Supplementary Information

Negatively charged Janus membrane with robust pore anti-wettability for stable membrane distillation of seawater

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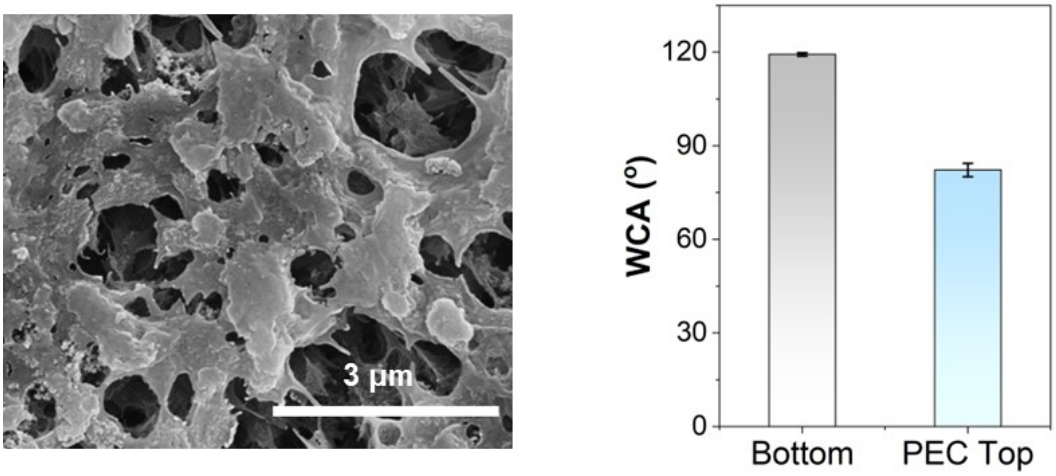

Fig. S1 SEM image of the PEC-based Janus membrane bottom surface and the water contact angle (WCA) difference between porous bottom and dense PEC top surface.

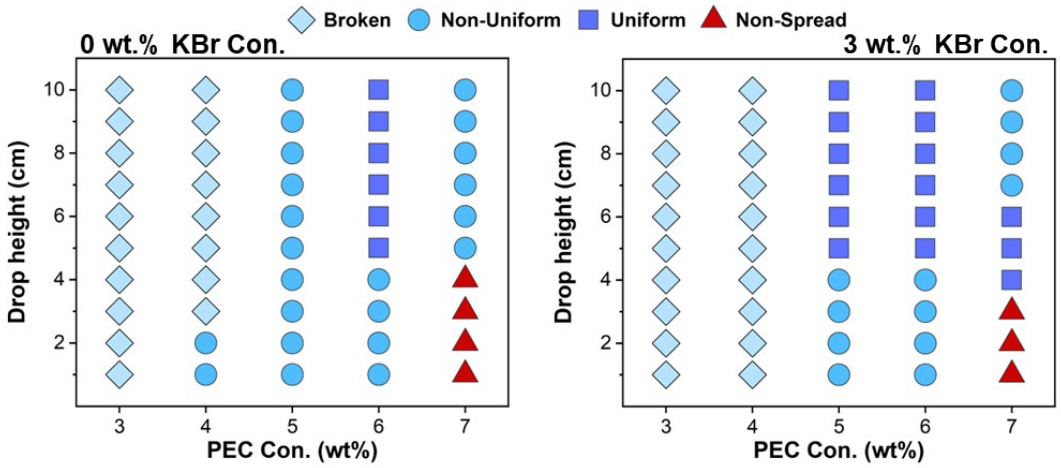

Fig. S2 Phase diagram of PE solution spreading status for drop height and PEC concentration under 0 and 3 wt.% KBr concentration in water.

