

Supplementary Materials: Mixed Matrix Membranes Based on Torlon® and ZIF-8 for High-Temperature, Size-Selective Gas Separations

Matilde De Pascale ^{1,2}, Francesco Maria Benedetti ^{1,3}, Elsa Lasseguette ⁴, Maria-Chiara Ferrari ⁴, Kseniya Papchenko ^{1,4}, Micaela Degli Esposti ^{1,5}, Paola Fabbri ^{1,5} and Maria Grazia De Angelis ^{1,4,5,*}

¹ Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, 40131 Bologna, Italy, micaela.degliesti@unibo.it (M.D.E.); p.fabbri@unibo.it (P.F.)

² GVS S.p.A via Guido Rossa 30, 40069, Zola Predosa (BO), Italy; matilde.depascale@gvs.it (M.D.P.)

³ Osmoses Inc., 444 Somerville Ave, Somerville, MA 02143, USA, fmben@mit.edu.

⁴ School of Engineering, University of Edinburgh, Sanderson Building, Robert Stevenson Road, Edinburgh, EH9 3FB, Scotland, UK; K.Papchenko@sms.ed.ac.uk (K.P.); E.Lasseguette@ed.ac.uk (E.L.); M.Ferrari@ed.ac.uk (M.-C.F.); grazia.deangelis@ed.ac.uk (M.G.D.A.)

⁵ Italian Consortium for Science and Technology of Materials (INSTM), 50121 Firenze, Italy

* Correspondence: grazia.deangelis@ed.ac.uk

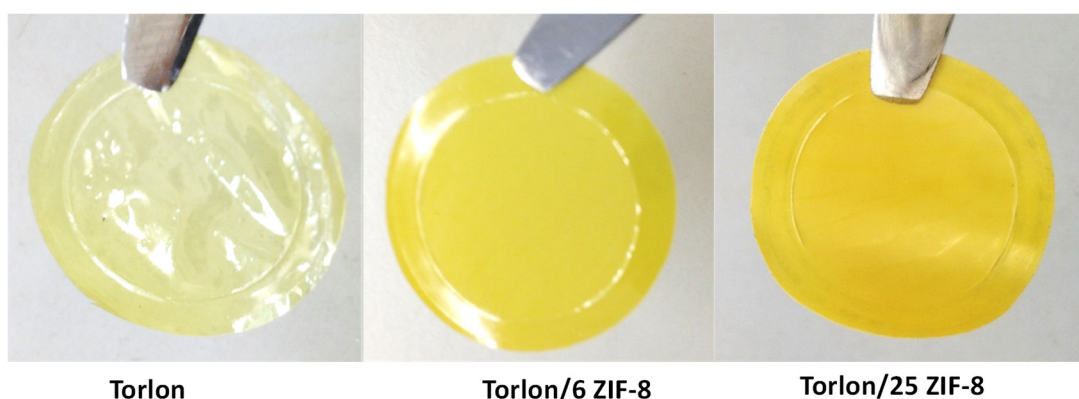


Figure S1. Pictures of the membranes produced: Torlon, Torlon/6 ZIF-8, Torlon/25 ZIF-8.

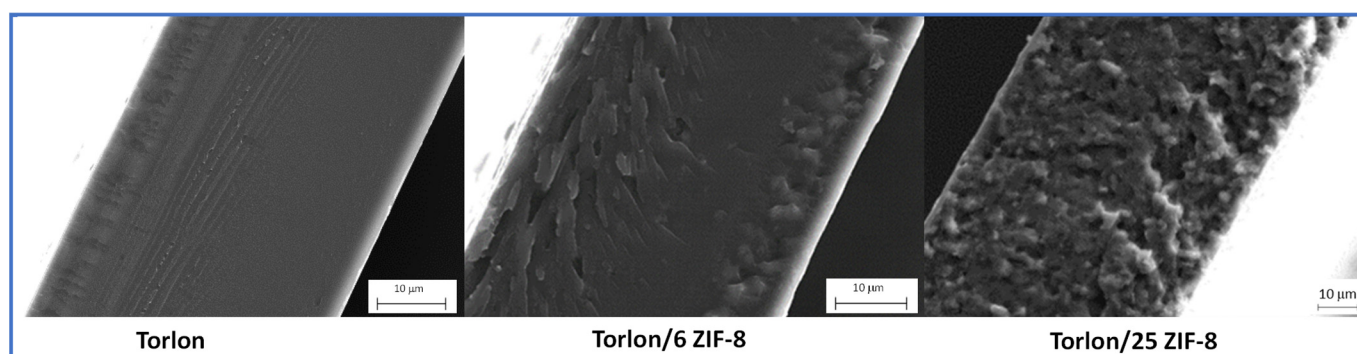


Figure S2. SEM images of cross sections of Torlon, Torlon/6 ZIF-8, Torlon/25 ZIF-8 samples.

