



Figure S1: Surface images of synthesized membranes

Table S1: The pure gas permeability and ideal gas selectivity of DES-ceria NPs based MMMs

Membrane	Permeability (Barrer)			Selectivity	
	CO ₂	CH ₄	N ₂	CO ₂ /CH ₄	CO ₂ /N ₂
M-0	6.7	0.27	0.25	24.81	26.8
M-1	9.9	0.32	0.3	30.94	33
M-2	13	0.37	0.35	35.14	37.14
M-3	14.9	0.39	0.38	38.21	39.21
M-4	17.2	0.41	0.42	41.95	40.95

Table S2: The mixed gas permeabilities and selectivities of DES-ceria NPs based MMMs

Membrane	Permeability (Barrer)		Selectivity	Permeability (Barrer)		Selectivity
	CO ₂	CH ₄	CO ₂ /CH ₄	CO ₂	N ₂	CO ₂ /N ₂
M-0	6.06	0.26	23.31	6.36	0.25	25.44
M-1	9.2	0.31	29.68	9.5	0.31	30.65
M-2	12.7	0.39	32.56	12.8	0.36	35.56
M-3	14.5	0.43	33.72	14.7	0.4	36.75
M-4	16.3	0.46	35.43	16.9	0.43	39.3