

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<sub>2</sub> Capture <sup>†</sup>

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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) wherein their 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, suitable for sensitive enzymes.

This case study involves the capture of CO<sub>2</sub> by the enzyme carbonic anhydrase (CA). The composition of oil phase was optimised amongst various edible oils aiming for the one with the highest CO<sub>2</sub> sorption capability. The water phase was optimised based on the stability of CA enzyme in 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 continuous phase and 0.5 g L<sup>-1</sup> CA enzyme with 5% PEG300 (*w/w*) in aqueous solution as the dispersed phase. The emulsions were prepared with 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<sub>2</sub> and CH<sub>4</sub>, through the SLM and E-SLMs were evaluated. The permeability of CO<sub>2</sub> increased (~15%) and CH<sub>4</sub> decreased (~60%) through the E-SLM containing CA when compared to the SLM and E-SLM without CA. Subsequently, the selectivity of CO<sub>2</sub> 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<sub>2</sub> capture.

**Keywords:** membrane emulsification; water-in-oil emulsions; CO<sub>2</sub> capture; carbonic anhydrase; enzyme; emulsion-based supported liquid membrane

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