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Gas and water vapor transport properties of mixed matrix membranes containing 13X zeolite

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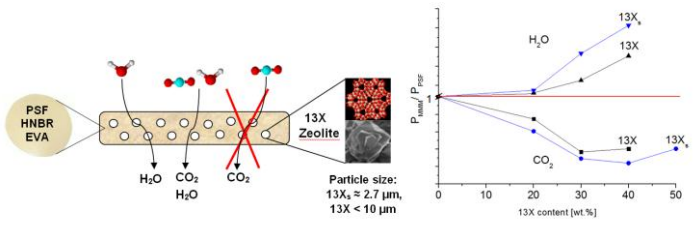
Abstract

Mixed matrix membranes (MMM) containing 13X zeolite particles were prepared to study the impact of hydrophilic inorganic component on membrane gas and water vapor transport properties. Rubbery ethylene-vinyl acetate copolymer (EVA), hydrogenated nitrile rubber (HNBR), and glassy polysulfone (PSF) varying in permeability were selected as membrane matrices. The incorporation of 13X decreased gas permeability of all MMMs and had only a marginal effect on ideal selectivity (e.g. 20 wt. % loading reduced N_2 permeability by 21%, 19%, and 4% for PSF, EVA, and HNBR, respectively). The observed trend was in agreement with the diminished free volume size obtained from the positron annihilation lifetime spectroscopy (PALS) measurements suggesting pore blockage. In contrary, water vapor permeability through all MMMs was significantly enhanced by zeolite filling (e.g. 30 wt. % loading increased H_2O permeability by 153%, 34%, and 22% for PSF, EVA, and HNBR, respectively). This was explained as due to the increased water solubility documented by the sorption results, that compensates for the effect of the reduced water diffusivity in MMMs. The variations in MMMs permeabilities were also found to depend on zeolite particle size and its porosity. Two opposite effects were noticed of increased water vapor permeability and decreased gas permeability for MMMs filled with smaller but more porous particles. The water permeation through PSF based membranes may cause debonding at the particle/matrix interface and deterioration of the MMMs properties as indicated by their enhanced gas permeability and reduced selectivity.

Graphical abstract



Keywords: Mixed matrix membrane, 13X zeolite, Gas, Water vapor, Permeation