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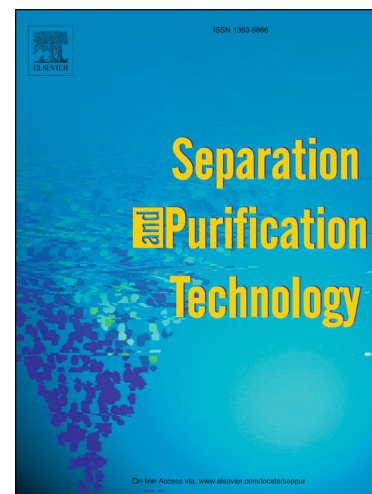
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Synthesis and fabrication of adsorptive carbon nanoparticles (ACNs)/PDMS mixed matrix membranes for efficient CO₂/CH₄ and C₃H₈/CH₄ separation

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Abstract

Polydimethylsiloxane (PDMS) mixed matrix membranes (MMM)s containing microporous adsorptive carbon nanoparticles (ACNs) are developed for CO₂/CH₄ and C₃H₈/CH₄ separation. The ACNs are produced by the pyrolysis of a phenolic resin precursor at 700 °C and transformed into fine particles through ball-milling. For functionalization of the particles and widening of the pores, the prepared ACNs undergo ozone treatment to increase the sorption capacity and to reduce diffusional limitations. Successful accomplishment of modification is evidenced by pore size distribution, X-ray diffraction, and Fourier transform infrared spectra analyses. MMMs containing different amounts of both native ACNs (ACN-N) and oxidized ACNs (ACN-O) are evaluated in terms of permeability, solubility and diffusivity coefficients for target gases. Based on the results, higher pressure and lower temperature promote gas separation due to capillary condensation of penetrants in the micropores of the particles present in the MMMs. Activation energy of permeation, diffusion, and enthalpy of sorption are also determined for MMMs and compared to the pure PDMS membrane. The real selectivity in PDMS/ACN-O (10%) membrane for CO₂/CH₄ and C₃H₈/CH₄ are 57.3% and 53.1% higher than those in pure PDMS membrane. This enhancement is attributed to the selective adsorption and surface diffusion of the more adsorbable component in ACNs as well as partial diffusion hindrance of less adsorbing component (CH₄) in the presence of more adsorbable component (e.g., CO₂, C₃H₈) onto surface of ACN pores. Also, CO₂ and C₃H₈ permeability improved by 61.6% and 47.7% respectively, compared to the pure PDMS membrane and is attributed to the formation of extra free volume in PDMS matrix as a result of chain packing disruption in the presence of ACNs. According to the findings, the fabricated membranes are promising candidates for natural gas sweetening and hydrocarbon recovery.

Keywords:

Mixed matrix membranes; adsorptive carbon nanoparticles; PDMS; ozone treatment; Surface diffusion.

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