New Amine-Based Membranes for Post- and Pre-Combustion CO_2 Capture

Yang Han, Witopo Salim, Kai Chen and W.S. Winston Ho

William G. Lowrie Department of Chemical and Biomolecular Engineering and
Department of Materials Science and Engineering
The Ohio State University, Columbus, OH 43210-1350, USA
E-mail: ho.192@osu.edu

Abstract

This presentation covers new advances in amine-containing membranes for post-combustion CO_2 capture from flue gas in coal- and/or natural gas-fired power plants and pre-combustion CO_2 capture from synthesis gas derived from coal and/or natural gas, e.g., in integrated gasification combined cycle (IGCC) operation. We have synthesized highly CO_2-selective membranes comprising fixed-site and mobile carriers, involving the facilitated transport mechanism based on reversible CO_2 reactions with amine carriers. The membranes remove H_2S even faster than CO_2 (~3 times or greater). In general, the membranes need to be tailor-made and tuned specifically for those applications. For example, post-combustion carbon capture requires a high CO_2/N_2 selectivity of 140 together with a very high CO_2 permeance of greater than 700 GPU (1 GPU = 10^{-6} cm^3 (STP)/(cm^2 • s • cmHg)) in order to use a stand-alone membrane process. On the other hand, pre-combustion carbon capture demands the membrane with a very high CO_2/H_2 selectivity of 100 along with a modest CO_2 permeance of about 200 GPU or greater. In order to achieve the membrane performance, highlighted are composite membranes comprising a high-selectivity layer on a highly permeable polymeric support for continuous roll-to-roll fabrication. Also highlighted are the effects of amine steric hindrance, CO_2 concentration, SO_2, temperature and permeate vacuum on membrane performance as well as the scale-up of the membrane through continuous roll-to-roll fabrication and spiral-wound membrane module scale-up and testing with simulated and actual flue gas streams. In addition, a pre-combustion carbon capture process has been proposed and designed based on the synthesized membranes with tuned H_2S/CO_2 selectivities, indicating 6 ppm H_2S in the H_2 product achievable and an attractive increase in the cost of electricity.