membranes

Supporting Information

Insights into the Influence of Membrane Permeability and Structure on Osmotically-Driven Membrane Processes

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S1. Setup for Membrane Permeability Measurement

A cross-flow filtration setup was used to determine the membrane permeability in reverse osmosis (RO) mode (Figure S1). Membrane sample was installed in the filtration cell with effective membrane area of 42 cm^2. Feed was pumped into the cell and flowed on the active layer of membrane. The concentrate and permeate were returned to the feed tank, and circulated in the system. Sample of permeate was taken to measure the water permeability coefficient, salt permeability coefficient, and salt rejection of membrane.

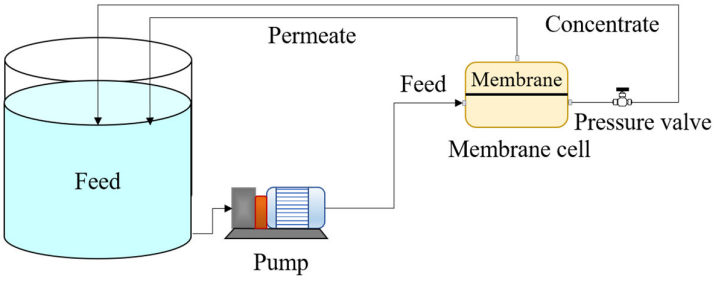

Figure S1. Schematic diagram of cross-flow reverse osmosis (RO) setup.

S2. Surface Morphology of TFC Membrane after Scaling Test

The surface of thin film composite membrane (TFC) was observed using field-emission scanning electron microscopy (FESEM) after scaling test. Damage of the active layer can be seen in Figure S2. TFC was susceptible to scaling because of the surface roughness and chemical property. Growth of gypsum crystals at the confined zone near spacer resulted in damage of the ultrathin active layer.

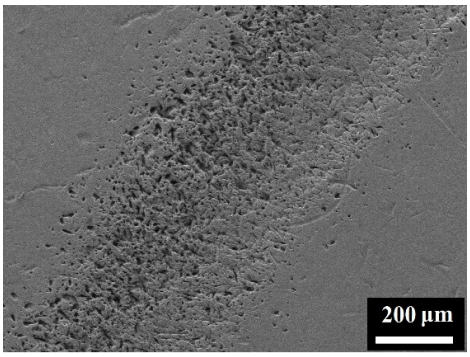

Figure S2. Field-emission scanning electron microscopy (FESEM) micrograph of thin film composite membrane (TFC) active layer (at 100x) after scaling test.

S3. Property and Performance of Lab-Scale FO Membranes in the Literature

Lab-scale forward osmosis (FO) membranes in the literature were investigated. Their water permeability, salt permeability and structural parameter are listed in Table S1. The abbreviations of membrane materials are shown in Table S2. To study the influence of membrane permeability and structure on water flux, FO performance of these membranes was summarized in Table S1.

Table S1. Property and performance of lab-scale FO membranes in the literature.

