

Supporting Information

Separation of refrigerant gas mixtures containing R32, R134a and R1234yf through poly(ether-block-amide) membranes

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Supporting information consists of:

- Number of pages: 6
- Number of tables: 5
- Number of figures: 4

SECTION A. EXPERIMENTAL

Table S1. Experimental conditions followed for the preparation of the polymeric films.

Polymer	Solution preparation			Solvent evaporation		
	Solvent	Temperature (°C)	Time (h)	Absolute pressure (mbar)	Temperature (°C)	Time (h)
Pebax® 1074	n-butanol	60		300	40	
Pebax® 1657	ethanol/water (70/30 wt%)	70	24	500	40	24
Pebax® 2533	i-propanol/n-butanol (50/50 wt%)	80		400	40	

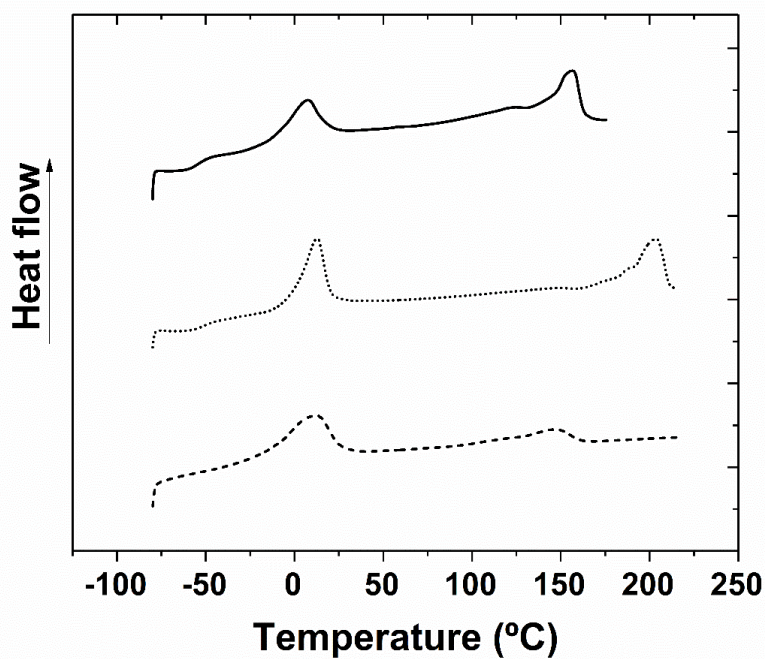


Figure S1. DSC thermograms (second heating) of films of Pebax® grades 1074 (solid line), 1657 (dotted line) and 2533 (dashed line). Heating rate: 15 °C min⁻¹.

