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

Supplementary Figures and Tables

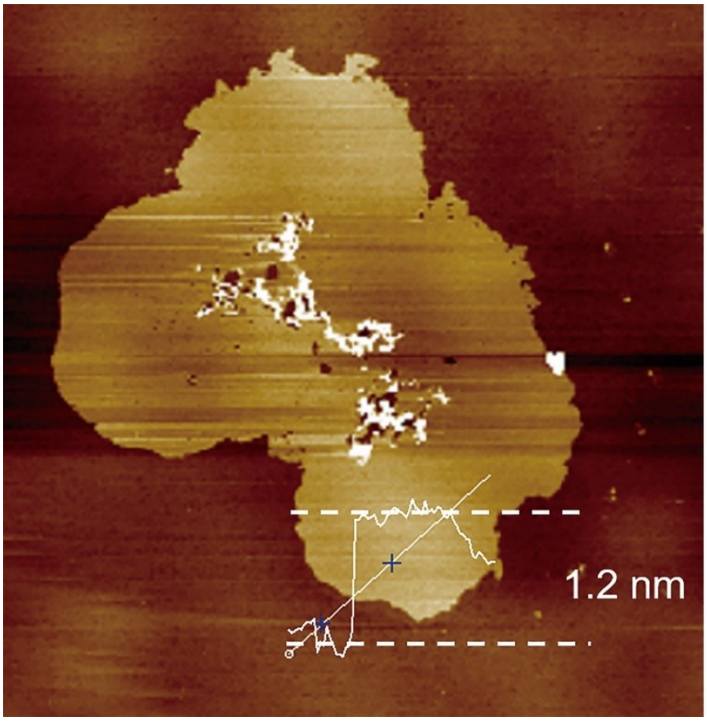

Figure S1 The AFM image of MoS_2 single layer.

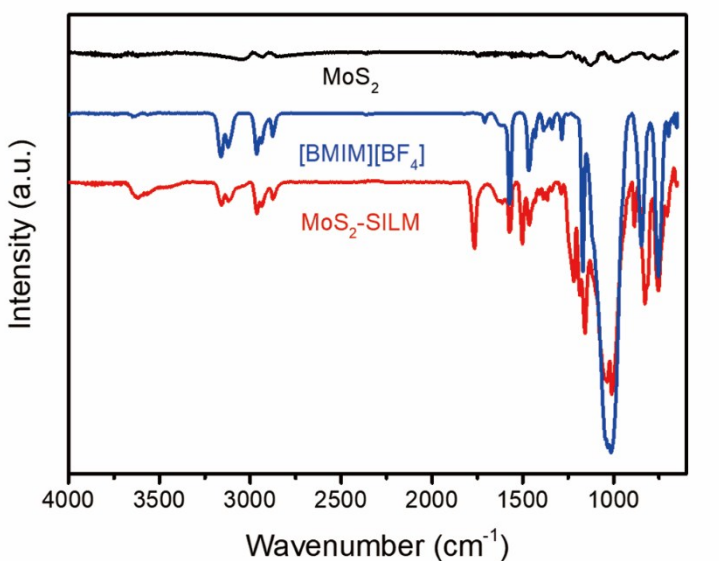

Figure S2 The FTIR spectra of MoS_2, [BMIM][BF_4] and MoS_2-SILM. Detail data are shown in Table S1.