	Membrane ID	Membrane structure	Membrane material	Membrane property				FO performance and testing conditions						Reference
				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
1	TFN0.008	TFC flat-sheet membrane	PA-GO/PSf	3.9 ± 0.2	1.1 ± 0.2	0.28 [b]	0.119 ± 0.0004	34.3 ± 0.1	1.1 ± 0.2	0.03	AL-FS	DI water	2 M NaCl	[1]
2	UiO-66-2/GO-1	TFC flat-sheet membrane	UiO-66-GO/nylon	73.20	0.11	0.0015	0.00103	29.16 ± 0.28	12.86 ± 0.82	0.44 [b]	AL-FS	DI water	2 M NaCl	[2]
3	TFC-30	TFC flat-sheet membrane	PA-AEPPS/PSf	4.81 ± 0.03	0.19 ± 0.01	0.039	0.747	27	12	0.45	AL-DS	DI water	1 M NaCl	[3]
								16	6	0.35	AL-FS	DI water	1 M NaCl	
4	DPE-TFC	TFC flat-sheet membrane	PA/PDA-PE	6.67 ± 0.15	0.68 ± 0.02	0.103 ± 0.004	0.168 ± 0.004	64.8	18.1 [b]	0.28	AL-DS	DI water	1 M NaCl	[4]
								53.0	14.8 [b]	0.28	AL-FS	DI water	1 M NaCl	
5	TFC_{TiO2}/GO	TFC flat-sheet membrane	PA/PSf-TiO_2-GO	0.58 ± 0.01	0.052 ± 0.012 [b]	0.089 [b]	0.20 ± 0.01	21.0	~3 [a]	~0.14 [a]	AL-DS	DI water	0.5 M NaCl	[5]
								12.3	~1 [a]	~0.08 [a]	AL-FS	DI water	0.5 M NaCl	
6	TFN-MMGO/Fe_3O_4-100	TFC flat-sheet membrane	PA-GO-Fe_3O_4/PES	2.69	0.26	0.10	N.A.	~62 [a]	~10 [a]	~0.16 [a]	AL-DS	DI water	1 M NaCl	[6]
								~55 [a]	~10 [a]	~0.18 [a]	AL-FS	DI water	1 M NaCl	
7	TFN0.05	TFC flat-sheet membrane	PA-g-C_3N_4/PSf	2.17 ± 0.18	0.38 [b]	0.179 ± 0.04	0.37 ± 0.09	18.88 ± 0.35	2.74 ± 0.15	0.15 [b]	AL-FS	DI water	2 M NaCl	[7]
8	PE-TFC	TFC flat-sheet membrane	PA/PE	3.15 ± 0.17	0.48 ± 0.19	0.133 ± 0.058	0.161	~32 [a]	~15 [a]	~0.5 [a]	AL-DS	DI water	0.5 M NaCl	[8]
								~28 [a]	~14 [a]	~0.5 [a]	AL-FS	DI water	0.5 M NaCl	

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				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
9	5wt%IER-Na	TFC flat-sheet membrane	PA/PSf-(IER-Na)	3.72	0.1078	0.03 [b]	0.742	43.8	~6 [a]	0.14	AL-DS	DI water	1.5 M NaCl	[9]
								~25 [a]	~5 [a]	~0.2 [a]	AL-FS	DI water	1.5 M NaCl	
10	TFN-ZSCSNP-1	TFC flat-sheet membrane	PA/PES-ZSCSNPs	3.47 ± 0.09	4.01 ± 0.08	1.1556 ± 0.0008	0.297 ± 0.012	25.93	~10 [a]	0.39 [b]	AL-FS	DI water	0.5 M NaCl	[10]
11	10 wt% PVDF (DMAc/Water = 50:50)	TFC flat-sheet membrane with dual-layer nanofiber substrate	PA/PVDF/PET-PVA	2.02 ± 0.20	1.09 ± 0.09	0.54 [b]	0.243 ± 0.0421	23.57 ± 1.08	~15 [a]	0.64 [b]	AL-DS	DI water	0.5 M NaCl	[11]
								~20 [a]	~13 [a]	0.65 [b]	AL-FS	DI water	0.5 M NaCl	
12	TFC-SUB 2	TFC flat-sheet membrane with mesh	PA/PVC-LDH/polyester	3.61 ± 0.019	0.1816 ± 0.033	0.05 [b]	0.303	50.89 ± 1.13	13.284 ± 0.67	0.26 [b]	AL-DS	DI water	1 M NaCl	[12]
								37.46 ± 0.85	3.57 ± 0.2	0.10 [b]	AL-FS	DI water	1 M NaCl	
13	MT-3	TFC flat-sheet membrane	PA/PVDF-PFSA	2.97 ± 0.06	0.39 ± 0.13	0.1284 ± 0.0422	0.33462 ± 0.00350	18.8	~5 [a]	0.27 [b]	AL-FS	DI water	0.5 M NaCl	[13]
14	TFN-0.04	TFC flat-sheet membrane	PA-MOF/PES	~5 [c]	~0.6 [c]	0.12 [c]	0.238	~42 [a]	N.A.	N.A.	AL-DS	DI water	0.5 M NaCl	[14]
								~30 [a]	~4 [a]	~0.12 [a]	AL-FS	DI water	0.5 M NaCl	
15	VOPS-TFC-1	TFC flat-sheet membrane	PA/PVDF	4.71 ± 0.22	N.A.	N.A.	0.0991 ± 0.0037	~65 [a]	~5 [a]	0.08 [b]	AL-DS	DI water	0.5 M NaCl	[15]
								~45 [a]	~5 [a]	0.11 [b]	AL-FS	DI water	0.5 M NaCl	