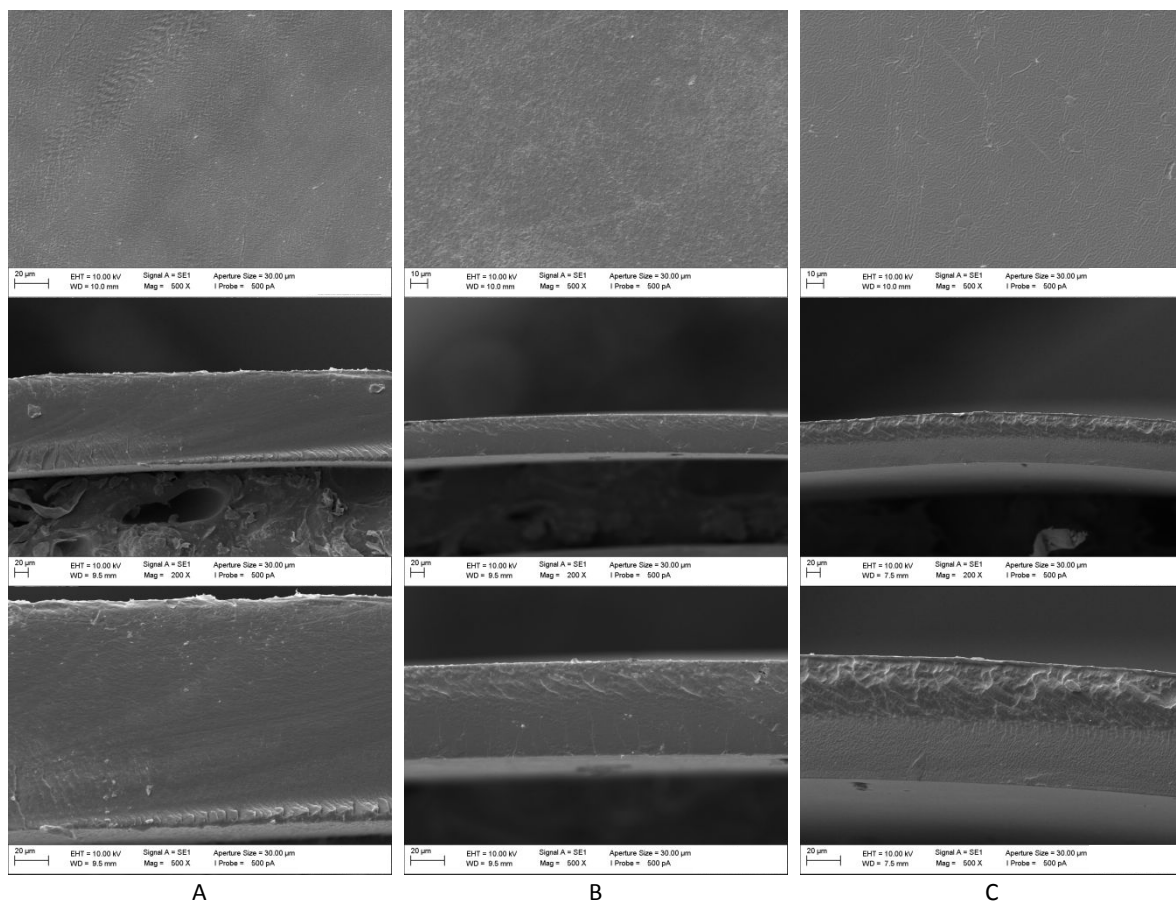


Figure S2. SEM images of the surface morphology (top, 500X) and cross-section (middle, 200X; and bottom, 500X) of: A) Pebax® 1074, B) Pebax® 1657 and C) Pebax® 2533 membranes.

SECTION B. RESULTS

Table S2. Permeability data of fluorinated gases R32, R134a and R1234yf through Pebax® membranes at 30 °C and several feed pressures.

Gas	Permeability (barrer)				
	Pressure (bar)				
	1.3	2.0	3.0	4.0	5.0
Pebax® 1074:					
R32	172.8	196.2	222.8	246.3	267.8
R134a	90.7	115.3	147.0	183.8	229.5
R1234yf	24.3	30.7	36.9	47.8	57.1
Pebax® 1657:					
R32	110.2	123.3	139.9	155.8	172.5
R134a	48.2	58.8	78.2	103.8	137.6
R1234yf	10.8	11.6	13.2	15.3	17.8
Pebax® 2533:					
R32	237.3	253.3	271.2	288.0	304.5
R134a	117.4	131.3	151.0	174.9	204.6
R1234yf	61.0	66.2	73.9	83.7	95.7

Table S3. Permeability data of nitrogen and hydrofluorocarbon/nitrogen selectivity through Pebax® membranes at 30 °C and 1.3 bar.

Polymer	N ₂ Permeability (barrer)	Selectivity		
		R32/N ₂	R134a/N ₂	R1234yf/N ₂
Pebax® 1074	6.5	26.6	14.0	3.7
Pebax® 1657	1.3	84.8	37.1	8.3
Pebax® 2533	8.1	29.3	14.5	7.5

Table S4. Ideal selectivity data of the gas pairs R32/R1234yf, R134a/R1234yf and R32/R134a through Pebax® membranes at 30 °C and several feed pressures.

Gas	Ideal selectivity				
	Pressure (bar)				
	1.3	2.0	3.0	4.0	5.0
Pebax® 1074:					
R32/R1234yf	7.1	6.4	6.0	5.2	4.7
R32/R134a	1.9	1.7	1.5	1.3	1.2
R134a/R1234yf	3.7	3.8	4.0	3.9	4.0
Pebax® 1657:					
R32/R1234yf	10.2	10.6	10.6	10.2	9.7
R32/R134a	2.3	2.1	1.8	1.5	1.3
R134a/R1234yf	4.5	5.1	5.9	6.8	7.8
Pebax® 2533:					
R32/R1234yf	3.9	3.8	3.7	3.4	3.2
R32/R134a	2.0	1.9	1.8	1.6	1.5
R134a/R1234yf	1.9	2.0	2.0	2.1	2.1

Table S5. Concentration of R32, R134a and R1234yf in Pebax® 1657 polymer matrix and Henry's law solubility coefficients (k_D) at 30 °C.

Gas	f (bar)	C (cm ³ _{STP} cm ⁻³)	k_D (cm ³ _{STP} cm ⁻³ bar ⁻¹)	R^2
R32	0.432	1.770	4.13	0.9999
	0.901	3.725		
	1.101	4.471		
	1.623	6.746		
R134a	0.383	1.941	5.51	0.9997
	0.853	4.488		
	1.138	6.307		
	1.516	8.481		
R1234yf	0.543	0.806	1.57	0.9997
	1.043	1.581		
	1.326	2.085		
	1.808	2.887		

