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Transport of Carbon Dioxide, Methane, Oxygen and Nitrogen in a Glassy Polyimide Membrane

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Biomethane is one of the controllable Renewable Energy Sources. It may be derived from biogas, a multicomponent gas mixture, using, among others, membrane processes. The proper optimization of such a process requires the knowledge of the phenomena accompanying each specific biogas–membrane separation system. Therefore, the solubility, permeance and diffusion of CO_2, CH_4, O_2 and N_2 in a polyimide-based sample were described and analyzed using the Dual Mode Sorption and partial immobilization models. The parameters of the models were determined based on pure gas sorption isotherms measured gravimetrically and experimental permeances of the four gases. The membrane swelling caused by CO_2 was observed at temperatures of 293 and 303 K and for pressures higher than 3 bar. The adsorption of CH_4, O_2 and N_2 in the fractional free volume (FFV) has a dominant (>50%) share in their total solubility in the entire pressure range. This makes them sensitive to the presence of CO_2, whose affinity is the strongest towards the tested polyimide-based sample. The diffusion of O_2 is the fastest which makes it competitive with CO_2 in permeation through the membrane, despite its low solubility. The ideal CO_2/O_2 selectivity is thus relatively low (2.3–5.1). Methane, which is competitive in solubility compared to CO_2, was found to diffuse the slowest and as a result, it is also the slowest permeating gas. This translates into the very high CO_2/CH_4 ideal selectivity (33–95.7), which is, however, strongly dependent on temperature and pressure.

Tagi: biogas

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