	Membrane ID	Membrane structure	Membrane material	Membrane property				FO performance and testing conditions						Reference
				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
16	SPSFco TFC	TFC flat-sheet membrane with dual-layer substrate	PA/PSf-SPEEK/polyether imide	2.16 ± 0.13	0.16 ± 0.05	0.10 [b]	0.191 ± 0.047	~20 [a]	N.A.	N.A.	AL-DS	DI water	0.5 M NaCl	[16]
								22.4 ± 2.1	3.58 [b]	0.16 ± 0.05	AL-FS	DI water	0.5 M NaCl	
17	TFN-U2	TFC flat-sheet membrane	PA-MOF/PSf	3.33 ± 0.48	0.33 ± 0.05	0.10 ± 0.005	0.532	29.4	N.A.	N.A.	AL-DS	DI water	0.5 M NaCl	[17]
								18.4	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	
18	AQP-TFC-HF-PEI	TFC flat-sheet membrane	PA-aquaporin /polyetherimide	7.6	~0.5 [a]	0.07 [b]	0.172 ± 0.006	64.7	8.3	0.13	AL-DS	DI water	0.5 M NaCl	[18]
								35.4	3.6	0.10	AL-FS	DI water	0.5 M NaCl	
19	TFC-PSfdGO	TFC flat-sheet membrane with dual-layer substrate	PA/PSf-GO/PSf-GO	1.46	0.25	0.17	0.130	61.5	~12 [a]	0.18	AL-DS	DI water	1 M NaCl	[19]
								33.8	~7 [a]	0.19	AL-FS	DI water	1 M NaCl	
20	$PS_{0.5}$-$TFN_{0.05}$	TFC flat-sheet membrane with mesh	PA/PSf-Al_2O_3/PET	8.43	1.66	0.20	1.028	~15 [a]	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[20]
21	PA/PAN-eTFC	TFC flat-sheet membrane with nanofiber substrate	PA/PAN	1.47 [c]	0.278 [c]	0.19 [b]	0.168	~18 [a]	~4 [a]	0.22 [b]	AL-FS	DI water	0.5 M NaCl	[21]
22	PK(35/200)	TFC flat-sheet membrane	PA/PK	2.79 ± 0.05	0.54 ± 0.02	0.19 [b]	0.176 ± 0.004	30.3 ± 0.5	4.56 ± 0.70	0.15 [b]	AL-FS	DI water	0.6 M NaCl	[22]

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23	TFC-1.5	TFC flat-sheet membrane	PA/PAN	1.439 ± 0.006	0.197 ± 0.002	0.137 ± 0.001	0.298	~23 [a]	~16 [a]	0.70 [b]	AL-DS	DI water	0.5 M NaCl	[23]
								16.7	10	0.60 [b]	AL-FS	DI water	0.5 M NaCl	
24	TFC-25.0	TFC flat-sheet membrane	PA/PSf	1.57 ± 0.11	0.32 ± 0.10	0.20 [b]	0.397	~35 [a]	~5 [a]	0.14 [b]	AL-DS	DI water	0.5 M NaCl	[24]
							0.186	~20 [a]	~5 [a]	0.25 [b]	AL-FS	DI water	0.5 M NaCl	
25	PA/PVDF/CA (8%)	TFC flat-sheet membrane with mesh-embedded dual-layer substrate	PA/PVDF/CA/polyester	1.2 ± 0.2	0.40 ± 0.03	0.33 [b]	0.391	~25 [a]	~5 [a]	0.20 [b]	AL-DS	DI water	0.5 M NaCl	[25]
								~12 [a]	~4 [a]	0.33 [b]	AL-FS	DI water	0.5 M NaCl	
26	Pa-Si15	TFC flat-sheet membrane with nonwoven-fabric-supported nanofiber substrate	PA/PAN-silica nanoparticles (NPs)/PET	2.54 ± 0.86	1.66 ± 0.47	0.65 [b]	0.065 ± 0.005	~82 [a]	~12 [a]	~0.15 [a]	AL-DS	DI water	1 M NaCl	[26]
								55.98	7.98	~0.15 [a]	AL-FS	DI water	1 M NaCl	
27	TFC3-20 ºC TMC	TFC flat-sheet membrane	PA/PES	5.78	4.96	0.86 [b]	0.436	~21 [a]	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[27]
28	nTFC0.15	TFC flat-sheet membrane	PA-CNTs-PDA/PSf	6.5	7.0 [d]	1.08 [b,d]	1.669	~13 [a]	~7 [a]	0.54 [b]	AL-FS	DI water	2 M $MgCl_2$	[28]

