Electronic Supplementary Material (ESI) for Soft Matter.

Selective Ion Transport through Three-Dimensionally Interconnected Nanopores of Quaternized Block Copolymer Membranes for Energy Harvesting Application

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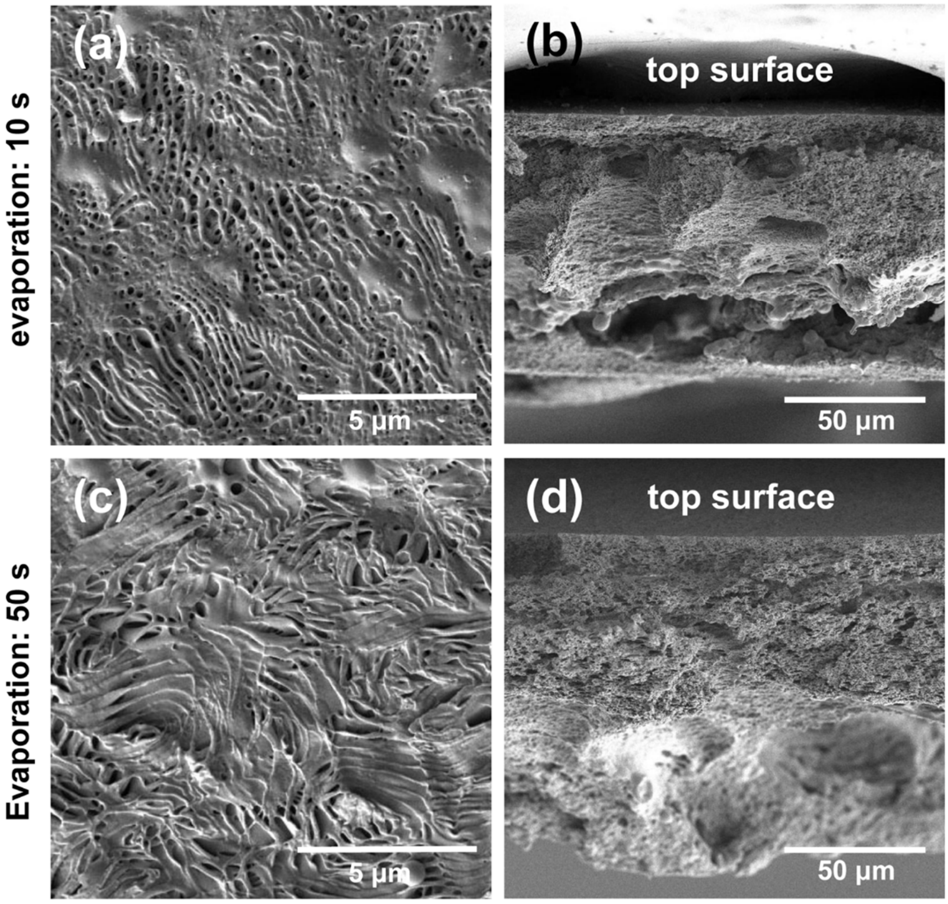

Figure S1. Plan-view (a, c) and cross-sectional (b, d) FE-SEM images of PS-P2VP membranes prepared by NIPS method with different evaporation time at room temperature. (a, b) 10 s; (c, d) 50 s.

