CLAIMS

1. A forward osmosis membrane comprising:

a hydrophilic porous support layer; and

a first polyamide rejection layer;

wherein the support layer and the rejection layer are incorporated into a thin film composite membrane, and are adjacent layers in the thin film composite membrane.

2. The forward osmosis membrane of claim 1, wherein the support layer comprises one or more aramid polymers.

3. The forward osmosis membrane of claim 1, wherein the support layer comprises one or more acrylate-modified poly(vinylidene fluoride) polymers.

4. The forward osmosis membrane of claim 1, further comprising a woven or non-woven mesh embedded in the support layer.

5. The forward osmosis membrane of claim 1, further comprising a second polyamide rejection layer in the thin film composite membrane, wherein the support layer is sandwiched between the first rejection layer and the second rejection layer.

6. The forward osmosis membrane of claim 1, wherein the membrane is configured as a flat sheet.

6. The forward osmosis membrane of claim 1, wherein the membrane is configured as a hollow fiber.

7. The forward osmosis membrane of claim 6, wherein the first polyamide rejection layer is at an outer surface of the hollow fiber.

8. The forward osmosis membrane of claim 6, wherein the first polyamide rejection layer is at an inner surface of the hollow fiber.

9. The forward osmosis membrane of claim 1, further comprising a plurality of carbon nanotubes disposed in the support layer.

10. A membrane element including the membrane of claim 1.

11. The forward osmosis membrane of claim 1, further comprising at least one anti-fouling layer disposed on the thin film composite membrane.

12. A hydration bag comprising the membrane of claim 1.

13. A method of concentrating industrial product or industrial waste using a forward osmosis apparatus comprising the membrane of claim 1.

14. A method of generating pressure and/or energy by pressure retarded osmosis (PRO) using a PRO apparatus comprising the membrane of claim 1.

15. A method for controlled release of chemicals using a controlled release apparatus comprising the membrane of claim 1.

16. A method of making a forward osmosis membrane, the method comprising:

providing a hydrophilic support layer; and

forming a polyamide rejection layer on the support layer by an interfacial polymerization process to form a thin film composite membrane.

17. The method of claim 16, wherein the support layer comprises one or more aramid polymers.

18. The method of claim 16, wherein the support layer comprises one or more acrylate-modified poly(vinylidene fluoride) polymers.

19. The method of claim 16, further comprising forming at least one anti-fouling layer on the thin film composite membrane by exposing the thin film composite membrane to a mixture of dopamine and an anti-fouling polymer.

Claims

1. A forward osmosis membrane comprising: a hydrophilic porous support layer comprising one or more aramid polymers;

a woven or non-woven mesh embedded in the support layer; and

a first polyamide rejection layer, wherein the support layer and the rejection layer are incorporated into a thin film composite membrane, and are adjacent layers in the thin film composite membrane.

2. The forward osmosis membrane of claim 1, further comprising a second polyamide rejection layer in the thin film composite membrane, wherein the support layer is sandwiched between the first rejection layer and the second rejection layer.

3. The forward osmosis membrane of claim 1, wherein the membrane is configured as a flat sheet.

4. The forward osmosis membrane of claim 1, wherein the membrane is configured as a hollow fiber.

5. The forward osmosis membrane of claim 4, wherein the first polyamide rejection layer is at an outer surface of the hollow fiber.

6. The forward osmosis membrane of claim 4, wherein the first polyamide rejection layer is at an inner surface of the hollow fiber.

7. The forward osmosis membrane of claim 1, further comprising a plurality of carbon nanotubes disposed in the support layer.

8. The forward osmosis membrane of claim 1, further comprising at least one anti-fouling layer disposed on the thin film composite membrane.

9. A method of making a forward osmosis membrane, the method comprising: providing a hydrophilic support layer comprising one or more aramid polymers; embedding a woven or non-woven mesh in the support layer; and forming a polyamide rejection layer on the support layer by an interfacial polymerization process to form a thin film composite membrane.

10. A method of filtering fluids, the method comprising:

providing a forward osmosis membrane, the forward osmosis membrane comprising:

a hydrophilic porous support layer comprising one or more aramid polymers;

a woven or non-woven mesh embedded in the support layer; and

a first polyamide rejection layer, wherein the support layer and the rejection layer are incorporated into a thin film composite membrane, and are adjacent layers in the thin film composite membrane; and

exposing a feed solution to the forward osmosis membrane, wherein the feed solution comprises water and a solute;

exposing a draw solution comprising water to the forward osmosis membrane such that at least some of the water from the feed solution flows through the forward osmosis membrane to the draw solution, increasing a concentration of the solute in the feed solution.

11. The method of claim 10 further comprising performing pressure retarded osmosis by generating a pressure change, energy, or combinations thereof due, at least in part, to a flow of water through the forward osmosis membrane.

12. The method of claim 10 wherein the solute in the feed solution is an industrial product, waste, or combination thereof.

13. The forward osmosis membrane of claim 1, wherein the forward osmosis membrane is sealed to a hydration bag.