Chemical Engineering Thesis Defense

Carbon dioxide transfer characteristics of hollow-fiber, composite membranes

School for Engineering of Matter, Transport and Energy

Tarun Shesh

Advisor: Bruce Rittmann

abstract

Carbon dioxide (CO_2) levels in the atmosphere have reached unprecedented levels due to increasing anthropogenic emissions and increasing energy demand. CO_2 capture and utilization can aid in stabilizing atmospheric CO_2 levels and producing carbon-neutral fuels. Utilizing hollow fiber membranes (HFMs) for microalgal cultivation accomplishes that via bubbleless gas-transfer, preventing CO_2 loss to the atmosphere. Various lengths and geometries of HFMs were used to deliver CO_2 to a sodium carbonate solution. A model was developed to calculate CO_2 flux, mass-transfer coefficient (K_L), and volumetric mass-transfer coefficient (K_La) based on carbonate equilibrium and the alkalinity of the solution. The model was also applied to a sparging system, whose performance was compared with that of the HFMs. Typically, HFMs are operated in closed-end mode or open-end mode. The former is characterized by a high transfer efficiency, while the latter provides the advantage of a high transfer rate. HFMs were evaluated under both modes of operation and a varying inlet CO_2 concentration to determine the effect of inert gas and water vapor accumulation on transfer rates. It was found that for pure CO_2, a closed-end module operates as well as an open-end module. Closed-end modules perform significantly worse when CO_2-enriched air is supplied. This was shown by the K_La values calculated using the model. Finally, a mass balance was conducted on the membranes in order to develop a model that provided insight into the gas concentration profiles inside the fiber lumen. For dilute CO_2 inlet streams, accumulation of inert gases like nitrogen (N_2), oxygen (O_2), and water vapor (H_2O) significantly affected module performance by reducing the average CO_2 partial pressure in the membrane and diminishing the amount of interfacial mass-transfer area available for CO_2 transfer.

July 12, 2018; 11 AM; BDA 204