

BOOK OF ABSTRACTS ▶▶▶



The 9th International Conference on
Energy and Environment Research

“Greening Energy to Shape a Sustainable Future”

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“Greening Energy to Shape a Sustainable Future”

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CONFERENCE PROGRAM

Offline Conference ISEP, Polytechnic of Porto (P.Porto), Portugal				Online Conference ZOOM with Portugal Time (GMT+1)			
12 September ISEP, I building, Room 306				12 September Test by ZOOM ID: 85809270050			
10:00-12:00		Registration & Collecting Materials		10:00-11:00		14:00-15:00	
				Session 9A		Session 3C	
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13 September Room A & ZOOM ID: 85809270050		14 September Room A & ZOOM ID: 85809270050		15 September ZOOM ID: 85809270050		16 September ZOOM ID: 85809270050	
09:15-09:30		Opening Ceremony		08:45-09:00		Welcome Online	
Session 1A		Session 4B		Session 9A		Session 4C	
09:30-10:15		09:30-10:15		09:00-09:45		09:00-10:00	
E043		E097		E027		E077	
E078		E099		E089		E030	
E079		E102		E105		E059	
						E025	
Session 2A		Session 7A		09:45-10:00		10:00-10:15	
10:15-11:15		10:15-11:15		Coffee Break		Coffee Break	
E026		E047		Session 5C		Session 4D	
E093		E086		10:00-11:00		10:15-11:00	
E104		E119		E109		E019	
E129		E064		E113		E114	
				E107		E130	
11:15-11:45		11:15-11:45		E031			
Coffee Break		Coffee Break		11:00-11:15		11:00-11:15	
Session 3A		Session 3B		Coffee Break		Coffee Break	
11:45-12:45		11:45-13:00		Session 8B		OF Session 2 + Poster C	
E053		E041		11:15-12:30		11:15-12:00	
E042		E083		E124		E073 / E035	
E076		E112		E063		E128 / E016	
E075		E081		E048		E006 / E012	
		E103		E049		E014 / E037	
				E082		E039 / E095	
						E101	
12:45-14:00		13:00-14:00		12:30-14:00		12:15-14:00	
Lunch Break & Poster A		Lunch Break & Poster B		Lunch Break		Lunch Break	
Session 4A		Session 5B		Session 3C		Session 8C	
14:00-15:00		14:00-15:00		14:00-15:00		14:00-15:00	
E033		E108		E072		E074	
E056		E066		E087		E092	
E100		E118		E051		E094	
E096		E050		E036		E021	
				15:00-15:15		15:00-15:15	
Session 5A		Session 8A		Coffee Break		Coffee Break	
15:00-15:45		15:00-16:15		Session 10A		Session 6B/7B	
E057		E020		15:15-16:15		15:15-16:15	
E061		E054		E004		E071	
E055		E080		E002		E010	
		E091		E024		E017	
		E126		E032		E018	
15:45-16:15		16:15-16:45					
Coffee Break		Coffee Break					
Session 6A		OF Session 1					
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E034		E084				Closing Ceremony	
E111		E098					
E046		E085 / E090					
KN 1		KN 2					
17:05-17:50		17:05-17:55					
Keynote 1 Antonio Zuorro		Keynote 2 Muhyiddine Jradi					
19:30-23:30							
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10:15-10:30

Development of Polyethersulphone Mixed Matrix Zeolite Membranes Functionalized with Ionic Liquids and Deep Eutectic Solvents for CO₂ Separation

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ABSTRACT

Mixed matrix membranes (MMM) combine the flexibility of polymers and the strength and durability presented by inorganic solids. In an economically point of view, the advantages of membrane separation are low capital investment and space requirements, high process flexibility and lower energy consumption, helping for a more cost-effective separation process and providing a high separation degree. The molecular sieves based on nano-sized silicoaluminophosphates (SAPO) appear as one of the main materials in MMM for gas separation because the pore size of chabazite (CHA) (0.38nm) is near the kinetic diameter of gases like H₂ (0.29nm), CO₂ (0.33nm), N₂ (0.36nm), CO (0.37nm), CH₄ (0.38nm) and reduced crystal size improves the dispersion and decreases interfacial defects. Besides, the addition of ionic liquids (IL) or Deep Eutectic Solvents (DES) with high affinity and selectivity to CO₂, onto the particle surface and then dispersing it in a polymer membrane can enhance the separation characteristics, resulting in better permeation and selectivity properties.

Keywords: Mixed matrix membranes; CO₂ separation, ionic liquids; deep eutectic solvent; permeability, selectivity.

