WHAT IS CLAIMED IS:

1. A method of manufacturing a multilayer polymeric and mixed matrix membrane comprising:

providing a support layer;

casting a hydrophilic layer on a surface of the support layer;

casting a hydrophobic layer on the hydrophilic layer; and

allowing the layers to form a multilayer polymeric and mixed matrix membrane.

2. The method according to claim 1, further comprising immersing said multilayer mixed matrix membrane in water to allow for gelation.

3. The method according to claim 1, wherein the hydrophobic layer comprises a hydrophobic polymer selected from the group consisting of polypropylene, polytetraflouroethylene, and polyvinylidene fluoride.

4. The method according to claim 3, wherein the hydrophobic layer further comprises a fluorinated hydrophobic surface modifying macromolecule selected from a group consisting of poly(urethane propylene glycol), poly(urethane diphenylsulfone), and poly(urea dimethylsiloxane urethane).

5. The method according to claim 1, wherein the hydrophilic layer comprises a hydrophilic polymer selected from the group consisting of polysulfone, polyether sulfone, polyetherimide, polyamide, cellulose acetate, and thermoplastics.

6. The method according to claim 5, wherein the hydrophilic layer further comprises an inorganic nanoparticle having high thermal conductivity selected from the group consisting of copper oxide, boron nitride, aluminum nitride, aluminum, iron, silicon carbide, and a metal or metal oxides.

7. The method according to claim 5, wherein the hydrophilic layer further comprises a non-solvent additive selected from a group consisting of γ-butyrolactone and ethanol.

8. The method according to claim 1, further comprising a step of maximizing the porosity of the hydrophobic layer.

9. The method according to claim 1, further comprising a step of minimizing the thickness of the hydrophobic layer.

10. The method according to claim 1, further comprising a step of maximizing the porosity of the hydrophilic layer.

11. The method according to claim 1, further comprising a step of maximizing the thickness of the hydrophilic layer.

12. The method according to claim 1, further comprising a step of maximizing the thermal conductivity of the hydrophilic layer.

13. The method according to claim 1, further comprising:

a step of using a hydrophilic polymer dope solution comprising a host hydrophilic polymer to cast the hydrophilic layer; and

a step of using a hydrophobic polymer dope solution comprising a hydrophobic polymer to cast the hydrophobic layer,

wherein the hydrophobic polymer dope solution has a lower viscosity and density than the hydrophilic polymer dope solution on the previously cast hydrophilic film.

14. A method of manufacturing a hollow fiber composite polymeric and matrix membrane comprising:

providing a first solution having a hydrophilic polymer;

providing a second solution having a hydrophobic polymer; and

extruding the first and second solutions to form a multilayer hollow fiber composite polymeric and matrix membrane.

15. The method according to claim 14, wherein the first solution in extruded as an outer layer.

16. The method according to claim 14, wherein the first solution in extruded as an inner layer.

17. The method according to claim 14, wherein the second solution comprises a hydrophobic polymer selected from the group consisting of polypropylene, polytetraflouroethylene, and polyvinylidene fluoride.

18. The method according to claim 17, wherein the second solution further comprises a fluorinated hydrophobic surface modifying macromolecule selected from a group consisting of poly(urethane propylene glycol), poly(urethane diphenylsulfone), and poly(urea dimethylsiloxane urethane).

19. The method according to claim 14, wherein the first solution comprises a hydrophilic polymer selected from the group consisting of polysulfone, polyether sulfone, polyetherimide, polyamide, cellulose acetate, and thermoplastics.

20. The method according to claim 19, wherein the first solution further comprises an inorganic nanoparticle having high thermal conductivity selected from the group consisting of copper oxide, boron nitride, aluminum nitride, aluminum, iron, silicon carbide, and a metal.

21. The method according to claim 19, wherein the first solution further comprises a non-solvent additive selected from a group consisting of γ-butyrolactone and ethanol.