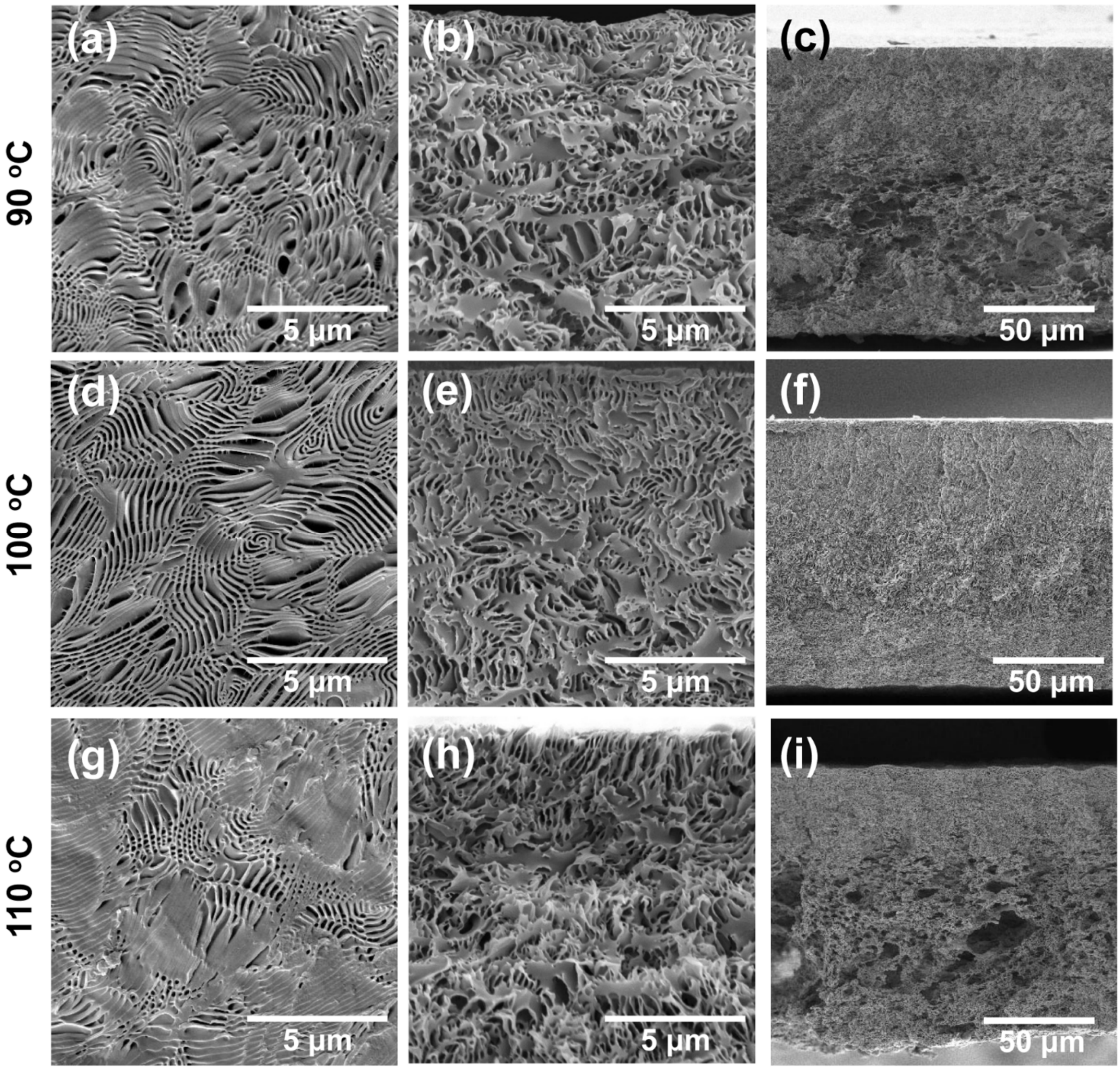

Figure S2. Plan-view and cross-sectional FE-SEM images of PS-P2VP membranes prepared by NIPS method with different evaporation temperature for 20 s. (a - c) 90 ºC; (d - f) 100 ºC; (g - i) 110 ºC.

To confirm the interconnectivity of nanopores in the PS-P2VP membrane, permeation tests with a deionized (DI) water were performed at different working pressure in a stirred cell module (Amicon 8010, Millipore). As shown in Figure S3, the PS-P2VP membrane exhibited a water flux of 17 L m^{-2} h^{-1} at a pressure of 0.1 bar and a linear increase in water flux with working pressure, indicating good dimensional stability of the PS-P2VP membrane.

