Enzyme-Based Hollow Fiber Contained Liquid Membrane for CO_2 Removal

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Abstract: Human activity continues to add CO_2 to the atmosphere at an alarming rate – today ca. 7GT/y. Exhaust stack gas CO_2 ranges from 0.03-0.15 atm. At present there are no cost efficient means of capturing this CO_2 for subsequent disposal. Facilitated transport liquid membranes that have been studied for CO_2 separation for many years may provide such a mechanism. These membrane system shows a significant increase in permeance and selectivity *via* the facilitation mechanism. However, the kinetic rates of hydration or dehydration of CO_2 occurring at the gas-liquid interfaces are the controlling steps under conditions in which mass transport resistance is minimized by use of thin and efficient liquid membranes. The fastest catalyst for CO_2 hydration and dehydration, carbonic anhydrase (CA) was introduced as a biomimetic catalyst in liquid membrane separations in the 1960s. Early work focused on flat sheet configurations. In this paper, we report the detailed studies on a hollow fiber contained liquid membrane configuration for CO_2 separation from air over CO_2 concentration range of 0.01–0.15 atm. In addition to the carrier, CA was added to the liquid membrane to catalyze the hydration and dehydration of CO_2 at the gas-liquid interfaces and thus increase CO_2 selectivity and permeance. Two sets of porous hydrophobic polypropylene hollow fibers were selected as the test membrane for this study. The feed gas passed through the bore of one set of fibers while the permeate was extracted from the bore of another set of fibers. The liquid phase was circulated between the module shell and a reservoir to ensure long-term operational stability. Vacuum or argon was used to remove CO_2 from the permeate side. The detailed structural parameters included CA concentration, CO_2 partial pressure in the feed, buffer species and concentration, temperature and pH. The results show that this membrane system separated CO_2 from air very efficiently when the CO_2 feed pressure ranged from 0.01–0.15 atm. The CO_2 selectivity and permeance increases 2–12 times in the presence of CA as compared to its absence.