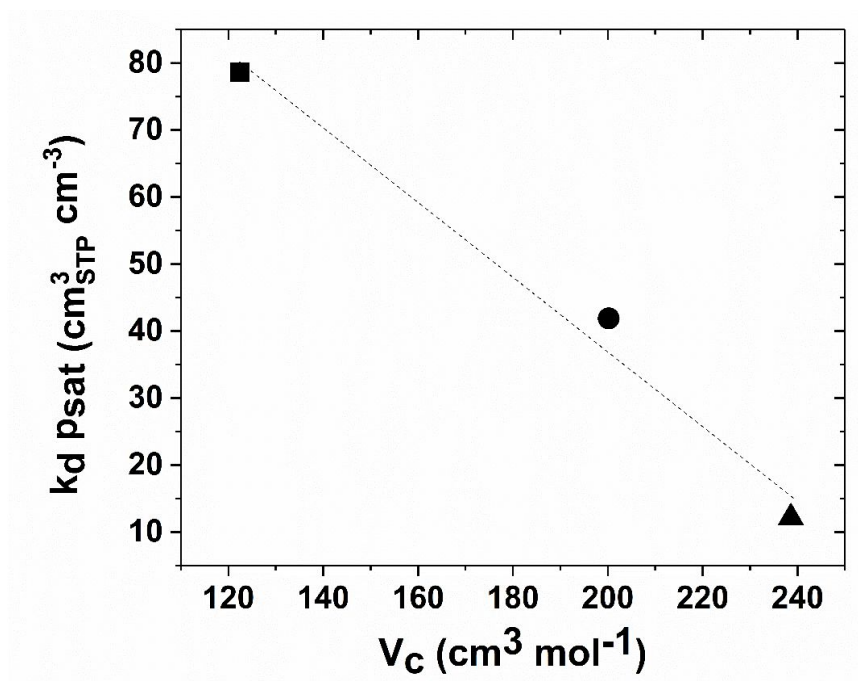


Figure S3. Relationship between activity-basis Henry's law coefficient and critical volume (penetrant size) of R32 (■), R134a (●) and R1234yf (▲) in Pebax® 1657 at 30 °C. Dashed line is a guide to the eye.

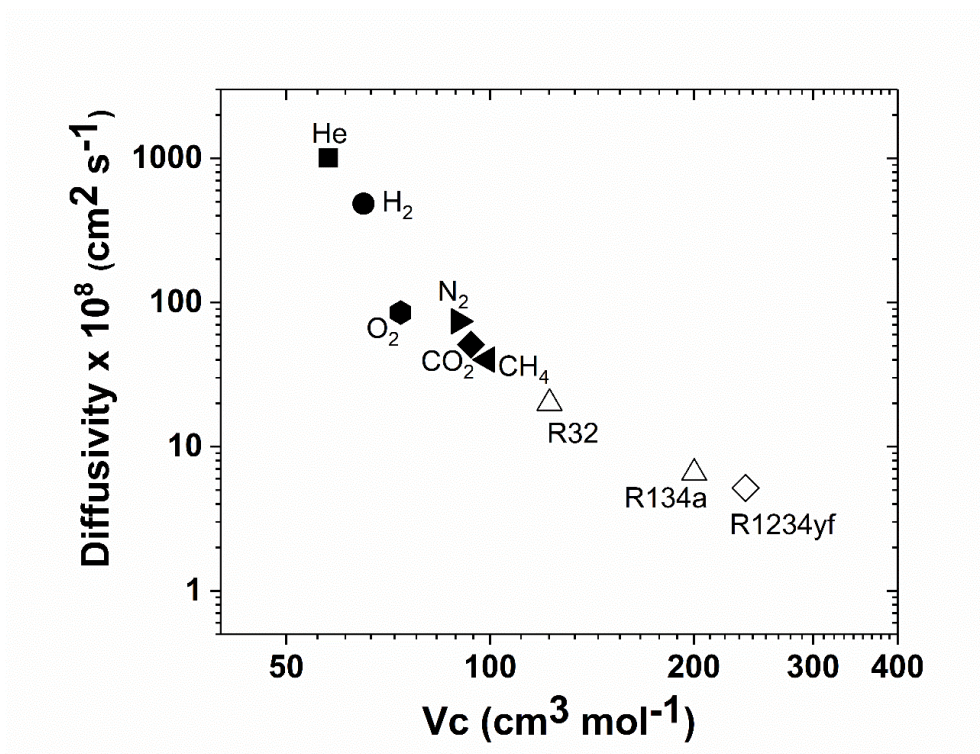


Figure S4. Diffusion coefficients as a function of gas critical volume (penetrant size) in Pebax® 1657. Data of N₂, H₂, O₂, He, CO₂ and CH₄ reported by Bernardo et al.¹

REFERENCES

- (1) Bernardo, P.; Jansen, J. C.; Bazzarelli, F.; Tasselli, F.; Fuoco, A.; Friess, K.; Izák, P.; Jarmarová, V.; Kačírková, M.; Clarizia, G., Gas transport properties of Pebax®/room temperature ionic liquid gel membranes. *Sep. Purif. Technol.* **2012**, 97, 73-82.