CLAIMS

1. A method of fabricating a membrane comprising proteoliposomes having protein water channels, the method comprising:

providing a porous substrate;

depositing a solution on the porous substrate, wherein the solution comprises the proteoliposomes; and

contacting the porous substrate with an aqueous monomer solution and an organic monomer solution to form a selective layer on the porous substrate embedding the proteoliposomes, wherein the solution is deposited prior to contacting the porous substrate with the aqueous monomer solution and the organic monomer solution.

2. The method of claim 1, wherein depositing the solution comprises moving the porous substrate unidirectionally under a discharge module which deposits the solution on the porous substrate.

3. The method of claim 1 or 2, wherein the porous substrate is formed of a polymer comprising polyetherimide, cellulose ester, polyacrylonitrile, polysulfone, polyethersulfone, polyvinylidene fluoride, cellulose acetate, or a derivative thereof.

4. The method of claim 1 or 2, wherein the porous substrate is formed of an inorganic material comprising carbon, titanium, aluminum oxide, or ceramic.

5. The method of any one of claims 1 to 4, wherein depositing the solution comprises spraying the solution to cover a surface of the porous substrate with the proteoliposomes.

6. The method of any one of claims 1 to 5, wherein the solution comprises the proteoliposomes in a concentration ranging from 1 mg/ml to 100 mg/ml.

7. The method of any one of claims 1 to 6, wherein the solution further comprises a (i) surfactant and/or (ii) a salt, wherein the surfactant comprises n-octyl-P-D-glucoside, n-octanoylsucrose, n-nonanoylsucrose, n-decanoylsucrose, n-undecyl-P-D-glucopyranoside, n-undecyl-P-D-thioglucoside, n-undecyl-β-O-thiomaltoside, n-undecyl-P-D-thiomaltopyranoside, n-undecyl-β-O-thioglucopyranoside, or a combination thereof, wherein the salt comprises sodium chloride, magnesium chloride, monosodium phosphate, or a combination thereof.

8. The method of claim 7, wherein the surfactant is present in the solution at a concentration ranging from 0.0002 wt% to 2 wt%.

9. The method of claim 7 or 8, wherein the salt is present in the solution at a concentration ranging from 0.001 M to 0.5 M.

10. The method of any one of claims 1 to 9, wherein contacting the porous substrate with the aqueous monomer solution and the organic monomer solution comprises soaking the porous substrate in the aqueous monomer solution prior to soaking the porous substrate in the organic monomer solution.

11. The method of any one of claims 1 to 10, wherein contacting the porous substrate with an aqueous monomer solution and an organic monomer solution comprises

(i) dissolving a polyfunctional amine in an aqueous solution to form the aqueous monomer solution; and

(ii) dissolving a polyfunctional acyl chloride or a polyfunctional sulfonyl chloride in an organic solvent to form the organic monomer solution.

12. The method of claim 11, wherein the polyfunctional amine comprises o-phenylenediamine, m-phenylenediamine, or piperazine.

13. The method of claim 11 or 12, wherein the polyfunctional acyl chloride comprises trimesoyl chloride, isophthaloyl chloride (IPC), 5-isocyanato-isophthaloyl chloride (ICIC), or 5-chloroformyloxy-isophthaloyl chloride (CFIC).

14. The method of claim 11 or 12, wherein the polyfunctional sulfonyl chloride comprises 1,5-naphthalene-bisulfonyl chloride, 1,3-dimethyl 2-imidazolidinone, or 1,3-dioxo-1,3-dihydroisobenzofuran-5-sulfonyl chloride.

15. The method of any one of claims 1 to 14, further comprising drying the porous substrate having the solution deposited thereon before contacting the porous substrate with the aqueous monomer solution and the organic monomer solution.

16. A method of fabricating a membrane comprising proteoliposomes having protein water channels, the method comprising:

providing a porous substrate;

contacting the porous substrate with an aqueous monomer solution;

depositing a solution on the porous substrate, wherein the solution comprises the proteoliposomes; and

contacting the porous substrate with an organic monomer solution to form a selective layer on the porous substrate embedding the proteoliposomes, wherein the solution is deposited after contacting the porous substrate with the aqueous monomer solution but prior to contacting the porous substrate with the organic monomer solution,

wherein depositing the solution comprises spraying the solution to cover a surface of the porous substrate with the proteoliposomes.