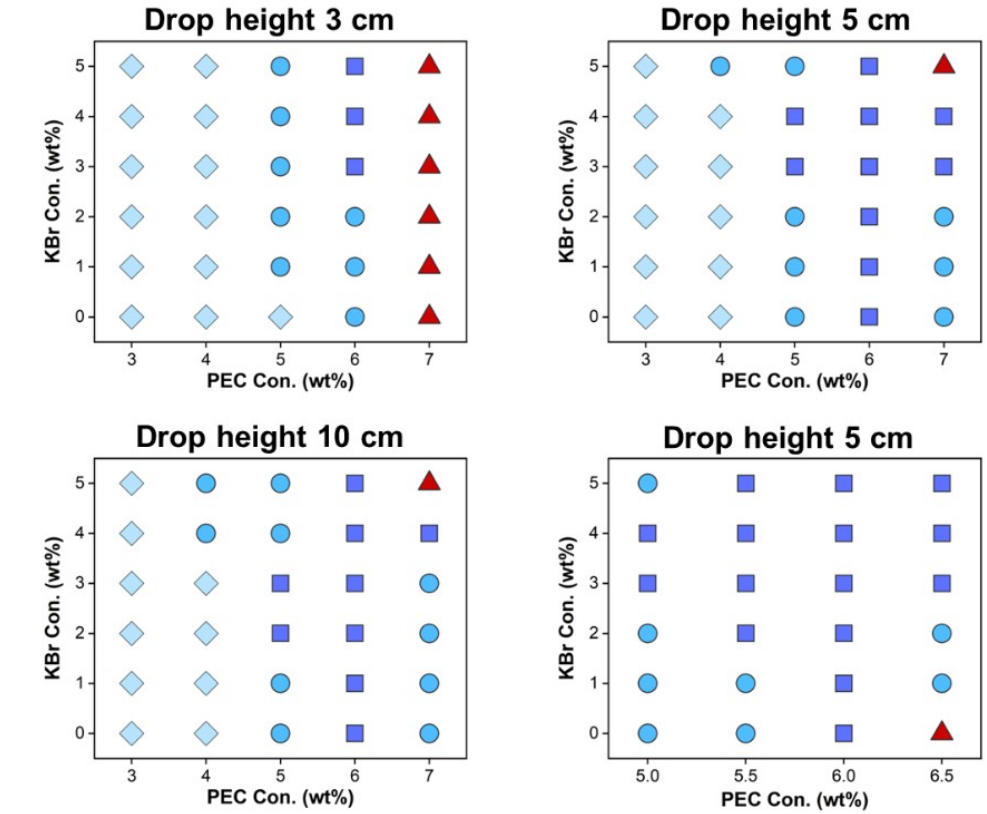

Fig. S3 Phase diagram of PE solution spreading status for KBr concentration in water and PEC concentration under various drop heights.

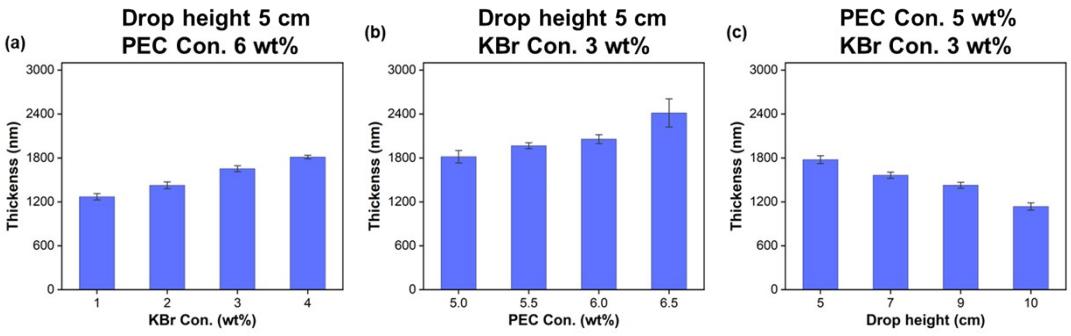

Fig. S4 PEC layer thickness vs various spreading parameters. (a) Related to KBr concentration in water. (b) Related to PEC concentration. (c) Related to drop height.

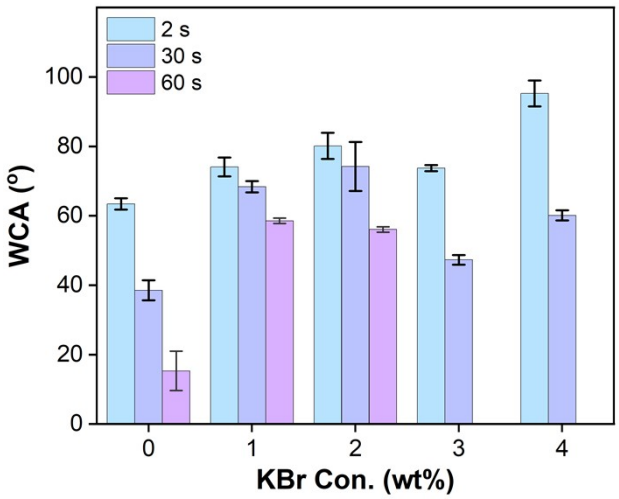

Fig. S5 WCAs of PEC-based Janus membranes with various KBr concentration in coagulation bath within 60 s.

