Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Electronic Supporting Information

Fabrication of mixed-matrix membrane containing selective and facilitated CO_2 transport metal-organic framework composite with task-specific ionic liquid for efficient CO_2 separation

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1. Transmission electron microscope (TEM) analysis

The TEM images were investigated using a Tecnai $G^2$20 equipment.

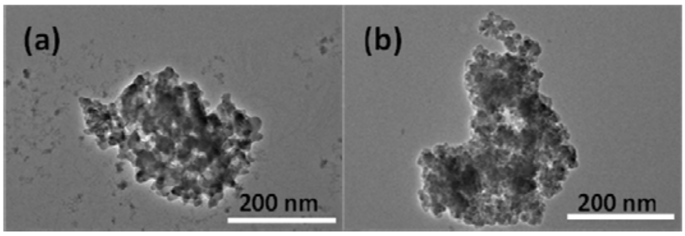

Fig. S1 TEM images of TSIL@NH_2-MIL-101(Cr) (a); NH_2-MIL-101(Cr) (b).

2. EDX-mapping

The EDX-mapping analysis was carried out using a FEI S-4800 equipment.

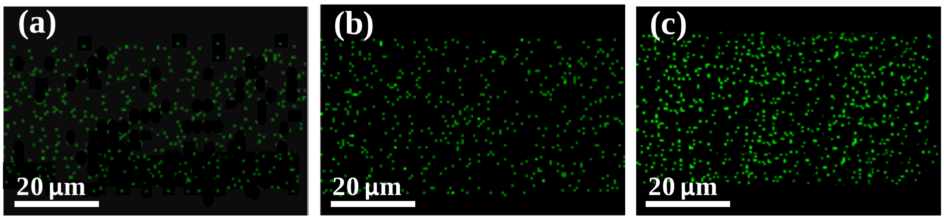

Fig. S2 Cr mapping of (a) 5% TSIL@NH_2-MIL-101(Cr)/PIM-1, (b) 10% TSIL@NH_2-MIL-101(Cr)/PIM-1, (c) 15% TSIL@NH_2-MIL-101(Cr)/PIM-1 membranes.

3. Thermogravimetric (TGA) analyses

Thermal stability of NH_2-MIL-101(Cr), TSIL, TSIL@NH_2-MIL-101(Cr) as well as the fabricated membranes were characterized on a TGA 1/1100 SF instrument with a heating rate of 10 °C/min under nitrogen atmosphere and the resultant thermograms were shown in Fig. S3. In the first step (< 250 °C), the weight loss is due to the loss of the adsorbed water inside the pores. In the second step (250–300 °C), the weight loss is attributed to the decomposition of the NH_2-MIL-101(Cr) powder and TSIL. In the whole process, the TSIL@NH_2-MIL-101(Cr) showed less weight loss than NH_2-MIL-101(Cr) and TSIL, which indicates a better thermal stability due to the interaction between the TSIL and NH_2-MIL-101(Cr).[S1] In the case of membranes, the decomposition of TSIL@NH_2-MIL-101(Cr)/PIM-1 membrane is started at around 400 °C, signifying the TSIL@NH_2-MIL-101(Cr) decomposition. The second stage of weight loss occurs at around 500 °C, which is fully in agreement with the decomposition temperature of PIM-1 membrane. Besides, the TSIL@NH_2-MIL-101(Cr)/PIM-1 membrane shows a better thermal stability than NH_2-MIL-101(Cr)/PIM-1 membrane, which can also confirm the interaction between the TSIL and NH_2-MIL-101(Cr) in TSIL@NH_2-MIL-101(Cr).

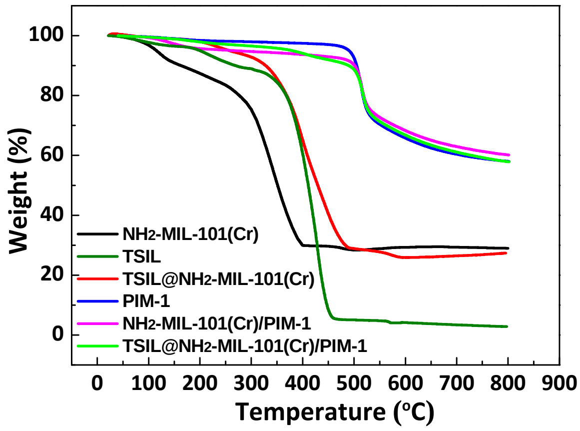

Fig. S3 Thermal stability of the samples.

