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Abstract

Design of Enzyme Stabilization Systems for Gas Separation: Novel Studies on Formation of Enzyme Based W/O Emulsions by Direct Membrane Emulsification to Synthesise Emulsion-Based Supported Liquid Membrane for CO_2 Capture †

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Abstract: Membrane-based gas separation is an important unit operation in chemical industries due to its simplicity, ease of operation, reduced energy consumption, and compact structure. For gas separation, novel studies were carried out by synthesising enzyme-stabilised systems consisting of emulsion-based supported liquid membranes (E-SLMs) the pores of which pores were impregnated with water-in-oil (W/O) emulsions produced by direct membrane emulsification. This technique has gained attention, as it consumes low energy and is mild and suitable for sensitive enzymes. This case study involves the capture of CO_2 by the enzyme carbonic anhydrase (CA). The composition of the oil phase was optimised amongst various edible oils, aiming for the one with the highest CO_2 sorption capability. The water phase was optimised based on the stability of the CA enzyme in the aqueous phase in the presence of various surfactants and their concentrations. The optimised emulsions consisted of 2% Tween 80 (w/w) in corn oil as the continuous phase and 0.5 g L^{-1} CA enzyme with 5% PEG300 (w/w) in aqueous solution as the dispersed phase. The emulsions were prepared with a Microdyn Nadir UP150 polymeric membrane. These emulsions were impregnated onto a hydrophobic PVDF membrane to prepare E-SLM. For comparative studies, liquid membranes were also prepared without the CA enzyme in the emulsions, and a supported liquid membrane (SLM) was prepared by impregnating corn oil onto the membrane. Lastly, the permeabilities of the main components of biogas, CO_2, and CH_4, through the SLM and E-SLMs, were evaluated. The permeability of CO_2 increased (~15%) and CH_4 decreased (~60%) through the E-SLM containing CA when compared to the SLM and E-SLM without CA. Subsequently, the selectivity of CO_2 increased in the presence of low concentration of CA. This work suggests the enhanced, synergetic effects of carbonic anhydrase within a bio-based emulsion system for CO_2 capture.

Keywords: membrane emulsification; water-in-oil emulsions; CO_2 capture; carbonic anhydrase; enzyme; emulsion-based supported liquid membrane

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