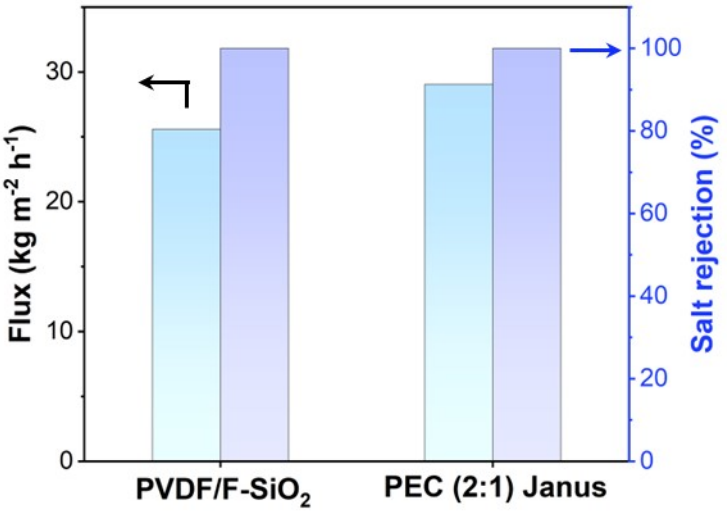

Fig. S6 MD flux of PEC-based Janus membranes compared to PVDF/F-SiO_2 nanocomposite substrate for seawater desalination with humic acid.

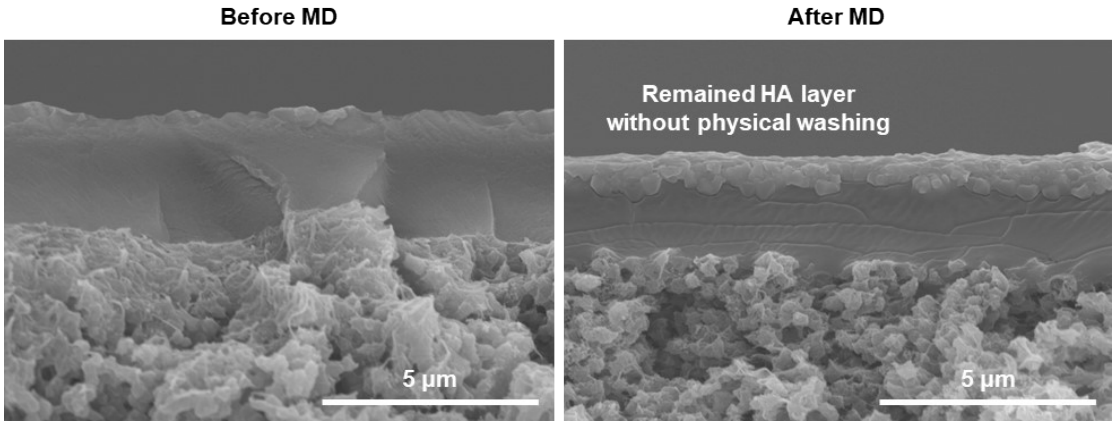

Fig. S7 Cross-sectional SEM images of the PEC-based Janus membrane before and after MD testing, showing the intimate contact between the PEC layer and the substrate.

