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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 CO₂, CH₄, O₂ and N₂ 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 CO₂ was observed at temperatures of 293 and 303 K and for pressures higher than 3 bar. The adsorption of CH₄, O₂ and N₂ 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 CO₂, whose affinity is the strongest towards the tested polyimide-based sample. The diffusion of O₂ is the fastest which makes it competitive with CO₂ in permeation through the membrane, despite its low solubility. The ideal CO₂/O₂ selectivity is thus relatively low (2.3–5.1). Methane, which is competitive in solubility compared to CO₂, was found to diffuse the slowest and as a result, it is also the slowest permeating gas. This translates into the very high CO₂/CH₄ ideal selectivity (33–95.7), which is, however, strongly dependent on temperature and pressure.

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