OXIDATIVELY STABLE MEMBRANES FOR CO2 SEPARATION AND H2 PURIFICATION

W.S. Winston Ho, William G. Lowrie Department of Chemical and Biomolecular Engineering; Department of Materials Science and Engineering, The Ohio State University, USA
ho.192@osu.edu
Varun Vakharia, William G. Lowrie Department of Chemical and Biomolecular Engineering, The Ohio State University, USA
Witopo Salim, William G. Lowrie Department of Chemical and Biomolecular Engineering, The Ohio State University, USA
Michael Gasda, Bloom Energy Corporation, 1252 Orleans Drive, Sunnyvale, USA

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CO2-selective facilitated transport membranes are well-known for providing remarkably high CO2/H2 selectivity along with high permeance at high temperatures (100 – 120°C). In some cases, it is desirable to use air as the sweep gas to enhance the driving force and membrane performance, and the membrane should be stable in the presence of oxygen. This work demonstrates the development of a new class of facilitated transport membranes containing quaternary ammonium hydroxide small molecules and quaternary ammonium hydroxide- and fluoride-containing polymers as mobile carriers and fixed-site carriers, respectively, for CO2 separation and H2 purification. The active nature of tetramethylquaternary ammonium hydroxide (TMAOH) as a mobile carrier was successfully demonstrated with the high CO2 permeance obtained by the TMAOH-containing membranes. However, the membrane performance was improved significantly by the incorporation of quaternary ammonium hydroxide- and/or fluoride-containing polymers in the membrane. The resulting hydroxide- and fluoride-containing membranes exhibited CO2 permeance > 100 GPU and CO2/H2 selectivity > 100 at 120°C using humid air as the sweep gas. The membrane composition was optimized, and the transport stability of the membrane was investigated. The membrane showed oxidatively stable during the 145-hour transport measurement at 120°C using air as the sweep gas. Furthermore, the effects of sweep steam content and membrane thickness were investigated. As the sweep steam content was increased (especially for steam content > 50%), both CO2 permeance and CO2/H2 selectivity increased. As the membrane thickness was reduced from 15 µm to 2 µm, a sharp drop in the CO2/H2 selectivity was observed whereas the CO2 permeance did not seem to increase as prominently as the H2 permeance. In addition, the membrane was successfully scaled up using a roll-to-roll continuous membrane fabrication machine, and the scale-up membrane showed similar performance as the lab-scale membrane.