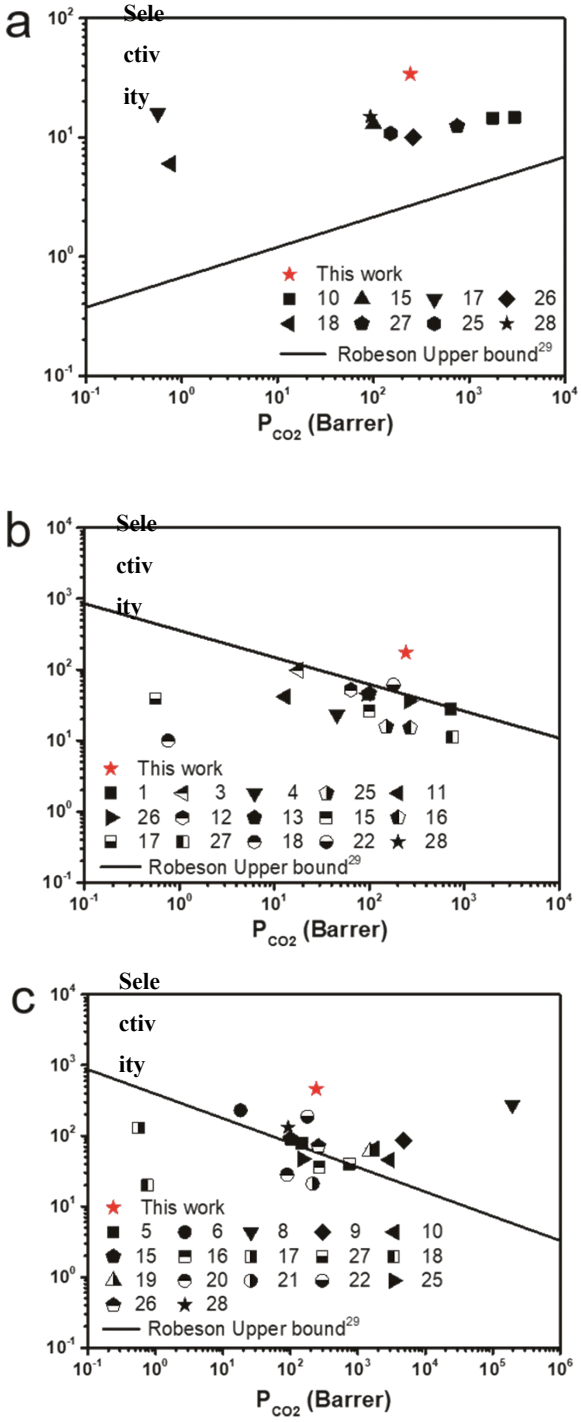

Figure S3 The separation performance (selectivity vs. permeability) of MoS_2-SILM under EEF compared with other membranes. (a) CO_2/H_2, (b) CO_2/CH_4 and (c) CO_2/N_2. The detail data is shown in Table S2 and from the Supplementary references.

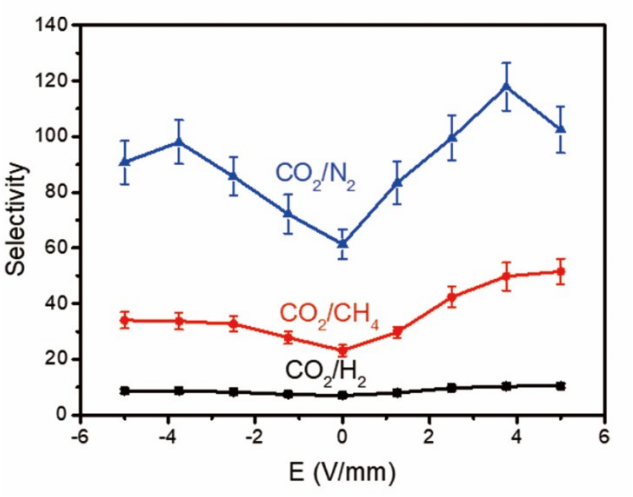

Figure S4 The mixed gas selectivity of MoS_2-SILM under EEF.