17. The method of claim 16, wherein depositing the solution comprises moving the porous substrate unidirectionally under a discharge module which deposits the solution on the porous substrate.

18. The method of claim 16 or 17, wherein the porous substrate is formed of a polymer comprising polyetherimide, cellulose ester, polyacrylonitrile, polysulfone, polyethersulfone, polyvinylidene fluoride, cellulose acetate, or a derivative thereof.

19. The method of claim 16 or 17, wherein the porous substrate is formed of an inorganic material comprising carbon, titanium, aluminum oxide, or ceramic.

20. The method of any one of claims 16 to 19, wherein the solution comprises the proteoliposomes in a concentration ranging from 1 mg/ml to 100 mg/ml.

21. The method of any one of claims 16 to 20, wherein the solution further comprises a (i) surfactant and/or (ii) a salt, wherein the surfactant comprises n-octyl-P-D-glucoside, n-octanoylsucrose, n-nonanoylsucrose, n-decanoylsucrose, n-undecyl-P-D-glucopyranoside, n-undecyl-P-D-thioglucoside, n-undecyl-β-O-thiomaltoside, n-undecyl-P-D-thiomaltopyranoside, n-undecyl-β-O-thioglucopyranoside, or a combination thereof, wherein the salt comprises sodium chloride, magnesium chloride, monosodium phosphate, or a combination thereof.

22. The method of claim 21, wherein the surfactant is present in the solution at a concentration ranging from 0.0002 wt% to 2 wt%.

23. The method of claim 21 or 22, wherein the salt is present in the solution at a concentration ranging from 0.001 M to 0.5 M.

24. The method of any one of claims 16 to 23, wherein contacting the porous substrate with the aqueous monomer solution comprises dissolving a polyfunctional amine in an aqueous solution to form the aqueous monomer solution.

25. The method of claim 24, wherein the polyfunctional amine comprises o-phenylenediamine, m-phenylenediamine, or piperazine.

26. The method of any one of claims 16 to 25, wherein contacting the porous substrate with the organic monomer solution comprises dissolving a polyfunctional acyl chloride or a polyfunctional sulfonyl chloride in an organic solvent to form the organic monomer solution.

27. The method of claim 26, wherein the polyfunctional acyl chloride comprises trimesoyl chloride, isophthaloyl chloride (IPC), 5-isocyanato-isophthaloyl chloride (ICIC), or 5-chloroformyloxy-isophthaloyl chloride (CFIC).

28. The method of claim 26, wherein the polyfunctional sulfonyl chloride comprises 1,5-naphthalene-bisulfonyl chloride, 1,3-dimethyl 2-imidazolidinone, or 1,3-dioxo-1,3-dihydroisobenzofuran-5-sulfonyl chloride.

29. The method of any one of claims 16 to 28, further comprising drying the porous substrate having the solution deposited thereon before contacting the porous substrate with the organic monomer solution.

30. A membrane comprising:

a porous substrate comprising proteoliposomes deposited thereon, wherein the proteoliposomes have protein water channels incorporated therein; and

a selective layer formed on the porous substrate, wherein the proteoliposomes are embedded in the selective layer,

wherein the proteoliposomes deposited on the porous substrate are present in an amount ranging from 0.8 mg/m^2 to 1000 mg/m^2.

31. The membrane of claim 30, wherein the porous substrate is formed of a polymer comprising polyetherimide, cellulose ester, polyacrylonitrile, polysulfone, polyethersulfone, polyvinylidene fluoride, cellulose acetate, or a derivative thereof.

32. The membrane of claim 30, wherein the porous substrate is formed of an inorganic material comprising carbon, titanium, aluminum oxide, or ceramic.

33. The membrane of any one of claims 30 to 32, wherein each of the proteoliposomes comprises a ratio of protein water channels to lipids ranging from 1:100 to 1:1000.

34. The membrane of any one of claims 30 to 33, wherein the proteoliposomes have an average diameter ranging from 50 nm to 400 nm.

35. The membrane of any one of claims 30 to 34, wherein the protein water channels comprise aquaporins, aquaglyceroporins, ion channel proteins, or analogues thereof.

36. The membrane of any one of claims 30 to 35, wherein the selective layer has a thickness ranging from 50 nm to 1500 nm.

37. The membrane of any one of claims 30 to 36, wherein the selective layer comprises a polyamide.

38. The membrane of any one of claims 30 to 37, wherein the membrane is a flat sheet membrane or a spiral wound membrane.