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29	TFNC-2	TFC flat-sheet membrane	PA/PSf-LDH NPs	0.61 [c]	0.27 [c]	0.45	0.148	34.6	12.7	0.37 [b]	AL-DS	DI water	1 M NaCl	[29]
								18.1	8.1	0.45 [b]	AL-FS	DI water	1 M NaCl	
30	#1 sPPSU-TFC	TFC flat-sheet membrane with mesh	PA/sPPSU/PET	3.7 ± 0.38	0.228 ± 0.012	0.06 [b]	0.256	~42 [a]	10.5 [b]	~0.25 [a]	AL-DS	DI water	~0.6 M NaCl	[30]
								~26 [a]	6.5 [b]	~0.25 [a]	AL-FS	DI water	~0.6 M NaCl	
31	Modified-TFC	TFC flat-sheet membrane with nonwoven-fabric-supported nanofiber substrate	PA/PVDF-nylon 6,6/PET	1.28 ± 0.36	0.25 ± 0.11 [c]	0.20 [b]	0.193 ± 0.022	~20 [a]	~7 [a]	0.35 [b]	AL-DS	DI water	0.5 M NaCl	[31]
								~15 [a]	~2 [a]	0.13 [b]	AL-FS	DI water	0.5 M NaCl	
32	TFC-flat	TFC flat-sheet membrane	PA/PSf	1.58 ± 0.04	0.17 ± 0.09	0.11 [b]	0.226 ± 0.057	18.1 ± 1.5	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[32]
33	PES/PAA 5/$CaCO_3$	TFC flat-sheet membrane	PA/PES-PAA-$CaCO_3$	~0.75	N.A.	N.A.	0.0357	62	21.6	~0.35 [a]	AL-DS	DI water	2 M NaCl	[33]
								52	16.8	~0.33 [a]	AL-FS	DI water	2 M NaCl	
34	TFN 0.5	TFC flat-sheet membrane	PA/PSf-HNT	2.00	0.34	0.1680	0.37 ± 0.05	26.91	8.50	0.32 [b]	AL-DS	10 mM NaCl	0.5 M NaCl	[34]
								14.88	5.95	0.40 [b]	AL-FS	10 mM NaCl	0.5 M NaCl	
35	Dual	TFC flat-sheet membrane	PA/CAP/PA	0.98 ± 0.01	0.09 ± 0.01 [c]	0.09 [b]	0.052 ± 0.008	40.4 ± 0.7	5.7 ± 0.4	0.14 [b]	AL-DS	DI water	1 M NaCl	[35]