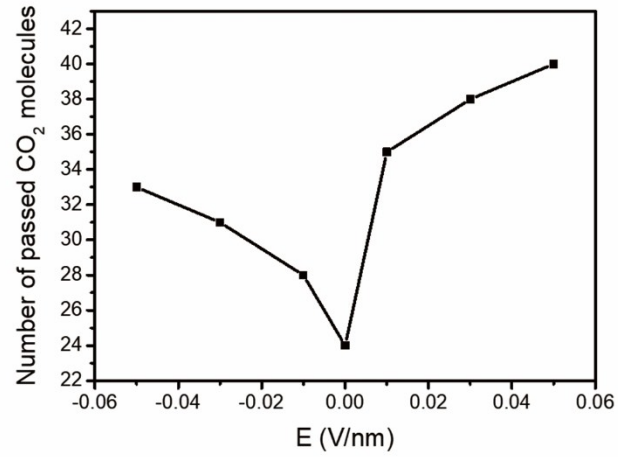

Figure S5 Molecular simulated CO_2 permeance under EEF.

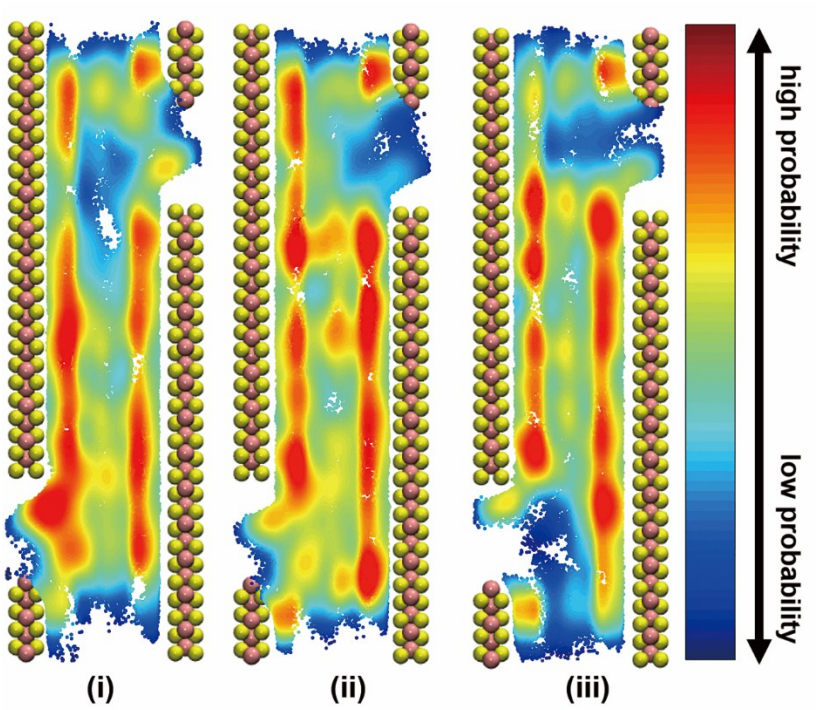

Figure S6 The density map of $[BMIM]^+$ inside the nanochannel under EEF of (i) E=-0.03 V/nm, (ii) E=0 V/nm, (iii) E=0.03 V/nm. Blue indicates the region that low probability to find $[BMIM]^+$, while red region indicates the high probability of finding $[BMIM]^+$.

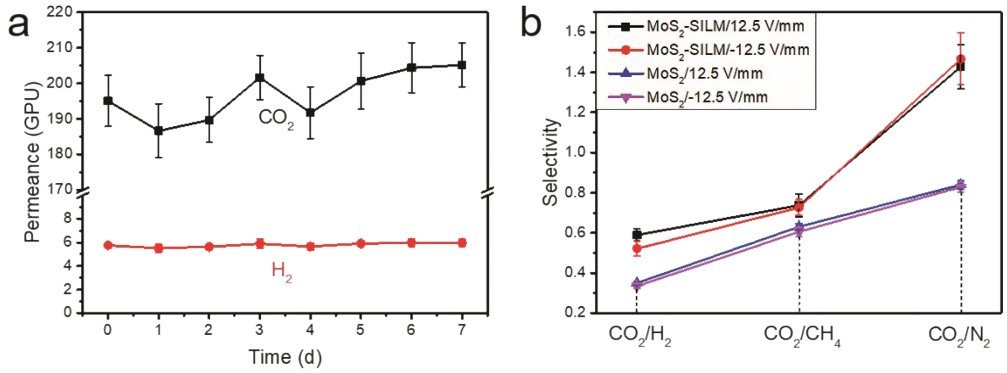

Figure S7 The durability of MoS_2-SILM. (a) is the permeance of CO_2 and H_2 tested under 3.75 V/mm for a week; (b) is the gas selectivity of MoS_2-SILM and MoS_2 under 12.5 V/mm and -12.5 V/mm after 1 day.