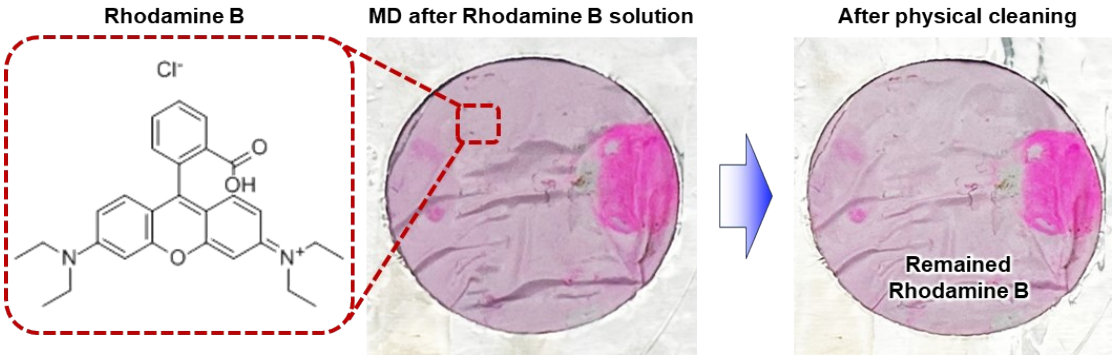

Fig. S8 Optical images for PEC-based Janus membrane surface after MD with positively charged dye (Rhodamine B) solution and after physical cleaning.

Table S1. Comparison of reported Janus membranes for MD desalination.

Sample	Thickness (μm)	WCA (°)	LEP (bar)	Specific LEP (bar μm^{-1})	MD type	Operation condition	Flux (kg/m^2 h)	Rejection (%)	Ref.
PEI/SA-PTFE	40.7	~0	2.7	0.0663	DCMD	60℃/20℃ 3.5 wt.% Seawater	52	~100	S1
HC-PTFE Janus	170	~40	10.3	0.0606	DCMD	65℃/20℃ 3.5 wt.% NaCl 0.4 mM SDS	18.86	>99.9	S2
Dense PVA/PVDF Janus	~125	11.83	>5.7	0.0456	DCMD	60℃/20℃ 3.5 wt.% NaCl	24.18	~100	S3
PVDF-$(PEI/PSS)_{3x}$	~150	32.1	3.08	0.0205	DCMD	60℃/20℃ 0.6 M NaCl 0.4 mM SDS	16.7	>99	S4
PA/PVDF Janus	~125.3	27.1	7.6	0.0607	DCMD	60℃/20℃ 3.5 wt.% NaCl	~25	~100	S5
PVAM/GA@PVDF/POTS-SiO_2	~144	~0	/	/	DCMD	70℃/20℃ 3.5 wt.% NaCl	16.7	>99.9	S6
p(ScA)/PEM_{5x}-PVDF	~67	9	3.1	0.0463	DCMD	60℃/20℃ 3.5 wt.% NaCl	23.76	>99.9	S7
HNW/PVDF Janus	6.7	~0	0.38	0.0567	VMD	60℃/20 kPa 3.5 wt.% NaCl	11	>99	S8
PA-TFC Janus	~200	16.5	~5.4	0.027	DCMD	60℃/20℃ 0.6 M NaCl	22.0	>99.9	S9
PEC-based Janus	30	82.3	4.82	0.161	DCMD	70℃/20℃ 3.5 wt.% NaCl 100 mg L^{-1} HA	29.0	>99.9	This work

References

S1. Y. Jia, K. Guan, P. Zhang, Q. Shen, Z. Li, T. Istirokhatun and H. Matsuyama, *J. Membr. Sci.*, 2022, **657**, 120697.

S2. X. Yang, N. Zhang, J. Zhang, W. Liu, M. Zhao, S. Lin and Z. Wang, *Environ. Sci. Technol.*, 2023, **57**, 15725-15735.

S3. D. Feng, Y. Chen, Z. Wang and S. Lin, *Environ. Sci. Technol.*, 2021, **55**, 14156-14164.

S4. Y. Chen, K.-J. Lu, S. Japip and T.-S. Chung, *Environ. Sci. Technol.*, 2020, **54**, 12713-12722.

S5. C. Wang, Z. Ma, Y. Qiu, C. Wang, L.-F. Ren, J. Shen and J. Shao, *Water Res.*, 2023, **242**, 120308.

S6. W. Li, M. Chen, G. Zhang, W. Chen, L. Zhang, S. Shen, D. Liu, X. Zhou and Y. Hong, *Desalination*, 2024, **582**, 117661.

S7. Y.-H. Huang, M.-J. Wang and T.-S. Chung, *Desalination*, 2023, **555**, 116527.

S8. M. Yang, N. Yao, X. Li, J. Yu, S. Zhang and B. Ding, *ACS Nano*, 2024, **18**, 33159-33167.

S9. T. Gong, D. Shi, Z. Zhu, B. Liu and S. Shao, *ACS ES&T Water*, 2023, **3**, 176-184.