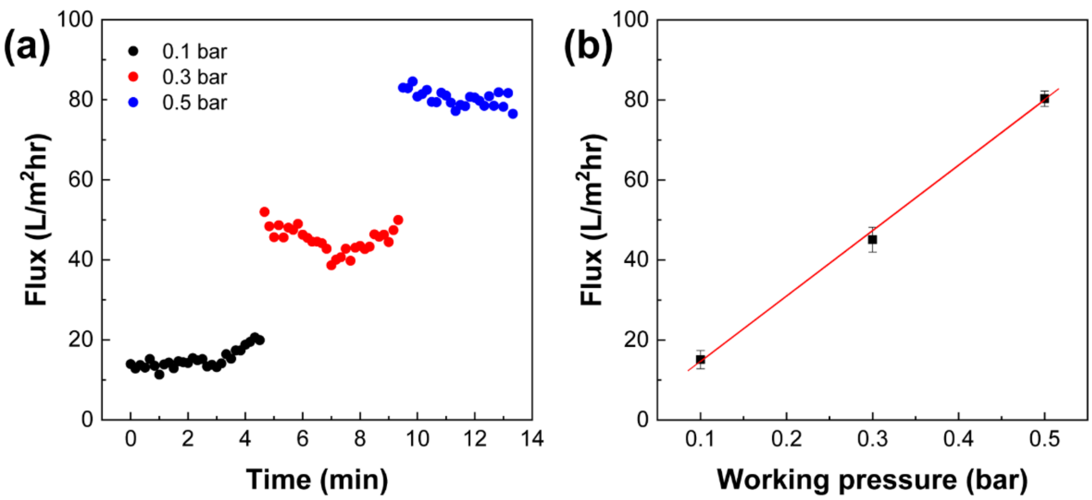

Figure S3. Flux data of deionized water using the PS-P2VP membrane from the evaporation condition of 100 ºC and 20 s. (a) Flux change with increasing working pressure in permeability test and (b) plot of water flux as a function of working pressure.

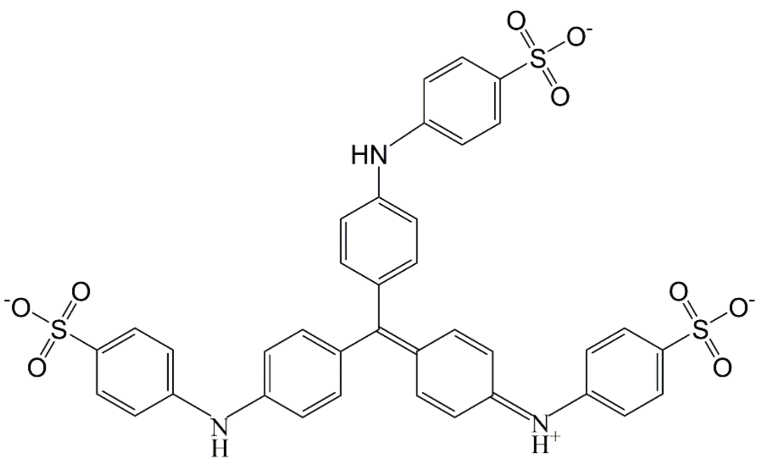

Figure S4. Molecular structure of methyl blue (CAS number: 28983-56-4).

Calcuation of ion transport number

To calculate ion transport number, the diffusion potential (E_{diff}), which is generated by ionic diffusion across the membrane, needs to be determined by $E_{diff} = V_{OC} - E_{redox}$.[1,2] In this equation, the redox potential (E_{redox}) is arose from the different potential drops at the electrode-solution interfaces in the two KCl reservoirs. We measured E_{redox} (18.5 mV) by inserting Ag/AgCl electrodes in the two KCl solutions (0.01M and 1M) that were connected by a salt bridge. From the diffusion potential, ion transport number (t) can be further determined by[1,2]

$$t = \frac{1}{2}\left[1 + \frac{F}{RT}\frac{E_{diff}}{\ln(a_H/a_L)}\right] \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

where F is the Faraday constant, R is the ideal gas constant, T is the temperature, and a_H (or a_L) is the activity of KCl in the solution at high (or low) concentration. From the equation (1), ion transport numbers were evaluated as 0.43, 0.57, 0.87, 0.87, and 0.68 for PS-QP2VP membranes with 0, 6, 12, 18, 24 h of quaternization, respectively.

