Claims

1. A thin film composite membrane wherein a thin selective layer, having incorporated amphiphilic vesicles, is supported by a microporous substrate.

2. The thin film composite membrane of claim 1, wherein said amphiphilic vesicles contain aquaporin water channels.

3. The thin film composite membrane of claims 1 or 2, wherein said selective layer is formed through interfacial polymerization of an aqueous solution of an amine with a solution of an acid chloride in an organic solvent, and wherein amphiphilic aquaporin vesicles are incorporated in said aqueous solution.

4. The thin film composite membrane according to any one of claims 1 to 3, wherein said amine is selected from the group consisting of meta-phenylene diamine, said acid chloride is selected from the group consisting of trimesoylchloride, and said organic solvent is selected from the group consisting of n-hexane, cyclohexane.

5. The thin film composite membrane according to any one of claims 1 to 4, wherein said amphiphilic vesicles are prepared from amphiphilic substances selected from the group consisting of lipids, block copolymers, and mixtures thereof.

6. The thin film composite membrane of claim 5, wherein said lipids are selected from DPhPC, DOPC, and E. coli mixed lipids.

7. The thin composite membrane of claim 6 having incorporated aquaporin water channels further comprising cholesterol in the range of 20 to 40 molar % of the lipid volume.

8. The thin film composite membrane of claim 5, wherein said amphiphilic substance is selected from block copolymers, such as triblock copolymers of the hydrophile-hydrophobe-hydrophile (A-B-A or A-B-C) type or diblock copolymers of the hydrophile-hydrophobe type (A-B).

9. The thin film composite membrane of claim 8, wherein said triblock copolymer is selected fromPMOXA-a-PDMS-b-PMOXA-a, more specifically$PMOXA_{15}$-$PDMS_{67}$-$PMOXA_{15}$, $PMOXA_{15}$-$PDMS_{110}$-$PMOXA_{15}$,$PMOXA_{15}$-$PDMS_{119}$-$PMOXA_{15}$, and $PMOXA_6$-$PDMS_{35}$-$PMOXA_6$ or the triblock copolymer can be a non-ionic detergent such as $EO_{10}PO_{30}EO_{10}$and $EO_{12}PO_{56}EO_{12}$.

10. The thin film composite membrane of claim 8, wherein said diblock copolymer is selected from $EO_{61}PO_{95}$, $EO_{10}Bd_{12}$, $EO_{14}Bd_{35}$, $EO_{23}Bd_{46}$, $EO_{48}DMS_{70}$, and $EO_{15}BO_{16}$.

11. The thin film composite membrane according to any one of the preceding claims, wherein said aquaporin water channel is a functional natural or synthetic aquaporin or aquaglyceroporin water channel, such as aquaporin Z, GlPf, SoPIP2;1, aquaporin 1, aquaporin 2.

12. The thin film composite membrane according to any one of the preceding claims, wherein said aquaporin water channels are present in a protein to amphiphilic substance molar ratio in the range of from about 1:20 to about 1:500, more preferably from about 1:50 to about 1:200.

13. The thin film composite membrane according to any one of the preceding claims, wherein said microporous substrate is selected from the group consisting of polysulfone and polyethersulfone membranes.

14. Use of the thin film composite membrane according to claims 1 to 13 in nanofiltration and in an osmotic process, such as forward osmosis, reverse osmosis and pressure retarded osmosis.

15. A process of preparing the thin film composite membrane according to any one of claims 1 to 13 through interfacial polymerization.

16. The process according to claim 15 comprising the steps of
a. providing a suitable microporous support membrane, such as according to claim 13,
b. applying an aqueous mixture of amine solution and concentrated vesicles solution with or without having incorporated aquaporins to at least one surface of said support membrane to allow soaking of said membrane,
c. applying an acyl chloride solution in an organic solvent to said soaked membrane to obtain formation of a thin polyamide layer having immobilized vesicles.

17. The process according to claim 16, wherein said amine is meta-phenylene diamine and wherein said acyl chloride is trimesoyl chloride.

18. An aqueous amine solution containing vesicles useful as an intermediary product in the process according to claims 15 to 17, wherein said amine is preferably an aromatic amine having two or more amine functionalities, such as meta-phenylene diamine, and said vesicles may be of amphiphilic block copolymer or of amphiphilic lipid.

19. The aqueous amine solution of claim 18 further containing aquaporin, such as AqpZ, and having an additional admixture of cholesterol, such as between about 20 to 40 molar % of the lipid in the vesicles.

