THE POTENTIALITY OF REACTIVE MEMBRANES FOR POST COMBUSTION CO_2 CAPTURE

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Key Words: CO_2 capture, Reactive membrane, Facilitated transport, Energy requirement, Process
CO_2 industrial emissions have a severe impaction on the global warming due the important CO_2 greenhouse effect. Post combustion gases represent one of the largest industrial source of CO_2 emitted to the atmosphere, currently 30 gigatons per year. CO_2 Flue gas composition varies widely from 4 to 30% depending on its origin. In order to capture and valorise CO_2, efficient processes with high capture ratio, high selectivity and low energetic footprint must be developed.

Among the process used for CO_2 recovery and concentration, membrane separation appears as a promising option. Membranes are environmentally friendly and have high potential for breakthroughs in energy consumption and overall cost, are solvent-free and are compatible for retrofit strategy. However, the CO_2 purity limitations with commercial membrane or the actual energy requirement limit the use of membranes in CO_2 capture. In order to improve membrane separation performance, Facilitated Transport Membranes (FTM) have been recently developed such as the Fixed Site Carrier Membrane (FSCM based on amine carrier fixed by covalent bond inside the dense polymeric membrane). In this case, facilitated transport is specific to CO_2 mass transfer. Amine reacts with CO_2 in presence of high relative humidity and makes a new complex, HCO_3^-. The anion crosses through the membrane by hopping mechanism. In the low pressure permeate side, the reversible reaction occurs and CO_2 is released.

In this work, the potential of these reactive membranes for CO_2 capture in post combustion flue gases is evaluated by simulation. Poly(vinyl alcohol) polymer with amine blend membrane is considered for the simulation. Literature data were collected [1], [2] and simulated. A tailor-made gas permeation membrane module is implemented in a PSE (Process System Engineering) software (Aspen Plus software) to simulate the two mechanisms of mass transfer (solution diffusion and reaction diffusion mechanisms are considered) inside the FSC membrane in a one stage process. The effect of operating parameters (pressures, thickness, surface area, stage cut) on separation performance is studied through a parametric sensitivity analysis. Energy and membrane surface requirement are evaluated. Finally reactive membranes are compared to classical membranes for CO_2 capture. Based on our simulations, general guidelines are drawn.

[1] A. Mondal and B. Mandal, "Synthesis and characterization of crosslinked poly(vinyl alcohol)/poly(allylamine)/2-amino-2-hydroxymethyl-1,3-propanediol/polysulfone composite membrane for CO2/N2 separation," J. Membr. Sci., vol. 446, pp. 383–394, Nov. 2013.
[2] A. Mondal, M. Barooah, and B. Mandal, "Effect of single and blended amine carriers on CO2 separation from CO2/N2 mixtures using crosslinked thin-film poly(vinyl alcohol) composite membrane," Int. J. Greenh. Gas Control, vol. 39, pp. 27–38, Aug. 2015.