

Polyionic liquid deposited biocatalytic membrane contactor for intensified CO₂ capture and conversion into bicarbonate

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The chemical absorption of CO₂ using amine-based solvents is currently the benchmark technology for CO₂ capture. However, the use of toxic and corrosive solvents with an energetically intensive solvent regeneration process have motivated the search for alternative greener technologies. Membrane contactor technology is a promising candidate due its low footprint, high specific surface area per unit volume, and operational flexibility that allows the use of benign aqueous-based solvents for CO₂ capture. Furthermore, enzymes such as carbonic anhydrase (CA) can be immobilized on their surface to catalyze both the capture and conversion of CO₂ into bicarbonate. Polyionic liquids (PILs) are polyelectrolytes that can be tailored to exhibit high CO₂ affinity. Whilst developments of PIL in CCU have steadily increased throughout the years, their practical implementation in CCU is currently limited due to their high cost. In this study, PIL was strategically deposited on the membrane contactor surface as a way to improve mass transfer coefficient. High CO₂-affinity PIL was synthesized via UV polymerization. The PIL composition and enzyme immobilization protocol were then optimized in terms of CA activity. The highest CA activity was obtained for a PIL composition of 0.25 g/mL monomer, 2 (w/w)% chitosan, 1 (v/v)% glutaraldehyde, pH 9, 0.7 mg/mL CA. Meanwhile, evaluation at the process-scale showed 3x increase in mass transfer coefficient relative to pristine membrane. Finally, the synthesized biocatalytic membrane was stable, retaining 92.6% of its performance after reusing four times. This study therefore proposes a strategy to further enhance process intensification of biocatalytic membrane contactor for CCU into bicarbonate.