1. INTRODUCTION

Matrix mixed membranes (MMM) containing zeolites have potential for separating CO₂ owing to their superior thermal, mechanical, and chemical stability, good erosion resistance, and stability at high CO₂ pressures. Zeolites have inorganic crystalline structures with uniform-sized pores of molecular dimensions. The molecular sieves based on silicoaluminophosphates (SAPO) (0.38nm) is near the kinetic diameter of gases like H₂ (0.29nm), CO₂ (0.33nm), N₂ (0.36nm), CO (0.37nm), CH₄ (0.38nm). The production of doped SAPO-34 with transition metals (Fe, Ni, Co, Mn), named MeAPSO-34, leads to a zeolite with higher negative surface charge [1]–[6].

The use of Ionic Liquids (IL) and Deep Eutectic Solvents (DES) arises to improve the zeolite-polymer matrix interaction promoting a link between the zeolite surface (inorganic) and the polymer matrix (organic) due to its organic-inorganic dual nature. Those additives can be used via direct addition in the casting solution or through a post-impregnation process, and reportedly reduces interfacial voids, which increase the separation performance of MMMs (Asghari et al., 2018; Hu et al., 2018; Huang et al., 2015; Hudiono et al., 2011).

2. MATERIALS AND METHODS

The synthesis of the SAPO-34 samples, a gel having the molar composition 1 Al₂O₃; 1 P₂O₅; 0.6 SiO₂; 1.5 Morpholine; 0.5 TEAOH; 70 H₂O was prepared, aged for 24 hours under mixing and then dried at 90°C for 24 hours. The samples were prepared by adding water to dried gel in the proportion 1:1 and heated at 200°C for 24 hours.

20%w/w Polyethersulfone (PES) membrane was prepared using 20%w/w zeolite, based on the polymer mass, in NMP and mixed for 24 hours. The resulting solution was casted with a knife of 0.2 mm, then dried at 90°C for 8 hours and at 160°C for 24 hours under vacuum. The samples were characterized by gas permeation tests to evaluate the separation performance. The membranes tested were placed in a kitasato, and vacuum was applied for a period of 1 hour to remove the air from the pores. The additive was then introduced with a syringe through a septum and the membrane stays under vacuum for 1 hour. The membrane was then removed, and dried using a tissue paper.

3. RESULTS AND DISCUSSION

SAPO-34 was synthesized starting from the same molecular composition 1 Al₂O₃; 1 P₂O₅; 0.6 SiO₂; 1.5

Morpholine; 0.5 TEAOH; 70 H₂O, using the dry-gel synthesis following the proportion 1:1 in mass for 24 hours.

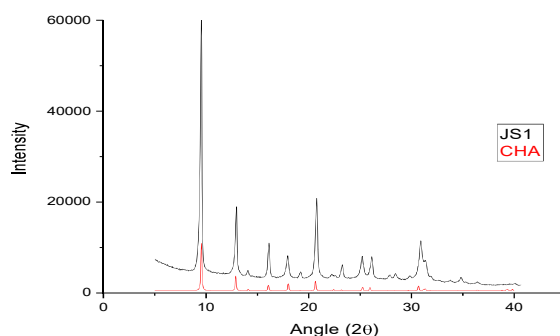


Fig. 1. XRD for JS1 sample.

The results presented in Fig. 1 showed that the SAPO-34 was obtained as presented in XRD when compared to a CHA standard x-ray dispersion analysis. The LDS analysis shows that the average particle size obtained was smaller, 0.198 μm .

The average value obtained for permeability were 17.40 GPU to N₂ and 55 GPU to CO₂ with CO₂/N₂ selectivity of 3.20, which can be related to values in literature. The initial tests using the DES ChCl/Urea 1:2 as a post-impregnant showed an increase between 4-12 times of CO₂/N₂ selectivity, specially decreasing the N₂ permeability post-impregnation.

4. CONCLUSION

It is stated for many authors that the use of mixed matrix membranes presents a great potential for further investigation and development in separation performance. The methodology for nano-sized SAPO-34 preparation was defined and the solid with the desired characteristics obtained to be used as filler in PES polymer membranes. The use of post-sealing impregnation can be a healing procedure for poor compatibility after synthesis. This work presents an innovation as preliminary results showing that 1:2 ChCl/Urea DES used as a post-sealing compound can reduce N₂ permeation and improve CO₂/N₂ separation performance by 4-12 times in neat PES membranes. Those results will be tested using PES/SAPO-34 membranes to verify if can also improve the separation performance in mixed matrix membranes.

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