Supplementary Information

Fluorine-Free Microporous Membranes with High Wetting Resistance for Membrane Distillation

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Text S1. Determination of water vapor permeance of membranes

The water vapor flux (J) was calculated as the permeate volume (V) collected during time (t) divided by the effective membrane area (A):

$$J = \frac{V}{A \cdot t}$$

where J is expressed in liters per square meter per hour (LMH).

To enable more accurate comparison of water vapor permeance across different membranes, the water vapor fluxes were further normalized by the transmembrane vapor pressure difference (ΔP_v) to obtain the water flux permeance (P, LMH/bar) of the membranes, as described below:[1-3]

$$P = \frac{J}{\Delta P_v}$$

The vapor pressures of the feed and permeate sides were determined using the Antoine equation[4, 5]:

$$p_v = e^{\left(25.317 - \frac{5144}{T+273.15}\right)}$$

where p_v is the saturation water vapor pressure, Pa, 1 Pa=10^{-5} bar; T is the temperature, °C. Finally, the transmembrane vapor pressure difference was obtained as:

$$\Delta P_v = p_{v,f} - p_{v,p}$$

where $p_{v,f}$ refers to the saturation water vapor pressure at the feed-side membrane interface, while $p_{v,p}$ corresponds to that at the permeate-side interface. The water vapor permeance was then determined from the slope of plotting water vapor flux versus ΔP_v.

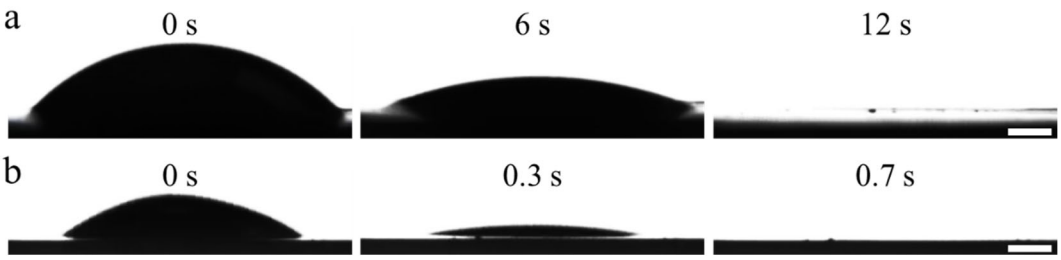

Figure S1. Series of images showing (a) water droplet on an as-received pristine 0.45 μm PES membrane and (b) water droplet on a 0.45 μm PES membrane subjected to 10 minutes oxygen plasma treatment. Scale bars represent 500 μm.

Figure S2. Image showing water droplet on a 0.45 μm PES membrane modified solely with Cl-PDMS. Scale bar represents 500 μm.

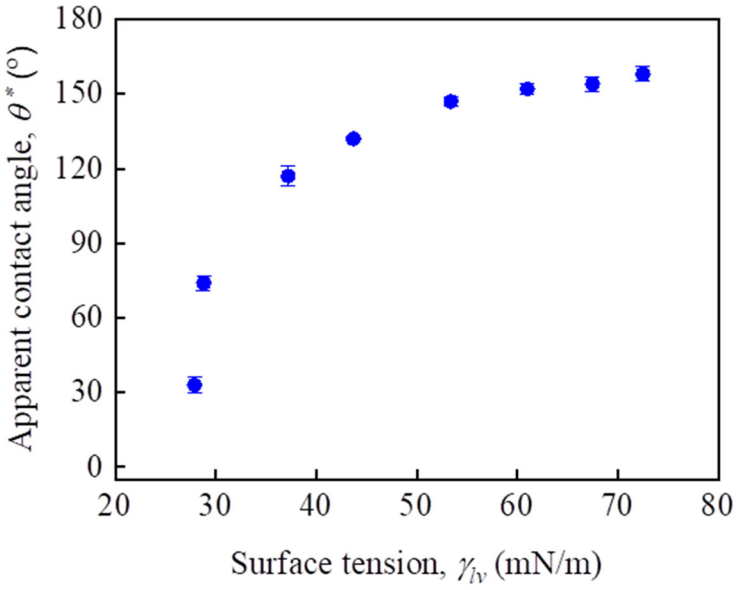

Figure S3. Apparent static contact angles of liquids with different surface tensions on 0.45 μm PDMS-PES modified with $\alpha \approx 0.35$.