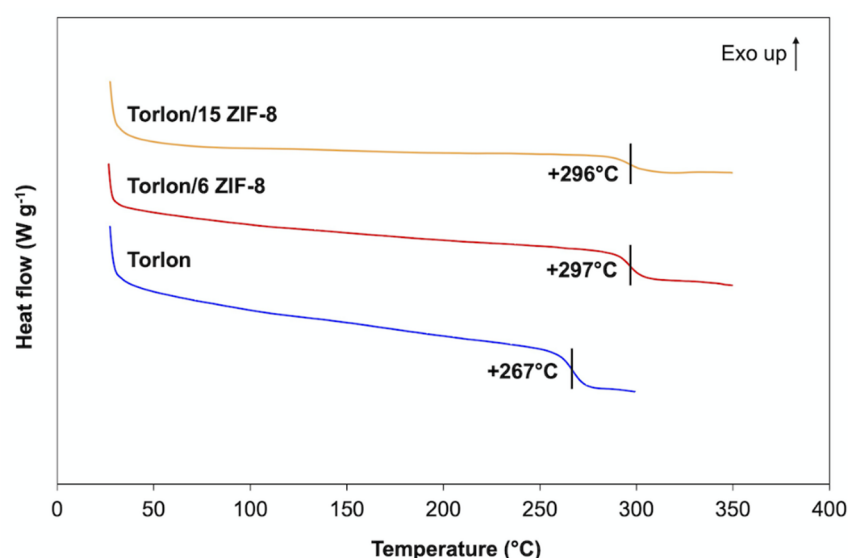


Figure S3. DSC thermograms of Torlon, Torlon/6 ZIF-8 and Torlon/15 ZIF-8 samples.

Table S1. MMM samples produced, thickness and tests performed.

ZIF-8 Weight %	Sample ID	Thickness (μm)	Permeability Tests	SEM Tests	DSC Tests
0	Torlon	10.5 \pm 1.4	He, CO ₂ , 35°C, 65°C	x	x
6	Torlon/6 ZIF-8	45.5 \pm 1.9	He, H ₂ , CO ₂ , 35°C, 65°C	x	x
15	Torlon/15 ZIF-8	-	-	-	x
25	Torlon/25 ZIF-8	64.7 \pm 5.0	He, CO ₂ , 35°C, 65°C	x	-

Table S2. Gas permeability data in Torlon® flat sheet membranes from this work and the literature.

Polymer Density	Permeability (Barrer)						T	Source	Notes
	He	H ₂	O ₂	N ₂	CH ₄	CO ₂			
1.252	-	3.730	0.130	0.018	0.013	0.541	°C 35	[1]	a
n.r.	5.53	4.44	0.212	0.037	0.030	0.83	35	[2]	b
n.r.	4.4 \pm 0.2	-	0.12 \pm 0.006	0.014 \pm 0.0007	0.009 \pm 0.0004	0.47 \pm 0.02	35	[3]	c
1.252 [1]	3.9 \pm 0.6	-	-	-	-	0.47 \pm 0.06	35	This work	d

^a Torlon 4000 TF, solvent NMP, dense films 50 microns, thermal treatment at 250°C for 12 h, upstream pressure 3.5 atm

^b Torlon 4000 T, solvent NMP, upstream pressure 10 atm

^c Torlon 4000T-LV, dense film, solvent NMP, membrane treated at 310°C for 1d

^d Torlon 4000TF, dense film, solvent NMP, membrane treated at 200°C under vacuum overnight, upstream pressure 1.3 bar, downstream pressure vacuum.

Table S3. Gas permeability data in Torlon/ZIF-8 mixed matrix membranes from this work and for ZIF-8 from the literature. Data marked with an asterisk are estimated values based on linear interpolation between permeability and kinetic diameter in each matrix.

Permeability (Barrer)	He	H ₂	CO ₂	He	H ₂	CO ₂
		35°C			65°C	
Torlon	3.9 \pm 0.6	2.43*	0.47 \pm 0.06	6.4 \pm 1.0	3.97*	0.72 \pm 0.09
Torlon/6 ZIF-8	5.3 \pm 0.2	3.8 \pm 0.2	0.97 \pm 0.04	9.0 \pm 0.4	7.0 \pm 0.3	1.4 \pm 0.1
Torlon/25 ZIF-8	10.0 \pm 0.9	6.66*	2.20 \pm 0.2	19.6 \pm 1.6	13.0*	4.2 \pm 0.4
20-35°C						
ZIF-8 [4,5]	3000 \pm 1322		1640 \pm 712			

Table S4. Ideal selectivity values in Torlon/ZIF-8 mixed matrix membranes from this work and 8 from the literature.

Ideal Selectivity	He/CO ₂	H ₂ /CO ₂	He/CO ₂	H ₂ /CO ₂
	35°C		65°C	
Torlon	8.2	5.2*	8.9	5.5*
Torlon/6 ZIF-8	5.4	3.9	6.6	5
Torlon/25 ZIF-8	5.0	3.0*	4.6	3.1*
20–35°C				
ZIF-8 [4,5]	1.8	3.9		

Table S5. Gas diffusivity and ideal diffusivity-selectivity in Torlon/ZIF-8 mixed matrix membranes.

	Diffusivity (cm ² /s)				Diffusivity-Selectivity α_D	
	He	CO ₂	He	CO ₂	He/CO ₂	
	35°C		65°C		35°C	65°C
Torlon	(1.6±0.4)×10 ⁻⁷	(3.5±1)×10 ⁻¹⁰	(1.6±0.4)×10 ⁻⁷	(1.4±0.4)×10 ⁻⁹	448	116
Torlon/6 ZIF-8	(4.4±0.4)×10 ⁻⁷	(9.6±0.8)×10 ⁻¹⁰	(4.5±0.4)×10 ⁻⁷	(2.3±0.2)×10 ⁻⁹	457	198
Torlon/25 ZIF-8	(6.6±1)×10 ⁻⁷	(2.3±0.4)×10 ⁻⁹	(1.3±0.2)×10 ⁻⁶	(9.3±1.4)×10 ⁻⁹	290	139

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