22. The method according to claim 14, further comprising a step of maximizing the porosity of the hydrophobic layer.

23. The method according to claim 14, further comprising a step of minimizing the thickness of the hydrophobic layer.

24. The method according to claim 14, further comprising a step of maximizing the porosity of the hydrophilic layer.

25. The method according to claim 14, further comprising a step of maximizing the thickness of the hydrophilic layer.

26. The method according to claim 14, further comprising a step of maximizing the thermal conductivity of the hydrophilic layer.

27. The method according the claim 14, further comprising a step of producing void-free fibres to avoid mechanical weaknesses.

28. A plate-and-frame membrane module for direct contact membrane distillation using a multilayer polymeric or mixed matrix membrane, the plate-and-frame membrane module comprising:

a feed inlet capable of distributing process solution throughout the membrane module;

a permeate inlet capable of distributing process solution throughout the membrane module;

a tortuous promoter comprising multiple flow channels;

a feed outlet; and

a permeate outlet.

29. The membrane module of claim 28, wherein the matrix membrane is configured as a hollow fibre membrane or a flat sheet membrane.

30. The membrane module according to claim 28, wherein the flow regimes of the feed and permeate flow solutions during direct contact membrane distillation is a turbulent regime.

31. The membrane module according to claim 28, wherein the feed and permeate flow channels are configured such that there is no liquid stagnation in the flow channels.

32. The membrane module according to claim 28, configured for direct contact membrane distillation wherein seawater desalination flux is up to 142 kg/m^2h.

33. The membrane module according to claim 28, configured for direct contact membrane distillation such that it maximizes the Reynolds number.

34. The membrane module according to claim 28, configured for direct contact membrane distillation such that it improves flow hydrodynamics.

35. The membrane module according to claim 28, configured for direct contact membrane distillation such that it maximizes heat transfer coefficients and minimizes heat and mass transfer resistances in boundary layers.

36. The membrane module according to claim 28, configured for direct contact membrane distillation such that it maximizes temperature polarizing coefficient until it reaches unity.

37. An array comprising multiple plate-and-frame membrane modules according to claim 28.

CLAIMS

1. A method of manufacturing a multilayer polymeric and mixed matrix membrane comprising:

providing a support layer;

casting a hydrophilic layer on a surface of the support layer;

casting a hydrophobic layer on the hydrophilic layer; and

allowing both hydrophilic and hydrophobic layers to form a multilayer polymeric and mixed matrix membrane via immersion into water (phase inversion method);

wherein the hydrophobic layer comprises a hydrophobic polymer selected from the group consisting of polypropylene, polytetraflouroethylene, and polyvinylidene fluoride wherein the hydrophobic layer further comprises a fluorinated hydrophobic surface modifying macro-molecule selected from a group consisting of polyurethane propylene glycol), poly(urethane diphenylsulfone), and poly(urea dimethyl-siloxane urethane).

2. The method according to claim 1, further comprising immersing said multilayer mixed matrix membrane in water to allow for gelation.

3. The method according to claim 1, wherein the hydrophilic layer comprises a hydrophilic polymer selected from the group consisting of polysulfone, polyether sulfone, polyether-imide, polyamide, cellulose acetate, and hydrophilic thermoplastics.

4. The method according to claim 3, wherein the hydrophilic layer further comprises an inorganic nanoparticle having high thermal conductivity selected from the group consisting of, boron nitride, aluminium nitride, silicon carbide, and a metal (such as copper or aluminium or iron) or metal oxides (such as copper oxide).

5. The method according to claim 3, wherein the hydrophilic layer further comprises a non-solvent additive selected from: a group consisting of γ-butyrolactone and ethano1.

6. The method according to claim 1, further comprising a step of maximizing the porosity of the hydrophobic layer.

7. The method according to claim 1, further comprising a step of minimizing the thickness of the hydrophobic layer.

8. The method according to claim 1, further comprising a step of maximizing-the porosity of the hydrophilic layer.

9. The method according to claim 1, further comprising a step of maximizing the thickness of the hydrophilic layer.

10. The method according to claim 1, further comprising a step of maximizing the thermal conductivity of the hydrophilic layer.