Claims

1. A thin film composite membrane wherein a thin selective layer, having incorporated amphiphilic vesicles, is supported by a microporous substrate, wherein said amphiphilic vesicles are prepared from lipids, wherein said lipids are selected from DPhPC(1,2-diphytanoyl-sn-glycero-3-phosphocholine), DOPC(1,2-dioleoyl-*sn*-glycero-3-phosphocholine), and E. coli mixed lipids, wherein said amphiphilic vesicles contain aquaporin water channels and further comprises cholesterol in the range of 20 to 40 molar % of the lipid volume.

2. The thin film composite membrane of claim 1, wherein said selective layer is formed through interfacial polymerization of an aqueous solution of an amine with a solution of an acid chloride in an organic solvent, and wherein amphiphilic aquaporin vesicles are incorporated in said aqueous solution.

3. The thin film composite membrane according to claim 2, wherein said amine is selected from the group consisting of meta-phenylenediamine, said acid chloride is selected from the group consisting of trimesoylchloride, and said organic solvent is selected from the group consisting of n-hexane, cyclohexane.

4. The thin film composite membrane according to any one of claims 1 to 3, wherein said amphiphilic vesicles further comprise block copolymers.

5. The thin film composite membrane of claim 4, wherein said amphiphilic substance is selected from block copolymers, such as triblock copolymers of the hydrophile-hydrophobe-hydrophile (A-B-A or A-B-C) type or diblock copolymers of the hydrophile-hydrophobe type (A-B).

6. The thin film composite membrane of claim 5, wherein said triblock copolymer is selected from PMOXA-a-PDMS-b-PMOXA-a, more specifically $PMOXA_{15}$-$PDMS_{67}$-$PMOXA_{15}$, $PMOXA_{15}$-$PDMS_{110}$-$PMOXA_{15}$, $PMOXA_{15}$-$PDMS_{119}$-$PMOXA_{15}$, and $PMOXA_{6}$-$PDMS_{35}$-$PMOXA_{6}$ or the triblock copolymer can be a non-ionic detergent such as $EO_{10}PO_{30}EO_{10}$ and $EO_{12}PO_{56}EO_{12}$, wherein PMOXA is poly(2-methyloxazoline), PDMS is poly(dimethylsiloxane), EO is ethylene oxide, and PO is propylene oxide.

7. The thin film composite membrane of claim 5, wherein said diblock copolymer is selected from $EO_{61}PO_{95}$, $EO_{10}Bd_{12}$, $EO_{14}Bd_{35}$, $EO_{23}Bd_{46}$, $EO_{48}DMS_{70}$, and $EO_{15}BO_{16}$, wherein EO is ethylene oxide, PO is propylene oxide, Bd is butadiene, DMS is dimethylsiloxane, and BO is butylene oxide.

8. The thin film composite membrane according to any one of the preceding claims, wherein said aquaporin water channel is a functional natural or synthetic aquaporin or aquaglyceroporin water channel, such as aquaporin Z (AqpZ), GlPf, SoPIP2;1, aquaporin 1, aquaporin 2.

9. The thin film composite membrane according to any one of the preceding claims, wherein said aquaporin water channels are present in a protein to amphiphilic substance molar ratio in the range of from about 1:20 to about 1:500, more preferably from about 1:50 to about 1:200.

10. The thin film composite membrane according to any one of the preceding claims, wherein said microporous substrate is selected from the group consisting of polysulfone and polyethersulfone membranes.

11. Use of the thin film composite membrane according to any one of claims 1 to 10 in nanofiltration and in an osmotic process, such as forward osmosis, reverse osmosis and pressure retarded osmosis.

12. A process of preparing the thin film composite membrane according to any one of claims 1 to 10 through interfacial polymerization, comprising the steps of
a. providing a suitable microporous support membrane, such as according to claim 10,
b. applying an aqueous mixture of amine solution and concentrated vesicles solution having incorporated aquaporins to at least one surface of said support membrane to allow soaking of said membrane, wherein said vesicles solution contains aquaporin water channels and further comprises cholesterol in the range of 20 to 40 molar % of the lipid volume,
c. applying an acyl chloride solution in an organic solvent to said soaked membrane to obtain formation of a thin polyamide layer having immobilized vesicles.

13. The process according to claim 12, wherein said amine is meta-phenylenediamine and wherein said acyl chloride is trimesoyl chloride.

14. An aqueous amine solution containing vesicles useful as an intermediary product in the process according to claim 12 or 13, wherein said amine is preferably an aromatic amine having two or more amine functionalities, such as meta-phenylenediamine, and said vesicles may be of amphiphilic lipid, wherein said aqueous amine solution further containing aquaporin, such as AqpZ, and having an additional admixture of cholesterol, such as between about 20 to 40 molar % of the lipid in the vesicles.