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Data Article

The permeability and selectivity of nanocomposite membrane of PEBAx 1657/PEI/SiO₂ for separation of CO₂, N₂, O₂, CH₄ gases: A data set



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ABSTRACT

The poly ether-block-amide (PEBAx)/Poly-ether-imide (PEI)/SiO₂ nanocomposite membranes were fabricated using the solution casting method and utilized for separation of N₂, O₂, CH₄, and CO₂ gases. The effect of SiO₂ nanoparticles loading on permeability and selectivity of gases using the nanocomposite membranes was tested. The data showed that the permeability of the gases increased with increasing SiO₂ nanoparticle content. By adding SiO₂ nanoparticles (10 wt%), the permeability of N₂, O₂, CH₄, and CO₂ gases elevated from 0.39, 1, 1.83 and 11.1 to 2.01, 1.95, 2.98 and 19.83 Barrer unit, respectively (at a pressure of 2 Bar). In contrast, with increasing SiO₂ content the selectivity of the studied gases decreased. The morphology, crystallinity and the functional groups of the fabricated membranes were evaluated using scanning electron microscopy (SEM), X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR) techniques. The data

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presented confirm the influence of the nanoparticles on the membrane structure and thus on the permeability and selectivity of the membranes.

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Specification Table

| | |
|-----------------------|---|
| Subject area | Chemical engineering |
| More subject area | Gas separation |
| Type of data | Figure, image, table |
| How data was acquired | <ul style="list-style-type: none"> - FTIR (Spectrum-65, Perkin Elmer) analysis was used to investigate the functional groups of membranes - XRD patterns of fabricated membranes were prepared using X-Ray Diffractometer, Bruker, D8-Advance model. - Scanning electron microscopy (MIRA3, Tescan) was utilized to study the morphology of prepared membranes |
| Data Format | Raw |
| Experimental factors | <ul style="list-style-type: none"> • The membranes were fabricated using the phase inversion method. • SiO₂ nanoparticles were used to modify the permeability of membranes. • The permeability and selectivity of membranes were investigated. • The constant temperature- pressure method was used to measure the permeability of membranes. |
| Experimental features | Separation of N ₂ , O ₂ , CH ₄ , and CO ₂ gases using Pebax/PEI- SiO ₂ nanocomposite membranes. |
| Data source location | Jundi Shapur University of Technology, Dezful, Iran |
| Data accessibility | Data were presented with the article. |

Value of the Data

- This data can be useful for developing the nanocomposite polymeric membranes.
- The study may be applicable for oil, gas and petrochemical industries for natural gas sweetening and purification processes.
- Our data can be helpful for power plants to the separation of CO₂ gas released from fossil fuels.
- This paper introduces a membrane to the world of industry that can be useful for controlling carbon dioxide gas and thus controlling global warming.

1. Data

The X-Ray Diffraction (XRD) of SiO₂ nanoparticles and fabricated membranes is shown in Fig. 1. Also, the FTIR analysis of SiO₂ nanoparticles and membranes are depicted in Fig. 2. Four SEM images of prepared membranes have been indicated in Fig. 3. The effect of SiO₂ nanoparticle loading on permeability in various feed gas pressure is shown in Fig. 4. Table 1 is related to the kinetic diameter and condensability of the studied gases. The selectivity of CH₄, N₂, and O₂ gases is depicted in Table 2. The raw data for this work are presented in the Supplementary section.

2. Experimental design, materials, and methods

2.1. Membrane fabrication

The polymer membranes were prepared by solution casting method [1]. To prepare the PEBA/PEI/SiO₂ nanocomposite membranes with 0, 5, 10 and 20 wt% of SiO₂ nanoparticles, first SiO₂ nanoparticles

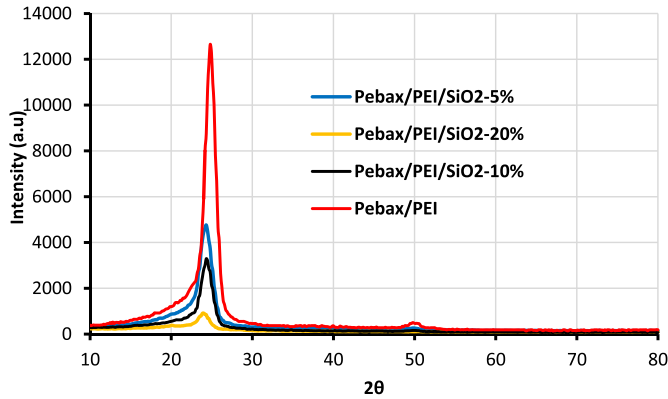


Fig. 1. XRD pattern of fabricated membranes.