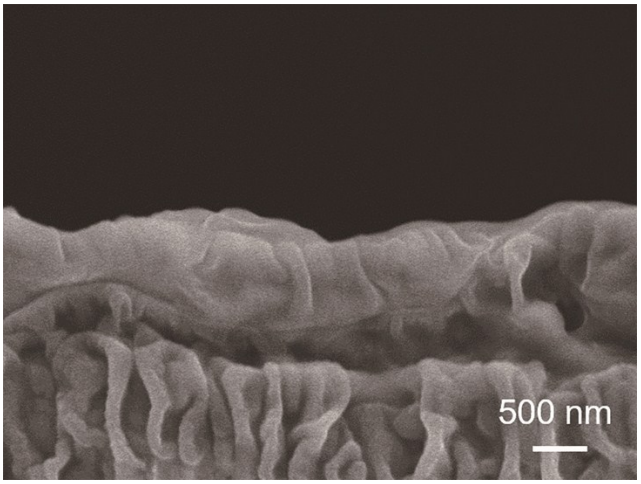

Figure S8 Cross-section SEM image of MoS_2-SILM after testing under 12.5 and -12.5 V/mm.

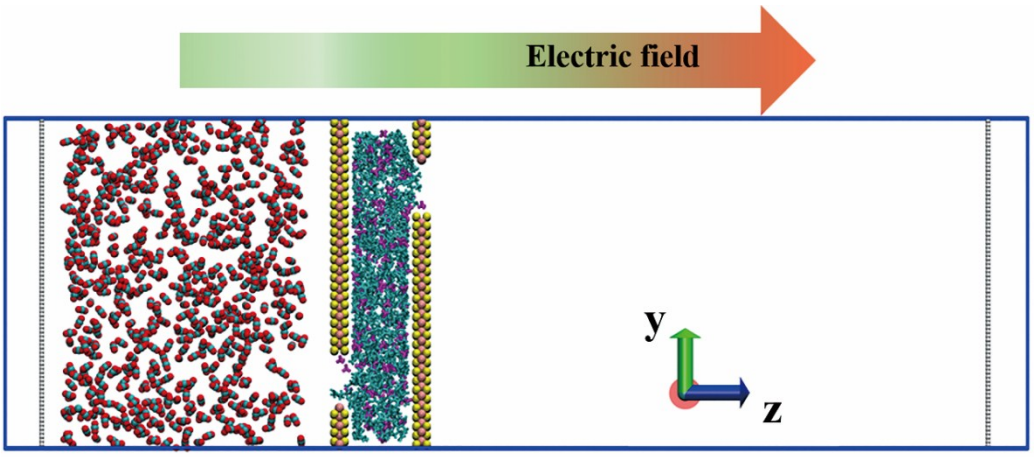

Fig. S9 A bichamber system for simulations of CO_2 permeance through the MoS_2-SILM. White, cyan, and red balls denote helium, carbon, and oxygen, respectively. Green-cyan and magenta stick represent $[BMIM]^+$ and $[BF_4]^-$ ions.

Table S1 The data of FTIR peaks in Fig. S2.