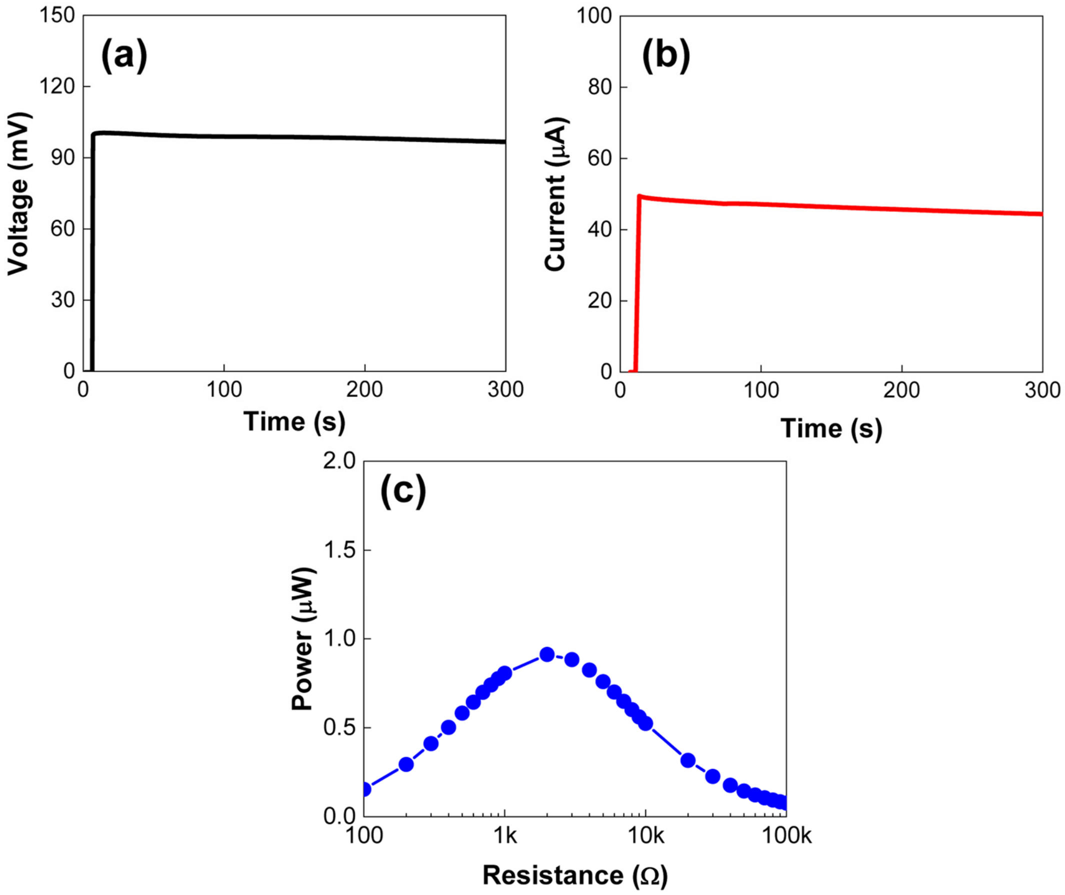

Figure S5. (a) Open-circuit voltage, (b) short-circuit current and (c) output power of concentration-gradient cells with commercial anionic-exchange membrane (Fujifilm) under the same experimentals with Figure 3 (main text).

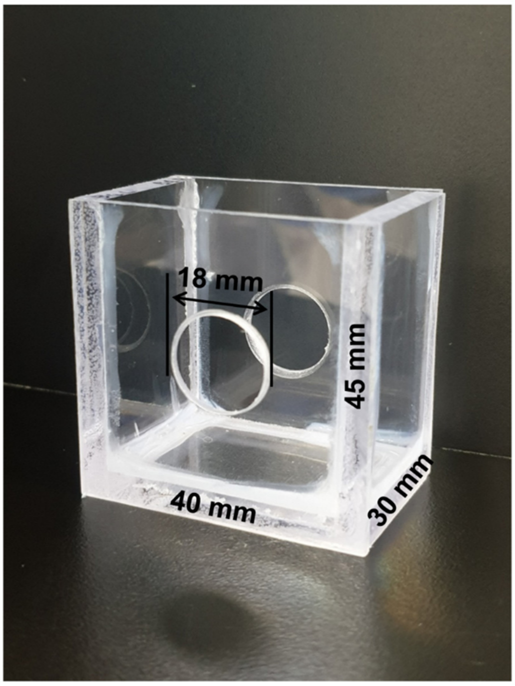

Figure S6. Photograph of polycarbonate containers utilized for the connection of concentration-gradient cells.

References

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