OXIDATIVELY STABLE MEMBRANES FOR CO2 SEPARATION AND H2 PURIFICATION

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CO_2-selective facilitated transport membranes are well-known for providing remarkably high CO_2/H_2 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 quaternaryammonium hydroxide small molecules and quaternaryammonium hydroxide- and fluoride-containing polymers as mobile carriers and fixed-site carriers, respectively, for CO_2 separation and H_2 purification. The active nature of tetramethylquaternaryammonium hydroxide (TMAOH) as a mobile carrier was successfully demonstrated with the high CO_2 permeance obtained by the TMAOH-containing membranes. However, the membrane performance was improved significantly by the incorporation of quaternaryammonium hydroxide- and/or fluoride-containing polymers in the membrane. The resulting hydroxide- and fluoride-containing membranes exhibited CO_2 permeance > 100 GPU and CO_2/H_2 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 CO_2 permeance and CO_2/H_2 selectivity increased. As the membrane thickness was reduced from 15 µm to 2 µm, a sharp drop in the CO_2/H_2 selectivity was observed whereas the CO_2 permeance did not seem to increase as prominently as the H_2 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.