Modeling and Simulation of Flat Sheet Membrane with Physical and Chemical Absorption

N. Ghasem[1], M. Al-Marzouqi[1]

[1]UAE University, Al-Ain, UAE

Abstract

Greenhouse gases trap heat and make the planet warmer. The main greenhouse gases emitted by human activities are: Carbon dioxide (CO2). The use of fossil fuel is the primary source of CO2 [1, 2]. Accordingly, there is a need for an efficient and novel separation processes for removal of carbon dioxide from gas streams [3, 4]. Here, a flat sheet membrane contactor is used to remove carbon dioxide from natural gas. A 2D mathematical model was developed to describe the flow of gas with CO2 impurities and the solvent liquid in a counter current mode of operation. Simulations were done using COMSOL Multiphysics®. In the model, material transport equation in the flat sheet membrane for laminar flow conditions were considered. Physical and chemical absorption was considered in the simulations for the absorption of CO2 in aqueous solvent solution. Simulation predictions were in good agreement with the experimental data. Figure 1 shows the surface plot across the flat sheet membrane. The figure revealed that the concentration of CO2 decreases through the membrane surface as it passes to the end side of the membrane. As the surface area of flat sheet membrane is not as large as hollow fiber membrane contactor, complete removal of CO2 could not be achieved. The COMSOL simulation results were in good agreement with experimental data. Results shows also chemical absorption is more efficient than physical absorption. In the physical absorption the liquid film resistance is the limiting factor to mass transfer. By contrast, in the chemical absorption, the membrane and gas film is the main resistance to mass transfer.

Reference

[1] N. Abdul Rahim et al., Absorption of CO2 from natural gas using different amino acid salt solutions and regeneration using hollow fiber membrane contactors, Journal of Natural Gas Science and Engineering, Vol. 26, pp. 108-117 (2015)
[2] N. M. Ghasem et al., Gas–liquid membrane contactor for ethylene/ethane separation by aqueous silver nitrate solution, Separation and Purification Technology, Vol. 127, pp. 140–148 (2014)
[3] Y. Le Moullec et al., Process modifications for solvent-based post-combustion capture, Int. J. Greenhouse Gas Control, Vol. 31, pp. 96–112 (2014)
[4] S. M. R. Razavi et al., CFD simulation of capture from gas mixtures in nanoporous membranes by solution of 2-amino-2-methyl-1-propanol and piperazine, Int. J. Greenhouse Gas Control, Vol. 15, pp. 142–149 (2013)

Figures used in the abstract

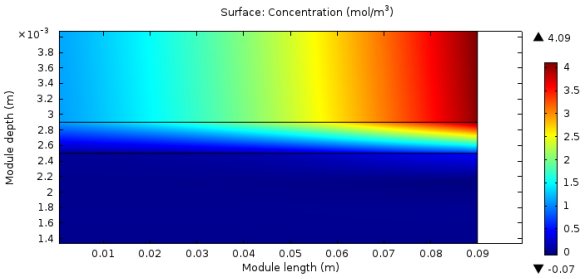

Figure 1: Surface plot for CO2 concentration in flat sheet membrane.