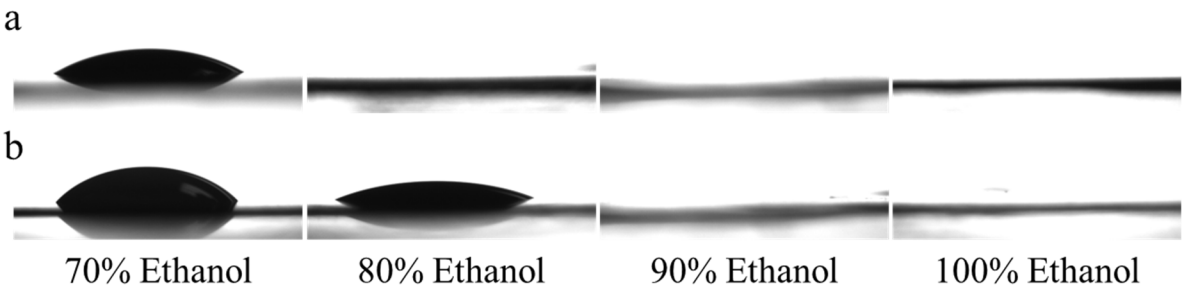

Figure S4. Droplets of water-ethanol mixtures with varied ethanol concentrations on (a) 0.45 μm and (b) 0.22 μm PDMS-PES membranes modified with $\alpha \approx 1.05$.

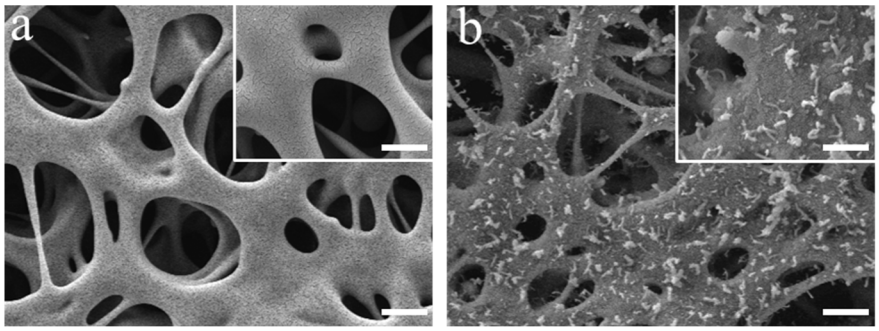

Figure S5. SEM images of (a) 0.22 μm pristine PES membrane and (b) 0.22 μm PDMS-PES membrane modified at PDMS/TEOS ratio of 1.05. The scale bars represent 1 μm and 500 nm (inset), respectively.

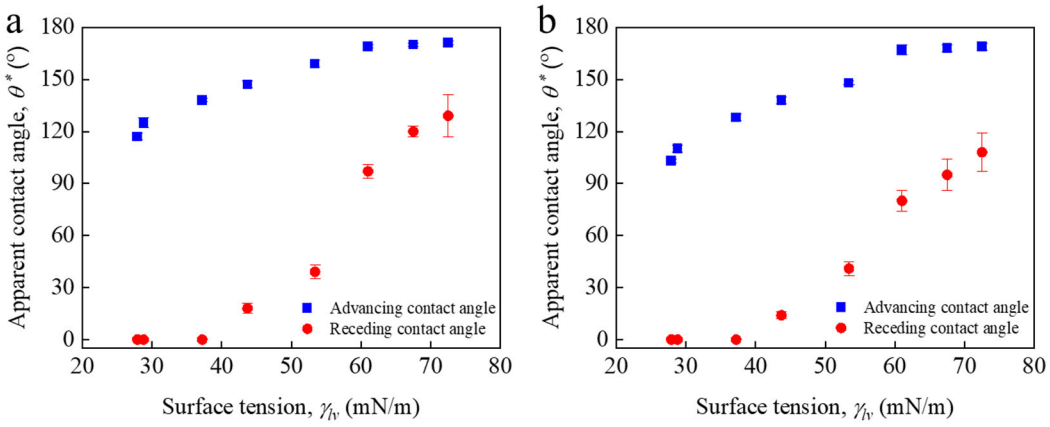

Figure S6. Apparent advancing and receding contact angles of liquids with different surface tensions on (a) 0.45 μm and (b) 0.22 μm PDMS-PES membranes.