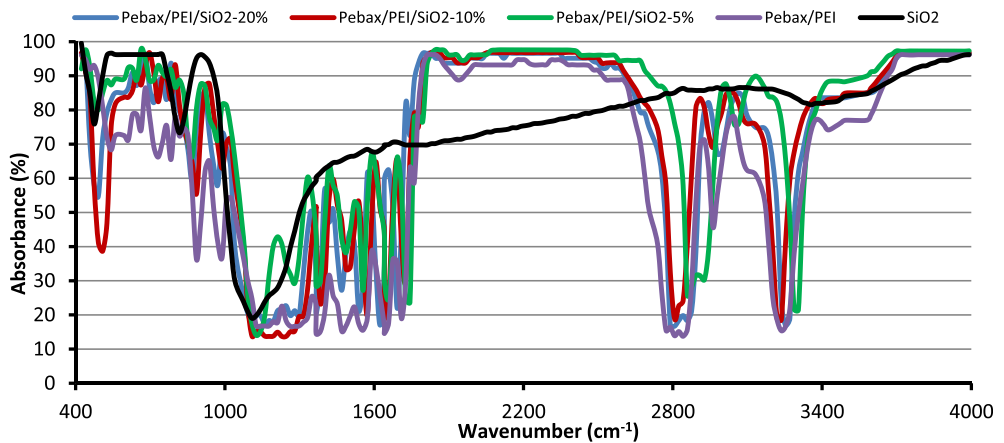


Fig. 2. FTIR spectrum of prepared membranes.

were dispersed in di-methyl-formamide by the ultrasonic process for 60 min at 50 °C. A 6% w/v of polymer solution was fabricated by adding Pebax 1657 and PEI (4:1 wt ratio) to the solution at 120 °C. To form a homogeneous solution, the mixing was continued for 24 h. Afterward, the solution was poured on Teflon mold at 70 °C. Then, the solvent completely removed from the membranes by vacuum drying in the ambient temperature for 4 h. Finally, the thickness of the prepared membranes was measured by a micrometer. A schematic for the membrane fabrication is illustrated in Fig. 5.

2.2. Gas permeability and selectivity measurement

The gas permeability was measured using the time lag method [2,3]. The gas flow rate was obtained using a constant pressure method. In this method, by connecting the downstream space to the water column, and by measuring the changes of water column's height over time, the gas flow rate passing through the membrane is obtained. The gas flow rate can achieve from the slope of the linear part of the water column height as a function of time. Then, the permeability coefficient can be calculated using the following equation [4]:

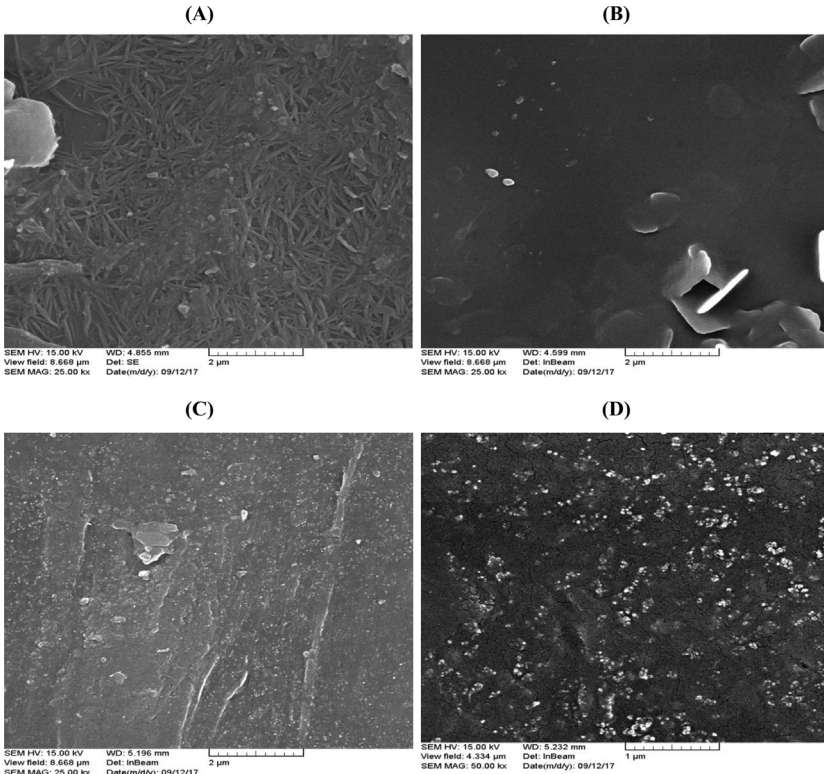


Fig. 3. SEM images of fabricated membranes, (A) Pebax/PEI, (B) Pebax/PEI/SiO₂-5%, (C) Pebax/PEI/SiO₂-10% and (D) Pebax/PEI/SiO₂-20%.