4. Long-term operation stability measurement

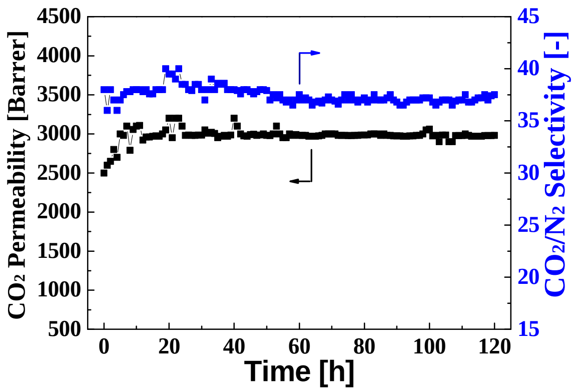

Fig. S4 Evolution of the CO_2 permeability (left-axis) and the CO_2/N_2 selectivity (right-axis) of TSIL@MOF/PIM-1 membrane with 5 wt% loading. Operation conditions: T = 298 K, ΔP = 3 bar.

5. Gas separation performance comparison

Table S1 Comparison of gas separation performance of related membranes

Filler	Polymer	Loading (wt %)	Operation conditions		$P(CO_2)$ [Barrer]	α (CO_2/N_2)	Ref.
			T (℃)	ΔP (bar)			
Cu 1,4-BDC	PVAc	15	30	4	3.3	35.4	S2
ZIF-8	Matrimd	50	25	2.7	4.7	26.2	S3
HKUST-1	PMDA-ODA	6	25	10	227.2	5.5	S4
ZIF-8	PPEES	30	30	1	50	24.5	S5
ZIF-7	Pebax	22	20	2.75	111	97	S6
HKUST-1	PPO	40	30	-	115	26	S7
ZIF-8	Pebax	35	25	6	1287	32.3	S8
$[Cd_2 6FDA(H_2O)$-$5H_2O$	6FDA-ODA	10	25	2	37.8	35.1	S9
ZIF-8	6FDA-durene	30	25	6	2185.5	17	S10
MIL-53(Al)	Matrimd	37.5	35	2	40	95.2	S11
c-MOF-5	PEI	25	25	6	5.4	28.4	S12

HKUST-1	Ultem	35	35	3.5	4.1	28	S13
ZIF-71	6FDA-durene	20	35	3.5	4006	12.9	S14
PEG−PEI−GO	Pebax	10	25	1	1330	120	S15
Mg_2(bobdc)	PI	10	25	2	850	23	S16
GO	Pebax	0.1	25	3	100	91	S17
PEI@MIL-101(Cr)	SPEEK	40	25	1.5	2490	80	S18
NH_2-MIL-101(Al)	6FDA-DAM	20	25	1	737	26.3	S19
ZIF-8	PIM-1	39	22	1	4270	21.89	S20
PAF-1	PIM-1	30	25	1	3250	22	S21
Ti_5UIO-66	PIM-1	5	25	2	5340	24	S22
ZIF-71	UV-PIM-1	30	35	3.5	3458.6	26.9	S23
CC3	PIM-1	30	25	1	5430	20	S24
MFI	PIM-1	23.5(v%)	25	1	2530	30	S25
RTIL@ZIF-8	PSF	6(v%)			312	117	S26
RTIL	PVDF	PVDF/RTIL (1/2)	35	2	1778	41.1	S27
ZIF-8	P[vbim][Tf_2N]	18.9	35	3.5	198.8	19.5	S28
[emim][Tf_2N]/ZIF-8	P[vbim][Tf_2N]	23.7			693.6	19.6	
--	Cellulose acetate		30		6.3	30	S29
--	Ethyl cellulose		30		26.5	8.28	
--	Polycarbonate, brominated		30		4.23	23.5	
--	PDMS		30		2700	10.8	
--	Matrimid		30		10.7	33.4	
--	Polymethylpentene		30		84.6	12.63	
--	Polyphenyleneoxide		30		75.8	19.9	
--	Polysulfone		30		5.6	22.4	
--	Polyetherimide		30		1.32	28.09	
	PIM-1		25	3	2430	16.99	This work
TSIL@NH_2-MIL-101(Cr)	PIM-1	5	25	3	2979	37.24	

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