Understanding the effects of multilayer assembly of tubular alumina-supported polyetherimide membranes on H_2, CO_2 and N_2 separation performance

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Abstract

Research in CO_2 capture and H_2 purification technology has garnered increased momentum due to global warming and world energy strategies. In this study, tubular polyetherimide (PEI) membranes were successfully prepared on the outer surface of tubular alumina (α-Al_2O_3) support using dip-coating and multilayer assembly techniques and examined for CO_2/N_2 and H_2/N_2 separations. This study systematically investigated the effects of support calcination temperature, polymer solution concentration, withdrawal speed, and the coating number of polymer layers on membrane gas separation performance in single and binary gas conditions.

The best PEI membrane prepared with substrate calcined at 1200 °C, 10 wt.% of PEI solution, 300 μm s^{-1} of withdrawal speed, and three deposited layers produced gas permeances (10^{-12} mol m^{-2} s^{-1} Pa^{-1}) of 310, 150 and 1 for H_2, CO_2 and N_2 respectively with a CO_2/N_2 and H_2/N_2 permselectivities of 149 and 308 (Figure 1).

In the binary gas testing, the membrane delivered an exclusive 100% permeate purity for CO_2 and H_2 in different feed gas concentrations and achieving maximum CO_2 and H_2 permeances of 4.3 and 6.0 $\times 10^{-10}$ mol m^{-2} s^{-1} Pa^{-1}, respectively. Suppression of glass transition temperature and crystallinity compared to the bulk polymer led to interfacial confinement phenomena which was confirmed by DSC, X-ray diffraction and Raman spectroscopic analyses [1]. The polymer interfacial confinement facilitated the exclusive H_2 and CO_2 transports without much affecting the N_2 permeance.

Keywords: Polyetherimide, Gas separation, CO_2 separation, multilayer assembly, Polymer confinement, Sintering temperature.

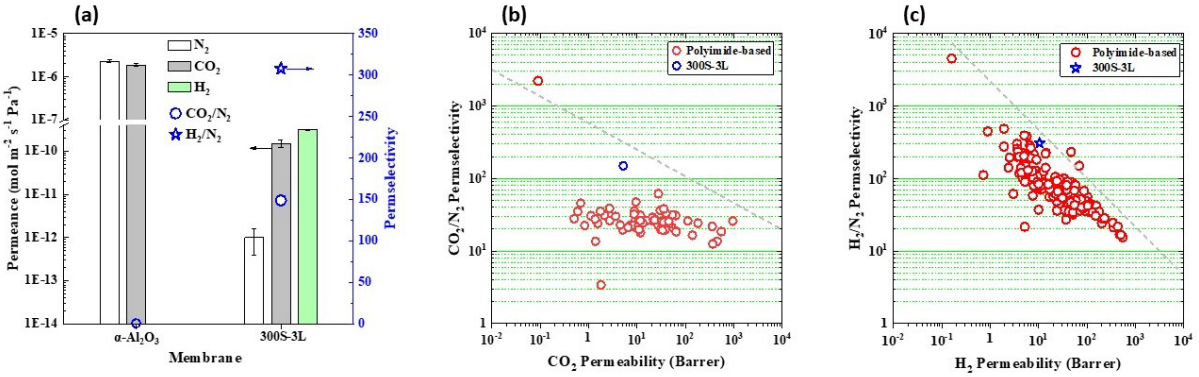

Figure 1. (a) Single gas permeance and selectivity of PEI/alumina membranes. A comparison plot for literature data of (a) CO_2/N_2, and (b) H_2/N_2 for polyimide-based membranes [2, 3]. The grey dash line represents 2008 Robson Upper bound.

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