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		with double-skinned substrate						34.5 ± 1.7	3.5 ± 0.6	0.10 [b]	AL-FS	DI water	1 M NaCl	
36	GOT-0.25	TFC flat-sheet membrane	PA/PSf-GO	1.76	0.19	0.11	0.191	40.50	~6.5 [a]	0.16 [b]	AL-DS	DI water	0.5 M NaCl	[36]
								19.77	~3.5 [a]	0.18 [b]	AL-FS	DI water	0.5 M NaCl	
37	PMM_{C300}	Layer-by-layer (LbL) flat-sheet membrane	PAH-PSS/PAN-MOF	~8 [a]	N.A.	N.A.	0.19 ± 0.02	107.4	~0.17 [a]	0.002 [b]	AL-DS	DI water	0.5 M $MgCl_2$	[37]
								~38 [a]	~0.3 [a]	0.01 [b]	AL-FS	DI water	0.5 M $MgCl_2$	
38	Hydrogel/GO	Composite flat-sheet membrane	Hydrogel/PES-GO	1.52 ± 0.12	N.A.	N.A.	0.197 ± 0.021	16.05 ± 1.40	1.27 ± 0.44	0.08 [b]	AL-FS	DI water	0.5 M Na_2SO_4	[38]
39	mLbL-10 TFC	TFC flat-sheet membrane with nonwoven fabric	PA/PEI-PAA/PAN/PET	2.72 ± 0.06	1.07 ± 0.10	0.395 ± 0.045	0.35	32.9	3.77	0.11	AL-DS	DI water	0.5 M NaCl	[39]
								24.6	2.36	0.10	AL-FS	DI water	0.5 M NaCl	
40	PSf_{co}-TFC	TFC flat-sheet membrane	PA/PSf	1.65 ± 0.06	0.12 ± 0.05	0.07 [b]	0.167 ± 0.016	33.1 ± 1.4	2.58 [b]	0.078	AL-DS	DI water	0.5 M NaCl	[40]
								20.1 ± 0.9	2.01 [b]	~0.1 [a]	AL-FS	DI water	0.5 M NaCl	
41	CN/rGO-M-0.5	TFC flat-sheet membrane	PA/PSf-CN/rGO	1.59 [c]	0.329 [c]	0.21	0.163	~21 [a]	~5 [a]	0.24 [b]	AL-FS	DI water	0.5 M NaCl	[41]
42	TFC-D4	TFC flat-sheet membrane	PA/PSf/PET	1.82 ± 0.11	0.28 ± 0.10	0.15	0.195 ± 0.039	60.3	17.6	0.29 [b]	AL-DS	DI water	1 M NaCl	[42]

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				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
		with mesh-reinforced dual-layer substrate						31.1	8.5	0.27 [b]	AL-FS	DI water	1 M NaCl	
43	TFC/PSF 9	TFC flat-sheet membrane with mesh	PA/PSf/polyester	0.91 ± 0.10 [c]	0.25 ± 0.04 [c]	0.27 [b]	0.314 ± 0.029	49.4	~6 [a]	0.12 [b]	AL-DS	DI water	1 M NaCl	[43]
								17.1	~6 [a]	0.35 [b]	AL-FS	DI water	1 M NaCl	
44	TFC-O-II	TFC flat-sheet membrane	PA/CAP	2.85 [c]	0.345 [c]	0.12 [b]	0.0319	~60 [a]	~7 [a]	0.12 [b]	AL-DS	DI water	0.5 M NaCl	[44]
								~45 [a]	~6 [a]	0.13 [b]	AL-FS	DI water	0.5 M NaCl	
45	SPPO/PSf (50:50) – 45 s	TFC flat-sheet membrane	PA/PSf-SPPO	3.55	0.74	0.21 [b]	0.381 ± 0.098	~35 [a]	~5 [a]	0.14 [b]	AL-DS	DI water	0.5 M NaCl	[45]
							0.293 ± 0.022	~22 [a]	~5 [a]	0.23 [b]	AL-FS	DI water	0.5 M NaCl	
46	NC-PVA/PA	TFC flat-sheet membrane with nonwoven-fabric-reinforced nanofiber	PA/PVA/PET	1.69	0.24	0.14 [b]	0.066 ± 0.0079	27.24	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[46]
47	TFN	TFC flat-sheet membrane	PA/PSf-TiO_2 NPs	1.96	0.38	0.1955	0.42	31.1	6.43	0.22	AL-DS	10 mM NaCl	0.5 M NaCl	[47]
								17.1	3.97	0.16	AL-FS	10 mM NaCl	0.5 M NaCl	

