

Supporting Information

Mixed matrix membranes with covalent triazine framework fillers in polymers of intrinsic microporosity for CO₂ separations

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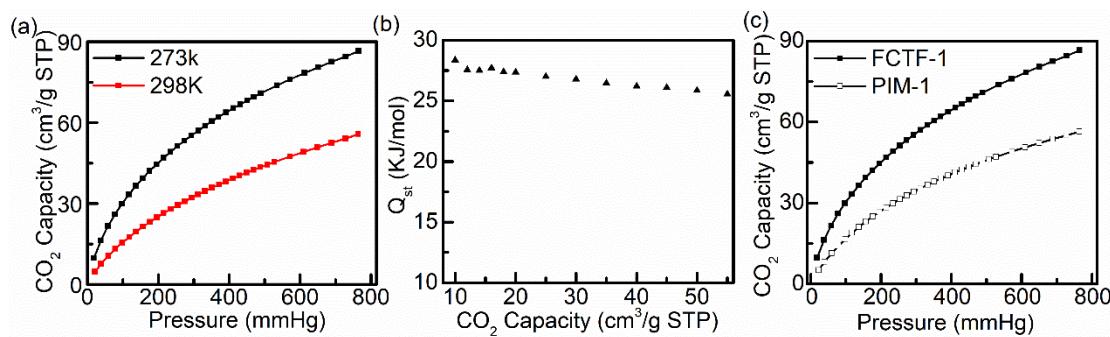


Figure S1 (a) CO₂ adsorption isotherms of FCTF-1 at 273 K and 298 K, (b) the calculated isosteric heat values of CO₂ adsorption of FCTF-1 powder, (c) CO₂ adsorption isotherms of FCTF-1 and PIM-1.



Figure S2 Optical images of (a) a suspension of ground FCTF-1 in CHCl₃ after standing for 2 d, (b) casting solutions of PIM-1 containing different filler-loadings of FCTF-1 after standing for 1 day.

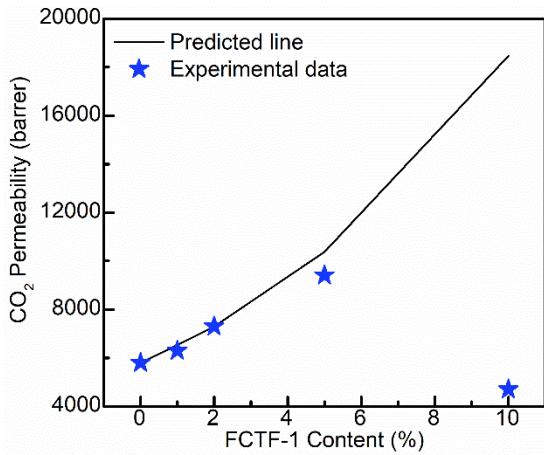


Figure S3. Comparison of Maxwell model predicted values and experimental values.