11. The method according to claim 1, further comprising:

a step of using a hydrophilic polymer dope solution comprising a host hydrophilic polymer to cast the hydrophilic layer; and

a step of using a hydrophobic polymer dope solution comprising a hydrophobic polymer to cast the hydrophobic layer,

wherein the hydrophobic polymer dope solution has a lower viscosity and density-than the hydrophilic polymer dope solution on the previously cast hydrophilic film.

12. A method of manufacturing a hollow fiber composite polymeric and mixed matrix membrane comprising:

providing a first solution having a hydrophilic polymer;

providing a second solution having a hydrophobic polymer; and

extruding the first and second solutions to form a multilayer hollow fiber composite polymeric and mixed matrix membrane wherein the first solution in extruded as an outer layer.

13. The method according to claim 12, wherein the first solution in extruded as an inner layer.

14. The method according to claim 12, wherein the second solution comprises a hydro-phobic polymer selected from the group consisting of polypropylene, polytetraflouroethylene, and polyvinylidene fluoride.

15. The method according to claim 14, wherein the second solution further comprises a fluorinated hydrophobic surface modifying macromolecule selected from a group consisting of poly(urethane propylene glycol), poly(urethane diphenylsulfone) , and poly(urea dimiethylsiloxane urethane).

16. The method according to claim 12, wherein the first solution comprises a hydro-philic polymer selected from the group consisting of polysulfone, polyether sulfone, poly-etherimide, polyamide cellulose acetate, and hydrophilic thermoplastics.

17. The method according to claim 16, wherein the first solution further comprises an inorganic nanoparticle having high thermal conductivity selected from the group consisting of boron nitride, aluminium nitride, silicon carbide, and a metal (such as copper or aluminium or iron) or metal oxides (such as copper oxide).

18. The method according to claim 16, wherein the first solution further comprises:

a non-solvent additive selected from a group consisting of γ-butyrolactone and ethanol, providing a second solution having a hydrophobic polymer; and

extruding the first and second solutions to form a. multilayer hollow fiber composite polymeric and matrix membrane.

19. The method according to claim 12, further comprising a step of maximizing the porosity of the hydrophobic layer.

20. The method according to claim 12, further comprising a step of minimizing the thickness of the hydrophobic layer.

21. The method according to claim 12, further comprising a step of maximizing the porosity of the hydrophilic layer.

22. The method according to claim 12, further comprising a step of maximizing the thickness of the hydrophilic layer.

23. The method according to claim 12, further comprising a step of maximizing the thermal conductivity of the hydrophilic layer.

24. The method according the claim 12, further comprising a step of producing void-free fibres to avoid mechanical weaknesses.

25. A plate-and-frame membrane module formed by the method of any one of the preceding claims, for direct contact membrane distillation using a multilayer polymeric or mixed matrix membrane, the plate-and-frame membrane module comprising:

a feed inlet capable of distributing process solution throughout the membrane module;

a permeate inlet capable of distributing process solution throughout the membrane module;

a tortuous promoter comprising multiple flow channels;

a feed outlet; and

a permeate outlet.

26. The membrane module of claim 25, wherein the polymeric or mixed matrix membrane is configured as a hollow fibre membrane or a flat sheet membrane.

27. The membrane module of claim 25, wherein the flow regimes of feed and permeate flow solutions during direct contact membrane distillation is a turbulent regime.

28. The membrane module according to claim 25, wherein the feed and permeate flow channels are configured such that there is no liquid stagnation in the flow channels.

29. The membrane module according to claim 25, configured for direct contact membrane distillation wherein seawater desalination flux is up to 142 kg/m^2h.

30. The membrane module according to claim 25, configured for direct contact membrane distillation such that it maximizes the Reynolds number.

31. The membrane module according to claim 25, configured for direct contact membrane distillation such that it improves flow hydrodynamics.

32. The membrane module according to claim 25, configured for direct contact membrane distillation such that it maximizes heat transfer coefficients and minimizes heat and mass resistances in boundary layers.

33. The membrane module according to claim 25, configured for direct contact membrane distillation such that it maximizes the temperature polarization coefficient until it reaches unity.

34. An array comprising multiple plate-and-frame membrane modules according to claim 25.