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Cellulose based hollow fiber carbon membranes for CO_2 removal from high pressure natural gas in subsea process

Xuezhong He
Norwegian University of Science and Technology, Norway

Natural gas (NG) is becoming one of the most attractive growing fuels for world primary energy consumption due to its availability, versatility and because it is a cleaner energy source compared to coal and crude oil. However, raw natural gas in reservoirs or wells usually contains considerable amount of light and heavy hydrocarbons (HHCs), as well as the impurities of water, H_2S, CO_2, N_2 and helium. Natural gas sweetening is needed to remove acid gases of H_2S and CO_2 to meet the legal requirements and natural gas network grid specifications. Developing novel environmentally friendly and energy efficient technology for CO_2 removal from natural gas is essential to improve the competition of natural gas processing plants. Although chemical absorption is still the state-of-the-art technology in this area, membrane technology has many advantages such as small footprint, low capital and operating costs, being environmentally friendly, and exhibiting process flexibility shows great potential. The challenges on natural gas sweetening membranes in the market today are the membrane compaction and plasticization, which points to the need of development on novel membrane materials for high pressure application in subsea process. Carbon membranes showed great potentials for CO_2/CH_4 selectivity. But the challenges on high production cost, brittleness of carbon fiber, low gas permeance due to the symmetric structure should be addressed by developing innovative low cost high performance asymmetric carbon membranes. Thus, in this work, we aim at developing mechanical strong, high performance asymmetric hollow fiber carbon membranes that can exceed CO_2/CH_4 Robeson upper bound (CO_2 permeance >0.3 m^3(STP)/(m^2.h.bar) and CO_2/CH_4 selectivity >100) from cheap cellulose materials for natural gas sweetening. In order to achieve this objective: 1) Suitable ionic liquids with appropriate physicochemical property was designed by molecular dynamic simulation, and synthesized for dissolution of cellulose at room temperature (<50°C); 2) Asymmetric cellulose hollow fibers with desired structure and morphology will be spun from cellulose/ionic liquids dope solution by controlling liquid-liquid demixing mechanism based on equilibrium thermodynamics of ternary phase diagram; 3) Asymmetric, defect-free and straight hollow fiber carbon membranes will be prepared by controlling carbonization protocol, and employing post-oxidation and post-reduction; the prepared carbon membrane performance for high pressure CO_2/CH_4 separation will be tested and reported.

xuezhong.he@ntnu.no

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