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48	TFI-$M_{1.1}$	Thin film inorganic flat-sheet membrane	Silica xerogels/stainless steel mech	1.15	0.648	0.56 [b]	0.038	~25 [a]	4.25 [b]	~0.17 [a]	AL-DS	DI water	0.5 M NaCl	[48]
								~25 [a]	4.25 [b]	~0.17 [a]	AL-FS	DI water	0.5 M NaCl	
49	TFN 0.1	TFC flat-sheet membrane with nonwoven fabric	PA-F-MWCNTs /PSf/PET	4.47 ± 0.24	0.170 ± 0.025	0.042 ± 0.03	0.41 ± 0.1	95	~5 [a]	0.05 [b]	AL-DS	10 mM NaCl	2 M NaCl	[49]
								40	~3 [a]	0.08 [b]	AL-FS	10 mM NaCl	2 M NaCl	
50	sPPSU-2,5	TFC flat-sheet membrane	PA/sPPSU	3.23	1.05	0.33 [b]	0.652	~32 [a]	~5 [a]	0.16 [b]	AL-DS	DI water	0.5 M NaCl	[50]
								~30 [a]	~5 [a]	0.17 [b]	AL-FS	DI water	0.5 M NaCl	
51	TFC-R	TFC flat-sheet membrane	PA/PSf	3.46 ± 0.34	0.40 ± 0.06	0.11 ± 0.01	0.87 ± 0.18	~25 [a]	N.A.	N.A.	AL-DS	10 mM NaCl	0.75 M NaCl	[51]
								~13 [a]	N.A.	N.A.	AL-FS	10 mM NaCl	0.75 M NaCl	
52	-$N(CH_3)_3^+$	TFC flat-sheet membrane with nonwoven fabric	PA-silica NPs/PSf/PET	~2.5 [a]	~1.7 [a]	0.68 [b]	~0.5 [a]	19.5	N.A.	N.A.	AL-FS	DI water	1 M NaCl	[52]
53	TFN0.1	TFC flat-sheet membrane	PA- NaY Zeolite NPs/PSf	2.57	1.57	0.611	0.782 ± 0.160	~22 [a]	N.A.	N.A.	AL-DS	DI water	0.5 M NaCl	[53]
								~12 [a]	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	
54	TMC 0.05	TFC flat-sheet membrane	PA/PSf	1.25 ± 0.17	N.A.	N.A.	0.71 ± 0.14	17.25 ± 0.96	6.56 [b]	0.38±0.056	AL-DS	10 mM NaCl	0.5 M NaCl	[54]

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				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
								9.03±0.44	2.89 [b]	0.32±0.12	AL-FS	10 mM NaCl	0.5 M NaCl	
55	xLbL3	LbL flat-sheet membrane	PAH-PSS/PAN	6.9 ± 1.6	N.A.	0.133 ± 0.018 [d]	N.A.	~60 [a]	6 [b]	~0.1 [a]	AL-DS	DI water	0.5 M $MgCl_2$	[55]
								~30 [a]	9 [b]	~0.3 [a]	AL-FS	DI water	0.5 M $MgCl_2$	
56	NC-FO	TFC flat-sheet membrane with nonwoven-fabric-reinforced nanofiber substrate	PA/PES/PET	1.65 ± 0.14	N.A.	N.A.	0.106 ± 0.008	~35 [a]	N.A.	N.A.	AL-DS	DI water	0.5 M NaCl	[56]
								~35 [a]	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	
57	3#LbL FO	LbL flat-sheet membrane	PAH-PSS/PAN	10.22 ± 2.34	3.46 ± 0.07 [d]	0.338 [d]	0.5 ± 0.2	31.7	46.65	1.48	AL-DS	DI water	1 M $MgCl_2$	[57]
								28.7	17.13	0.60	AL-FS	DI water	1 M $MgCl_2$	
58	TFC-2	TFC flat-sheet membrane	PA/PSf	1.78 ± 0.23	0.34 ± 0.07	0.20 ± 0.06	0.67 ± 0.17	20.5	5.9	0.29 [b]	AL-DS	10 mM NaCl	0.5 M NaCl	[58]
								12.0	4.9	0.41 [b]	AL-FS	10 mM NaCl	0.5 M NaCl	
59	TFC-FO	TFC flat-sheet membrane with nonwoven fabric	PA/PSf/PET	1.16 ± 0.06	0.47 ± 0.11	0.41 [b]	0.492 ± 0.038	~11 [a]	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[59]