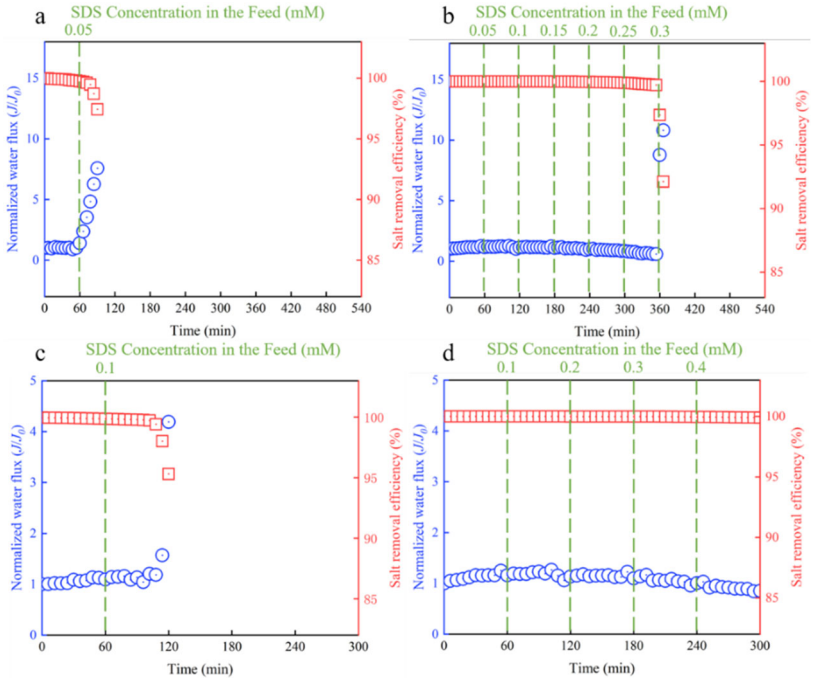

Figure S7. Normalized water vapor flux, J/J_0, (blue points), and salt rejection rate (red points) for (a) 0.45 μm PVDF membrane, (b) 0.45 μm PDMS-PES membrane, (c) 0.22 μm PVDF membrane, and (d) 0.22 μm PDMS-PES membrane tested under identical experimental conditions to those of Figure 6. The feed solution contained 1 M NaCl and varied SDS concentrations. The green dashed lines indicate the addition of SDS. These results are duplicate results of those presented in Figure 6 of the main text, confirming the reproducibility of the data.

Table S1. Compositions of the solutions used to modify PES membranes at different PDMS/TEOS ratios.

Samples	Hexane (mL)	Cl-PDMS (mL)	TEOS (mL)	PDMS/TEOS Volume Ratio	PDMS/TEOS Mass Ratio
PDMS-PES-1	72	1	7	0.14	0.15
PDMS-PES-2	72	2	6	0.33	0.35
PDMS-PES-3	72	4	4	1	1.05
PDMS-PES-4	72	5	3	1.67	1.76
PDMS-PES-5	72	6	2	3	3.16

Table S2. Summary of surface tensions of 1.0 M NaCl feedwater containing varying concentrations of SDS at 60 °C.[6]

SDS Concentration (mM)	Surface Tension (mN/m)
0.05	48
0.10	42
0.15	37
0.20	33
0.25	32
0.30	31
0.40	29

References

1. Chen, T. C.; Ho, C. D.; Yeh, H. M., Theoretical modeling and experimental analysis of direct contact membrane distillation. *J. Membr. Sci.,* **2009,** *330*, 279-287.
2. Diban, N.; Voinea, O. C.; Urtiaga, A.; Ortiz, I., Vacuum membrane distillation of the main pear aroma compound: Experimental study and mass transfer modeling. *J. Membr. Sci.,* **2009,** *326*, 64-75.
3. K.W. Lawson, D. R. L., Membrane distillation. *J. Membr. Sci.* **1997,** *124*, 1.
4. Buck, A. L., New equations for computing vapor pressure and enhancement factor. *J. Appl. Meteorol.,* **1981,** *20*, 1527-1532.
5. Sharma, M. K.; He, Z.; Verduzco, R.; Li, Q., Effect of operating temperature on vapor permeability of porous hydrophobic membranes used in membrane distillation. *J. Membr. Sci.,* **2025,** *735*, 124585.
6. Matijević, E. P., B., The Properties of Ionized Monolayers. Part 1. Sodium Dodecyl Sulphate at the Air/water Interface. *Trans. Faraday Soc.* **1958,** *54*, 1382-1389.