

ACCELERATED CO₂ ABSORPTION IN A MEMBRANE CONTACTOR USING ENZYME CARBONIC ANHYDRASE

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At the recent United Nations Climate Change conference (COP21) in Paris, France, 195 countries agreed on a plan to endeavor, to hold the global warming effect at less than 2 °C by 2020. In order to achieve this target, carbon capture technology for post combustion power plants will firmly remain part of the solution. CO₂ capture in absorption towers with monoethanolamine (MEA) solvent has been the most investigated technology. Although MEA has a fast CO₂ absorption rate, its use results in issues including corrosion of equipment, high energy demand for regeneration and degradation. MDEA (N-methyldiethanolamine) is an attractive alternative as it has a lower energy requirement for regeneration, is less corrosive and has greater chemical stability. The slower CO₂ absorption reaction rate is the major drawback. The enzyme carbonic anhydrase (CA) catalyzes CO₂ fixation in nature, by hydrating CO₂ to bicarbonate, which in turn enhances the CO₂ absorption rate [1]. In this study, the possibility of employing carbonic anhydrase for the acceleration of CO₂ reaction in MDEA in combination with the use of a membrane contactor is investigated in a lab scale module.

In a membrane contactor the advantages of absorption technology and membrane technology are combined, as direct contact between the solvent and gas feed stream are avoided. Operation problems, which are observed in absorption columns such as foaming, channeling and entrainment are minimized. The possibility of independent control of gas and liquid phases offers convenient operation flexibility. Compact membrane modules provide more efficient liquid-gas contact than in an absorption column and hence save space. In contrast to membrane technology, where nonporous selective membranes are used, the membrane contactor uses microporous membranes, which have a higher gas permeance without selectivity since the solvent can take up CO₂ exclusively (selectivity is ideally infinitive). However, if the membrane pores become filled with solvent (wetted), the mass transfer resistance of the membrane becomes significant, resulting in unviable operation.

The membranes employed in this study were chosen specifically to have both hydrophobic (bulk) and hydrophilic (surface) properties in order to avoid wetting of solvent and to simultaneously reduce fouling from the enzymes. Absorption measurements in the membrane contactor were performed using solvent systems of 30wt% MEA and 30wt% MDEA for comparison where a small amount of the enzyme was added. The enzyme carbonic anhydrase used in this study, was supplied by Novozymes A/S (Bagsvaerd, Denmark) as an extracellular protein of microbial origin [2]. The applied feed gas consisted of 15vol.% CO₂ and 85 vol.% N₂ represented of flue gas from coal-fired power plants, and the feed gas pressure was varied from slightly higher than atmospheric to ca. 2bar. The influence of the solvent holdup time (contact time) was studied and the duration of the enzyme activity over a test period of one week. In addition, the possibility of the enzyme deployment for desorption at mild temperature range (below 70°C) was investigated. The results showed significant acceleration of CO₂ reaction in 30 wt% MDEA when enzyme was added to membrane contactor system.

References

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