[BMIM][BF_4] (cm^{-1})	MoS_2-SILM (cm^{-1})	Shifts (cm^{-1})	Assignment
3160.81	3158.88	-1.93	νC4-H, νC5-H
3122.24	3118.38	-3.86	νC2-H
2939.03	2937.10	-1.93	νCH_2
2877.32	2875.39	-1.93	νCH_2
1708.65	1764.57	55.92	
1621.86	1614.15	-7.71	
1465.66	1463.73	-1.93	νCH_3
1384.66	1386.59	1.93	wCH_2
1373.09	1363.45	-9.64	νC2N1C5, wCH_2
1338.38	1340.31	1.93	νN-Bu, N-Me
1284.38	1288.24	3.86	νBF_4
1253.52			tCH_2, rC2-H
	1218.81		νBF_4
1168.67	1157.10	-11.57	νN-Bu, N-Me
1031.74	1035.60	3.86	νBF
1014.39	1010.53	-3.86	νBF_4
908.32	919.89	11.57	
846.61	827.32	-19.29	rC4-H, rC5-H
808.04	813.82	5.78	νC-C-C
696.19	705.83	9.64	νN-Bu, N-Me

Table S2 The data of gas separation performance of different membranes in Figure 3.

Number	Membrane	P_{CO2} (Barrer)	P_{CO2} (GPU)	CO_2/H_2	CO_2/CH_4	CO_2/N_2	Ref
1	ZIF-90/6FDADAM	720	12		28		1
2	PSF	-	19.86		23.12		2
3	DDR	17.9	35.8		98		3
4	MIL-53-NH2/organosilica	45.6	430		23.2		4
5	MMP-3/mPSf	150	3000			78	5
6	PAMAM dendrimer	18.3	61			230	6
7	DNMDAm–DGBAmE–TMC/PDMS/PS	-	1601			138	7
8	PVAm–PIP/PS	195000	6500			277	8
9	DAmBS–DGBAmE–TMC/PDMS/PS	4781	5831			86	9
10	SIPN:PEGMEA:PEGDA:PEGDME	2980	11.9-14.9	14.7		45.7	10
10	SIPN:PEGDA:PEGDME	1767	7.1-8.8	14.5		65.9	10
11	Matrimid® ZIF-8	12.96	180		41.5		11
12	6FDA-DAT/Ni2(dodbc)	63.9	0.91-1.6		52		12
13	6FDA-ODA UiO-66	100	1.26-2.52		46.1		13
14	Pebax/[emim][BF4]/GO	-	981			44	14
15	Pebax/GO	100	20	13	26	91	15
16	Pebax/[emim][BF4]	269	306		15	36	16
17	PAN/[emim][Ac]GO/PTMSP	0.56	37	16	39	130	17
18	GO	0.76	110	6	10	20	18
19	0.1water-[BMIM][BF_4]-PES	1518	13.8			60	19
20	[BMIM][BF_4]/AgO	89.7	14.1		-	28.2	20
21	[BMIM][BF_4]/CuO	214.84	52.4		-	21	21
22	Pebax/0.5%Ag/50%[BMIM][BF_4]	180	3.2		61	187.5	22
23	[BMIM][BF_4]/$LiBF_4$	-	13.36		8.25	8.4	23
24	[BMIM][BF_4]/cyanuric chloride	-	19.2		10.7	11	24
25	Pebax®/PEG	151	2.52	10.8	15.5	47	25
26	IL-Pebax 165/ZIF-8	261	20	10	36	71	26
27	PEO-PBT/PEG-DBE (PAN-PDMS)	750	15	12.4	11.2	40	27
28	MoS2-[BMIM][BF_4] (1940 nm)	92.9	47.88	14.95	43.52	131.42	28
29	MoS2-[BMIM][BF_4] (1120 nm) under positive EEF	243	195	34	174	462	This work

Table S3 Lennard-Jones parameters and atom charge of MoS_2 used in this work.[30, 31]

	CO_2		MoS_2	
	C	O	Mo	S
ε (Kcal/mol)	0.0559	0.1600	0.0135	0.4612
σ （Å）	2.7570	2.5650	4.2000	3.1300
q （e）	0.6512	-0.3256	0.7600	-0.3800

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