	Membrane ID	Membrane structure	Membrane material	Membrane property				FO performance and testing conditions						Reference
				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
60	RGO/CNT	Hollow fiber membrane	GO/PVB-CNT	2.11	0.051	0.024 [b]	0.202	22.6	1.6	0.07	AL-FS	DI water	0.5 M NaCl	[60]
61	100 kDa	TFC hollow fiber membrane	PA/PSf	~0.4 [c]	~0.02 [c]	0.05 [b]	0.725 ± 0.075	~29 [a]	3.3	0.11 [b]	AL-DS	DI water	1 M NaCl	[61]
								~10 [a]	2.1	0.21 [b]	AL-FS	DI water	1 M NaCl	
62	TFC-FO (HF-A)	TFC hollow fiber membrane	PA/PK	1.2 [c]	0.265 [c]	0.22 [b]	0.250	~41 [a]	~12 [a]	0.29 [b]	AL-DS	DI water	0.5 M NaCl	[62]
63	PES-hollow fiber	TFC hollow fiber membrane	PA/PES	2.21 ± 0.09	1.22 ± 0.05	0.55 [b]	1.09 ± 0.083	15.3 ± 1.3	N.A.	N.A.	AL-FS	DI water	0.5 M NaCl	[32]
64	DS#1.5	Double-skinned TFC hollow fiber membrane	PA/PES/PAH-PSS	2.64	0.14	0.05 [b]	N.A.	~40 [a]	4 [b]	~0.1 [a]	AL-DS	DI water	0.5 M NaCl	[63]
								~17 [a]	3.4 [b]	~0.2 [a]	AL-FS	DI water	0.5 M NaCl	
65	LBL-2I	LbL hollow fiber membrane	Poly(styrene sulfonate)-PAH-PDADMAC-PEI/PES	9.8	N.A.	N.A.	N.A.	73	4.38 [b]	0.06	AL-DS	DI water	0.5 M $MgCl_2$	[64]
66	LPR 100	TFC hollow fiber membrane	PA-aquaporin-incorporated	~8 [a]	~1.26 [a]	0.16 [b]	N.A.	55.2 ± 4.5	4.5 ± 0.2	0.08 [b]	AL-DS	DI water	0.5 M NaCl	[65]

	Membrane ID	Membrane structure	Membrane material	Membrane property				FO performance and testing conditions						Reference
				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
			proteoliposome/PES											
67	TFC-TB3	TFC hollow fiber membrane with tribore substrate	PA/matrimid	1.51	0.44	0.29 [b]	1.10	~22 [a]	~2.3 [a]	0.10 [b]	AL-DS	DI water	0.5 M NaCl	[66]
								~7 [a]	~1.5 [a]	0.21 [b]	AL-FS	DI water	0.5 M NaCl	
68	CTA TFC	TFC hollow fiber membrane	PA/CTA	0.85 ± 0.13	0.11 ± 0.02	0.13 [b]	0.236 ± 0.025	27	N.A.	N.A.	AL-DS	DI water	0.58 M NaCl	[67]
								13	N.A.	N.A.	AL-FS	DI water	0.58 M NaCl	
69	TFC 1.5 mol % sPPSU	TFC hollow fiber membrane	PA/PPSU-sPPSU	1.99 ± 0.02	0.0399 ± 0.002	0.02 [b]	0.163	49.39 ± 6.2	11.00 ± 1.36	0.22	AL-DS	DI water	0.5 M NaCl	[68]
								22.51 ± 2.3	5.49 ± 0.35	0.24	AL-FS	DI water	0.5 M NaCl	
70	DL-25K-d	Dual-layer hollow fiber membrane	Torlon® 4000T-MV-PEI-Poly(styrenesulfonate)-PAH-GA/PES	4.10	0.08 g/m² h [d]	N.A.	0.633	39.3	13.76 [b]	0.35	AL-DS	DI water	0.5 M $MgCl_2$	[69]
								20.8	6.45 [b]	0.31	AL-FS	DI water	0.5 M $MgCl_2$	
71	TFC-FO with PES_{water} supports	TFC hollow fiber membrane	PA/PES	1.18	0.135	0.11 [b]	0.219	25.6	3.2	0.13 [b]	AL-DS	DI water	0.5 M NaCl	[70]
								22.5	2.8	0.12 [b]	AL-FS	DI water	0.5 M NaCl	
72	TFC hollow		PA/PES	3.32	0.139	0.04 [b]	0.46	40.3	80.6 [b]	~2 [a]	AL-DS	10 mM NaCl	0.5 M NaCl	[71]

