Investigation of temperature effect on CO_2/CH_4 separation performance of synthesized PEBA-nanofiller membranes

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ABSTRACT

In this study, in order to investigate CO_2/CH_4 separation in varied temperatures, composite membrane based PEBA polymer and Zeolite 13X and Zeolite NaA as fillers were prepared. Crystallinity, filler dispersion and roughness of membrane surface analyzed by XRD, SEM and AFM, respectively. The permeability test of pure gases of CO_2, CH_4 and N_2 in a range of 15-55 °C and 4-10 bar, were investigated at 5 and 3 levels, respectively. Using the obtained results, the activation energy of permeation was calculated. N_2 and CO_2 have the highest and the lowest permeation activation energy, respectively. The composite membrane contain zeolite NaA showed better performance. In this membranes, the CO_2 permeability for PEBA-13X and PEBA-NaA at 10 bar and 55 °C is 245 barrer and 279 barrer, respectively. Also, the selectivity of CO_2/N_2 of PEBA-13X and PEBA-NaA is gained 111 and 120 and for CO_2/CH_4 obtained 29 and 28, respectively at 10 bar and 15 °C. At constant pressure by increasing the operating temperature, the CO_2 permeability increased and the selectivity of CO_2/N_2 and CO_2/CH_4 decreased.

Keywords: Composite membrane, gas separation, Operational temperature.

1. INTRODUCTION

Before natural gas can be used for power generation, thermal energy or fuel [1], it must first be cleansed of impurities such as carbon dioxide. CO_2 separation is called sweetening. Natural gas is sweetened to increase the heating value of natural gas, reduce its volume in pipeline transmission, reduce corrosion during transportation and gas distribution and reduce its impact on human health and the environment. Corrosion of operational equipment is the main reason for gas sweetening and the concentration of CO_2 must be less than 2% M [2-7].

Membrane separation is the newest method of sweetening and requires less energy consumption than other methods. Membranes are characterized by permeability and selectivity. Because they are low cost and offer high flexibility and ease of fabrication, most membranes are polymeric [8, 9]. Chemical modification is done through blocking, grafting or cross-linking and changes the structure of the macromolecules of a polymer [10-13]. One of the best copolymers is polyether block amide (PEBA 1657) which combines high permeation and selectivity in its hard polyamide (PA) and soft polytetramethylene oxide (PEO) [14-20].

To improve separation, mechanical resistance and thermal stability, inorganic materials are added to the matrix membranes as fillers. These are composite membranes such as zeolite 13X, NaA, carbon nanotubes, titanium dioxide and silica [13, 14, 21-25]. Li et al. prepared multi-composite membranes of PEBA1657-ZIF7/PTMS/PAN with 154 barrer and 97 CO_2 permeability and CO_2/N_2 selectivity, respectively [26]. Murali et al. added 10% loading of zeolite 4a to PEBA1657 and gained 94.2 for CO_2/N_2 selectivity [27]. Zarshenas et al. fabricated double-layer PEAB1657 as an active layer and PES as a support with 2% loading of zeolite NaX into a PEBA1657 matrix polymer with PCO_2 = 35.2 barrer and SCO_2 = 121.5 [28].

The film was produced as a single-layer composite membrane with 1%.wt loading of zeolite 13X or NaA to investigate the CO_2 capture from natural gas. The properties of polymeric membrane and inorganic nanoparticles had been combined and the permeability and selectivity were investigated under various operating condition.