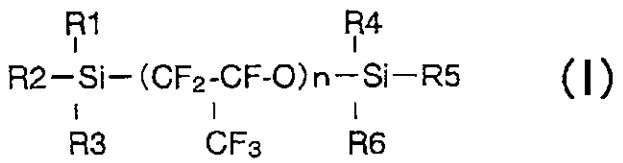
(4) a silicone compound that has perfluoroalkyl ethers.

5. The method of producing a separation membrane element as defined by any one of claims 2 to 4, wherein the perfluoropolyoxyalkane dicarboxylic acid is expressed as the formula $HOOCCF_2[(OCF_2CF_2)p—(OCF_2)q]—OCF_2COOH$ (in the formula, p = 2 to 20, and q = 2 to 20).

6. The method of producing a separation membrane element as defined by any one of claims 2 to 4, wherein the perfluoropolyoxyalkane dihydroxy is expressed as the formula $HOCF_2—[(OCF_2CF_2)p—(OCF_2)q]—OCF_2OH$ (in the formula, p = 2 to 20, and q = 2 to 20).

7. The method of producing a separation membrane element as defined by any one of claims 2 to 4, wherein the perfluoropolyoxyalkane having a silane functional group at the ends is expressed as the formula $XCF_2—[(OCF_2CF_2)p—(OCF_2)q]—OCF_2X$ (in the formula, X denotes a silane functional group, p = 2 to 20, and q = 2 to 20).

8. The method of producing a separation membrane element as defined by any one of claims 2 to 4, wherein the silicone compound that has perfluoroalkyl ethers is expressed by formula (I) below:



(I)

[in the formula, n = 2 to 50; R1, R2, R3, R4, R5, and R6 are each an alkyl group or an alkenyl group; and at least one group among R1, R2, and R3 and at least one group among R4, R5, and R6 are each an alkenyl group].

9. A separation membrane element, comprising a plurality of hollow-fiber-shaped porous

separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions; wherein:

the membrane-sealing portion is formed of a casting resin; and

pores in the hollow-fiber-shaped porous separation membranes are filled with a pore-filling resin at portions where the hollow-fiber-shaped porous separation membranes are in contact with the membrane-sealing portion, so that the casting resin is bonded with the pore-filling resin,

wherein the casting resin has a hardness of more than 40 degrees and the pore-filling resin has a hardness lower than that of the casting resin.

10. A separation membrane element, comprising a plurality of hollow-fiber-shaped porous separation membranes and a membrane-sealing portion that bundles end portions of the hollow-fiber-shaped porous separation membranes together to seal the end portions; wherein:

the membrane-sealing portion is formed of a casting resin; and

pores in the hollow-fiber-shaped porous separation membranes are filled with a pore-filling resin at portions where the hollow-fiber-shaped porous separation membranes are in contact with the membrane-sealing portion, so that the casting resin is bonded with the pore-filling resin,

wherein the casting resin has a hardness of less than 40 degrees and the pore-filling resin has the same hardness as or a hardness lower than that of the casting resin.

11. The separation membrane element as defined by any one of claims 1, 9 and 10, wherein the hollow-fiber-shaped porous separation membranes are formed of a fluororesin.

12. A separation membrane module, comprising the separation membrane element as defined by any one of claims 1, 9 and 10, and a housing that houses the separation membrane element;

wherein the separation membrane element is united with the housing.