	Membrane ID	Membrane structure	Membrane material	Membrane property				FO performance and testing conditions						Reference
				A (L/(m² h bar))	B_{NaCl} (L/(m² h))	B_{NaCl}/A (bar)	S (mm)	J_v (L/(m² h))	J_s (g/(m² h))	J_s/J_v (g/L)	Membrane orientation	Feed solution	Draw solution	
	fiber membrane	TFC hollow fiber membrane						17.3	17.3 [b]	~1 [a]	AL-FS	10 mM NaCl	0.5 M NaCl	
73	#A-FO	TFC hollow fiber membrane	PA/PES	3.29	0.11	0.03 [b]	0.63 ± 0.02	47.7	3.5	0.07 [b]	AL-DS	DI water	0.5 M NaCl	[72]
							0.49 ± 0.06	18.6	2.0	0.11 [b]	AL-FS	DI water	0.5 M NaCl	
74	#B-FO	TFC hollow fiber membrane	PA/PES	2.22	0.20	0.09 [b]	0.595	32.2	~4 [a]	0.11	AL-DS	DI water	0.5 M NaCl	[73]
								14	1.75	0.13	AL-FS	DI water	0.5 M NaCl	

[a] Data was obtained from the figures in the references. [b] The value was calculated based on the data provided in references. [c] The value was determined by FO experiments. [d] The value was measured using $MgCl_2$ solution as feed.

Table S2. Abbreviations of membrane materials

Abbreviations	Membrane materials
AEPPS	N-aminoethyl piperazine propane sulfonate
CA	Cellulose acetate
CAP	Cellulose acetate propionate
CN/rGO	Reduced graphene oxide modified graphitic carbon nitride
CNT	Carbon nanotube
CTA	Cellulose triacetate
F-MWCNTs	Functionalized multi-walled carbon nanotubes
GO	Graphene oxide
HNT	Halloysite nanotube
IER-Na	Na type strong acid cation exchange resin
LDH	Layered double hydroxide
MOF	Metal–organic framework
PA	Polyamide
PAA	Poly(acrylic acid)
PAH	Poly(allylamine hydrochloride)
PAN	Polyacrylonitrile
PDA	Polydopamine
PDADMAC	Poly(diallyl-dimethylammonium chloride)
PE	Polyethylene
PEI	Poly(ethylene imine)
PES	Poly(ether sulfone)
PET	Poly(ethylene terephthalate)
PFSA	Perfluorosulfonic acid
PK	Polyketone
PPSU	Poly(phenylene sulfone)
PSf	Polysulfone
PSS	Poly(sodium 4-styrene-sulfonate)
PVA	Poly(vinyl alcohol)
PVB	Poly(vinyl butyral)
PVC	Poly(vinyl chloride)
PVDF	Poly(vinylidene fluoride)
SPEEK	Sulfonated poly(ether ether ketone)
SPPO	Sulfonated poly(phenylene oxide)
sPPSU	Sulfonated poly(phenylene sulfone)
SPSf	Sulfonated polysulfone
ZSCSNPs	ZnO-SiO2 core-shell nanoparticles

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