

Carbon Molecular Sieve-derived POC/Mixed-Matrix Membranes for Gas Separation

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Abstract:

Membrane-based separations offer the potential for the lowest energy demand requirements of all separation options. Among all nanoporous membranes, the carbon molecular sieves (CMS), metal-organic frameworks (MOFs), and mixed-matrix membranes (MMMs) with angstrom level molecular discrimination properties makes them appealing for separating a wide spectrum of gas-pairs. Here we present results of gas selectivity and diffusion of different gases (C_2H_6 , C_2H_4 , C_3H_8 , C_3H_6 , H_2 , N_2 , CO_2 , and CH_4) in porous organic cages (POCs) incorporated into fluorinated copolyimides polymers (FCPs). The FCPs were synthesized by the iridization reaction of fluorinated dianhydrides, nonfluorinated dianhydride, and nonfluorinated diamine. Asymmetric hollow fiber membranes formed by the dry-jet/wet-quench spinning process. Once fresh FCP fibers were synthesized, they were crosslinked with POCs, vacuum dried at 90 °C. We investigated the uptake, gas selectivity and diffusion of different gases (C_2H_6 , C_2H_4 , C_3H_8 , C_3H_6 , H_2 , N_2 , CO_2 , and CH_4) over synthesized POC-mixed matrixed membranes (POC-MMM) at 25 °C and pressures up to 1 bar. At 1 bar and 25 °C, C_2H_6 , C_2H_4 , C_3H_8 , C_3H_6 adsorption capacities reached to 42.61, 2.56, 2.77 and 2.65 mmol/g over POC-MMM, respectively, while CO_2 , CH_4 , CO , N_2 and H_2 adsorption capacities of 1.48, 0.84, 0.33, 0.11, and 0.068 mmol/g, respectively. Furthermore, stable CMS membrane were formed by pyrolysis of POC-MMMs under an inert argon atmosphere at 1 atm. To test the gas transport properties of CMS-derived POC/MMM, a lab-scale hollow fiber module with two-five fibers was constructed. The results of longer-term operation of synthesized CMS membrane that was continuously operated for 264 h (10 days) with an equimolar binary H_2/CO_2 , CH_4/CO_2 and C_3H_6/C_3H_8 feed at 25°C and 1 bar feed pressure. The modification yielded promising results in the reduction of physical aging of CMS membranes.

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