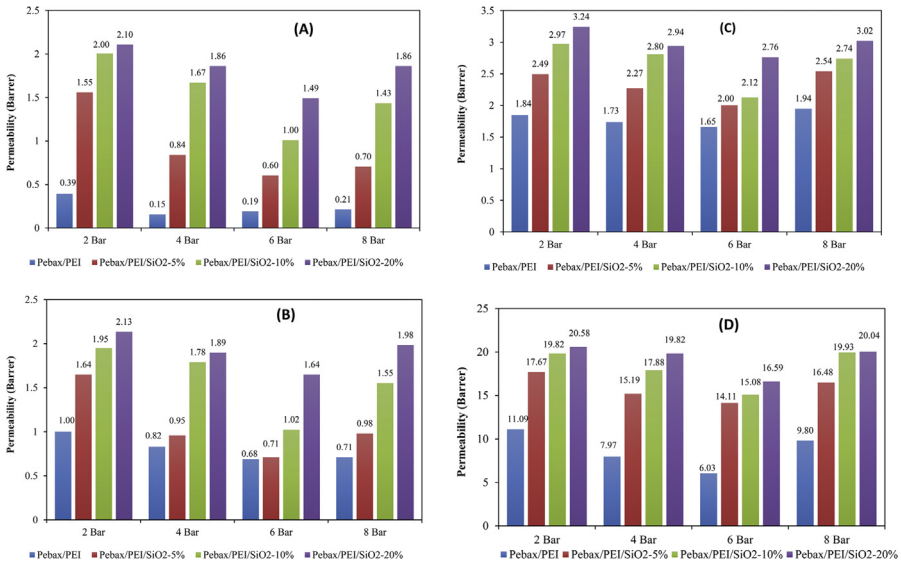


Fig. 4. The effect of nanoparticle loading on gases permeability in various feed gas pressure, (A) N₂, (B) O₂, (C) CH₄, and (D) CO₂.

Table 1
The kinetic diameter and condensability.

| Gas | Kinetic diameter (Å) | Condensability (K) |
|-----------------|----------------------|--------------------|
| CO ₂ | 3.30 | 195 |
| O ₂ | 3.46 | 107 |
| N ₂ | 3.64 | 71 |
| CH ₄ | 3.80 | 149 |

Table 2
The selectivity of prepared membranes.

| Pressure | Gas type | Membrane type | | | |
|----------|-----------------|---------------|--------------|---------------|---------------|
| | | Pebax/PEI | Pebax/PEI-5% | Pebax/PEI-10% | Pebax/PEI-20% |
| 2 Bar | CH ₄ | 6.05 | 7.08 | 6.66 | 6.34 |
| | O ₂ | 11.07 | 10.71 | 10.16 | 9.64 |
| | N ₂ | 28.28 | 11.34 | 9.88 | 9.76 |
| 4 Bar | CH ₄ | 4.59 | 6.68 | 6.37 | 6.73 |
| | O ₂ | 9.61 | 15.84 | 10 | 10.45 |
| | N ₂ | 50.80 | 18.07 | 10.70 | 10.65 |
| 6 Bar | CH ₄ | 3.63 | 7.04 | 7.09 | 6.00 |
| | O ₂ | 8.74 | 19.84 | 14.73 | 10.06 |
| | N ₂ | 31.66 | 23.31 | 14.95 | 11.12 |
| 8 Bar | CH ₄ | 5.03 | 6.49 | 7.27 | 6.63 |
| | O ₂ | 13.78 | 16.81 | 12.84 | 10.10 |
| | N ₂ | 46.03 | 23.34 | 13.89 | 10.77 |

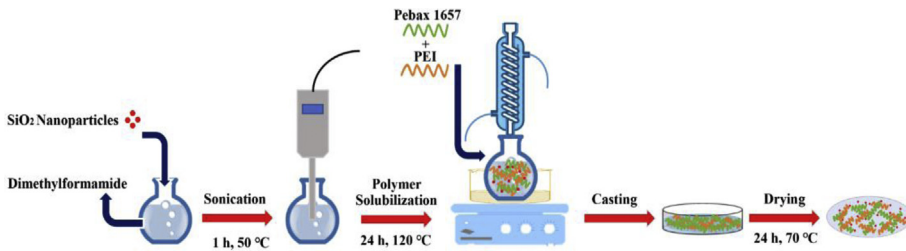


Fig. 5. A schematic for membrane fabrication.

$$P = \frac{Q \cdot l}{(P_1 - P_2) \cdot A} \quad (1)$$

where P is the gas permeability coefficient in the polymer (1 Barrer = cm^3 (STP). cm/cm^2 . $\text{S}.$ cmHg), Q is the gas flow rate (cm^3/s), l is the membrane thickness (cm), A is the cross-section area of membrane (cm^2), P_1 and P_2 are the gas pressure in upstream and downstream, respectively. The membrane ideal selectivity respect to a given gas can calculate through the following equation [5]:

$$\alpha = P_i / P_j \quad (2)$$

where α is the membrane ideal selectivity, P_i and P_j are the gas permeability coefficient of gas (i) and (j), respectively.

Acknowledgment

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dib.2019.104800>.

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