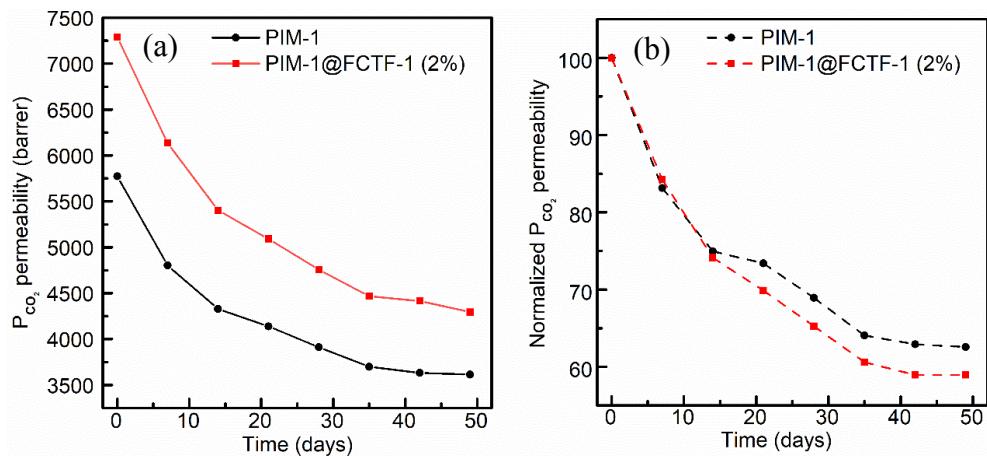


Figure S4. (a) Aging behavior of PIM-1 and PIM-1@FCTF-1 (2%), (b) Normalized CO₂ permeability vs. aging time.

Table S1 Thermal properties of MMMs

W _f (%)	W _l (%)	T ₁ (°C)	T ₂ (°C)
FCTF-1	41	187	438
0	39	410	487
1	33	445	511
2	31	456	516
5	30	383	516
10	32	322	507

W_f: weight ratio of FCTF-1 to PIM-1.W_l: weight loss at 700 °C.T₁: temperature (1% weight loss).T₂: temperature (5% weight loss).**Table S2.** Comparative mechanical properties of various purely polymeric and mixed matrix membranes.

Polymer matrix	Filler loading (%)	Tensile strength (MPa)	Ref.
PIM-1	—	29.3 (± 1.5)	this study
	FCTF-1 (1%)	27.9 (± 1.2)	this study
	FCTF-1 (2%)	23.9 (± 1.4)	this study
	FCTF-1 (5%)	13.1 (± 1.7)	this study
	FCTF-1 (10%)	7.0 (± 1.5)	this study
PIM-1	—	29.0	1
	PAF-1 (10%)	9.0	1
PTMSP	—	23.0	1
	PAF-1 (10%)	18.5	1
6FDA-DAM	—	67.0	2
	3D-COF (5%)	57.0	2
	3D-COF (10%)	43.0	2

Table S3. Comparison of gas separation performance with other related work

Filler	Polymer	Loading (wt%)	P_{CO_2} (barrer)	$\alpha_{\text{CO}_2/\text{CH}_4}$	Ref.
FCTF-1	PIM-1	0	5774	11.51	this study
		1	6292	15.53	this study
		2	7287	16.59	
		5	9422	14.79	
		10	4691	15.46	
PEG-POSS	PIM-1	1	3360	13	3
		2	3381	16	
		5	1875	21	
		10	1309	30	
		2	5236	11.8	4
SNW-1	PIM-1	5	6080	11.8	
		10	7553	13.5	
		15	7654	8.3	
		20	6460	11.8	
		2	842	23.5	5
COF-300	6FDA-DAM	4	972	26.2	
		7.5	1185	30.3	
		13.2	2842	24.6	
		18.3	4746	14.7	
		26.2			
ZIF-8	PIM-1	11	4815	15	6
		28	4270	18.6	
		36	6820	13.4	
		43	6300	14.7	
		2			
ZIF-67	PIM-1	5	4685	13.4	7
		10	4895	14.6	
		20	5206	16.8	
		30	6128	12	
		2			
PEG-2K	PIM-1	2.5	1575	39.2	8
PEG-6K	PIM-1	2.5	1708	37.4	
PEG-10K	PIM-1	2.5	1863	35.4	
PEG-20K	PIM-1	2.5	2278	33.3	

Table S4. Comparison of permeability and selectivity of PIM-1 and PIM-1@FCTF-1 MMMs at 35 °C.

Membrane	Permeability (C ₃ H ₆ , barrer)	Selectivity C ₃ H ₆ /C ₃ H ₈	Feed type	Ref.
pure PIM-1	2813	2.52	mixed gas	this study
PIM-1@FCTF-1 (2%)	1614	3.92	mixed gas	this study
pure PIM-1	2861	2.80	pure gas	9

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