Claims

1. A system for forward osmosis comprising an aqueous feed solution, and a draw solution comprising a draw solute comprising a semi-interpenetrating (semi-IPN) hydrogel, wherein the semi-IPN hydrogel comprises at least one thermally responsive polymer and at least one hydrophilic polymer, wherein:

the semi-IPN hydrogel has a repeat unit molar ratio corresponding to a ratio of moles of repeat units of the hydrophilic polymer to moles of repeat units of the thermally responsive polymer, wherein the repeat unit molar ratio is from 0.25:1 to 1:1;

the semi-IPN hydrogel switches between a hydrophilic state to allow absorption of water osmosed from a feed solution and a hydrophobic state to allow release of the absorbed water in response to changes in temperature;

the semi-IPN hydrogel is selected from the group consisting of: poly(N-isopropylacrylamide)/polysodium acrylate (PNIPAm/PSA), poly(N-isopropylacrylamide)/polyvinyl alcohol (PNIPAm/PVA), and combinations thereof;

the semi-IPN hydrogel is capable of being dewatered by heating to a temperature of about 40°C. in the absence of UV light; and

the semi-IPN hydrogel has a reversible swelling ratio span of at least 0.45, where the reversible swelling ratio span is the difference between the end point swelling ratio and the onset point swelling ratio, where

the swelling ratio at a time t is $(W_t-W_d)/W_d$, where W_t is weight of hydrogel at time t and W_d is the weight for the completely dry state;

the end point swelling ratio is the swelling ratio of the hydrogel at the end of a room temperature forward osmosis drawing process when the water flux is reduced to 0.1 LMH; and

the onset point swelling ratio is the plateau swelling ratio after dewatering in water at 40°C in the absence of UV light.

2. The system according to claim 1, wherein the semi-IPN hydrogel is in the form of a bulk hydrogel, continuous film or particle aggregate.

3. The system according to claim 1, wherein the semi-IPN hydrogel is capable of switching from the hydrophilic state to the hydrophobic state when the semi-IPN hydrogel is heated to a temperature above a lower critical solution temperature (LCST) of the semi-IPN hydrogel.

4. The system according to claim 1, wherein the semi-IPN is capable of switching from the hydrophilic state to the hydrophobic state when the semi-IPN hydrogel is heated to a temperature of 30-70°C.

5. The system according to claim 1, wherein the draw solute comprises a composite of semi-IPN hydrogel and carbon particles.

6. The system according to claim 1, wherein the draw solute comprises a composite of semi-IPN hydrogel and clay.

7. The system according to claim 1, wherein the LCST of the draw solute is from 30-55°C.

8. A forward osmosis method comprising:

contacting an aqueous feed solution and a draw solution comprising a draw solute via a semi-permeable membrane positioned therebetween, such that feed water in the aqueous feed solution passes through the semi-permeable membrane by osmotic pressure and moves into the draw solute in the draw solution, wherein the draw solute is a semi-interpenetrating (semi-IPN) hydrogel comprising at least one thermally responsive polymer and at least one hydrophilic polymer wherein the semi-IPN hydrogel has a repeat unit molar ratio corresponding to a ratio of moles of repeat units of the hydrophilic polymer to moles of repeat units of the thermally responsive polymer; wherein the repeat unit molar ratio is from 0.25:1 to 1:1; wherein the semi-IPN hydrogel is selected from the group consisting of: poly(N-isopropylacrylamide)/polysodium acrylate (PNIPAm/PSA), poly(N-isopropylacrylamide)/polyvinyl alcohol (PNIPAm/PVA) and combinations thereof and wherein the semi-IPN hydrogel is capable of being dewatered by heating to a temperature of about 40°C. in the absence of UV light; and

separating the water from the draw solute to form a purified water product.

9. The forward osmosis method according to claim 8, wherein the semi-IPN hydrogel is in the form of a bulk hydrogel, continuous film or particle aggregate.

10. The forward osmosis method according to claim 8, wherein the aqueous feed solution is at least one of an aqueous saline solution, seawater, brine, brackish water, mineralized water, or industrial waste water.

11. The forward osmosis method according to claim 8, wherein the separating comprises heating the draw solute.

12. The forward osmosis method according to claim 11, wherein the separating comprises heating the draw solute at a temperature above a lower critical solution temperature (LCST) of the draw solute.

13. The forward osmosis method according to claim 11, wherein the heating is at a temperature of 30-70°C.

14. The forward osmosis method according to claim 8, wherein the contacting is carried out at room temperature.

15. The forward osmosis method according to claim 8, further comprising conditioning the draw solute prior to the contacting.

16. The forward osmosis method according to claim 15, wherein the conditioning comprises swelling the hydrogels prior to the contacting.

17. The forward osmosis method according to claim 8, wherein the semi-permeable membrane comprises hollow fibers.

18. The forward osmosis method according to claim 17, wherein the hollow fibers are coated with at least one layer of the draw solute.