Supplementary Information

Water transport through graphene oxide membranes: the roles of

driving forces

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1. Experimental

1.1 Preparation of GO flat sheet membranes

GO suspension was synthesized using a modified Hummer's method.^{1, 2} Briefly, graphite powder was mixed with NaNO₃ and H₂SO₄ in an ice water bath, with KMnO₄ gradually added to the mixture after that. The ice water bath was removed after 5 hours and the mixture was stirred continuously for 5 days. Water was added at the end of the reaction and exfoliation, and H₂O₂ was added to remove the remaining manganese ions. The resultant GO dispersion was washed with deionized water for several cycles, and then centrifuged to control the size of GO flakes, which was determined to be 5–10 microns from the SEM. The GO dispersion was diluted to a concentration of 0.1 g L⁻¹ and was used for coating of GO membranes.

Flat sheet GO membranes were fabricated by using a filtration method. Supor[®] polyethersulfone (PES) microfiltration membranes with a pore size of 0.2 µm were used as the substrates of the GO membranes. A dead-end filtration cell (Sterlitech HP4750 Stirred Cell) was used for the filtration. During membrane synthesis, 20 ml of 0.1 g/L GO suspension was filtered on a PES substrate at 10 bar in the dead-end filtration cell. After that, GO membranes were dried in air for 2 days before being sealed in the filtration cell for further testing.

1.2 Water permeation and pervaporation

The pure water flux of GO membranes was tested using two different modes: pressure-driven filtration and pervaporation. During the pressure-driven permeation test, pressure was applied on the feed side, as shown in Figure S1. However, the permeate side of the membrane was connected to a vacuum system in pervaporation, as shown in Figure S2. The vacuum level was maintained at 1.3 mbar and a cold trap filled with liquid nitrogen was used to condensate the permeate. The permeation flux was determined by weighing the amount of permeate collected. For high temperature pervaporation, the membrane cell was immersed in a water bath to maintain the temperature. All GO membranes were first tested with pressure-driven pure water permeation at 6 bar for at least 24 hours to ensure the permeation flux reached a steady state. Then, the same GO membrane samples were used for the pervaporation test.



Figure S1: Schematic illustration of the pressure-driven permeation test set-up



Figure S2: Schematic illustration of the pervaporation set-up

2. Calculation of capillary pressure in GO membranes

The capillary pressure in GO membranes can be calculated using the Young–Laplace equation based on the interlayer spacing of GO membrane. The interlayer space is similar to the space between two flat plates, and then the form of the Young–Laplace equation is:

$$P_c = \frac{\gamma \cos \theta}{r}$$

where P_c is the capillary pressure, γ is the water-air interfacial tension, θ is the wetting angle and r is the half of the interlayer distance. By assuming θ to be zero and r to be 0.5 nm, the capillary pressure calculated is 1440 bar. The value is similar to what reported previously by Nair et al.³

References:

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