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Synthesis of STT zeolite membranes for He or H_2 separation from methane

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Abstract

Helium (He) is a noble gas widely used in medical, refrigeration, and semiconductor industries due to its unique physical properties. Commercial helium is generally extracted from natural gas through cryogenic technology, but the process is complex, costly, and energy-intensive because of the extremely low He fraction and operating temperature. Membrane gas separation is highly desired because of the atmospheric temperature operation, which is attracting more and more attention [1]. Herein all-silica STT zeolite membranes were prepared on four-channel hollow fibers under a rotation state [2]. A static synthesis approach was further explored, wherein the precursor in-situ transformed from liquid to a semi-solid state to efficiently suppress the nucleation in the bulk gel (Figure 1) [3]. The precursor could be reused one more time to remarkably reduce the total amount of chemical waste by 50%. Initially, both 7MR and 9MR channels served as the transport pathway, however, 7MR channels became the dominant one by modulating synthesis period and precursor composition. The low He concentration (0.2%) is increased by 15-18 times through the one-stage membrane separation at 0.7 MPa. The optimal H_2 permeance and H_2/CH_4 mixture selectivity was up to 6.1 × 10-8 mol·m^{-2}·s^{-1}·Pa^{-1} and 115 at atmosphere pressure. The H_2 permeation flux monotonically increased to 2.0 Nm^3·m^{-2}·h^{-1} under feed pressure up to 2.1 MPa. The long-term stability of STT zeolite membrane (>450 h) was demonstrated in the ternary mixture containing 1 mol% C_2H_6. Therefore, the membrane is expected to be a high potential for helium or hydrogen extraction from natural gas.

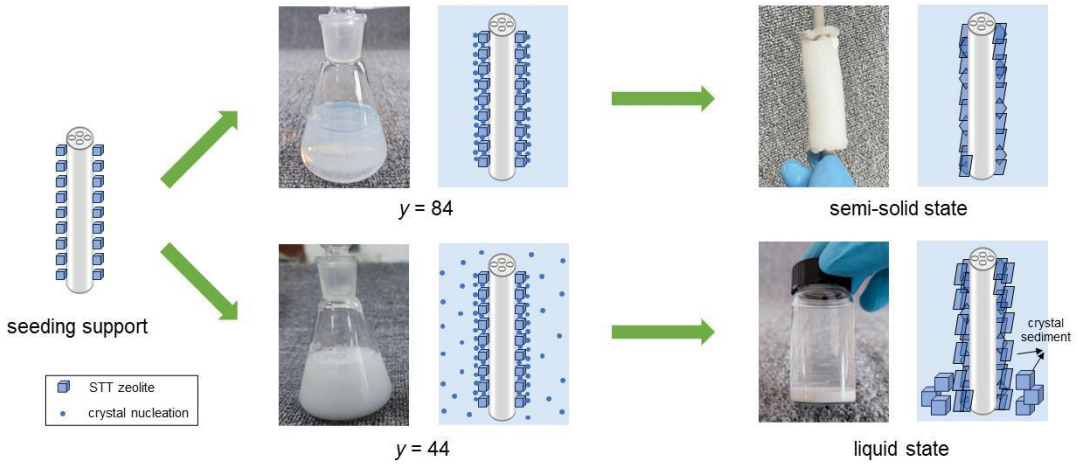

Fig. 1 Schematic diagram of STT zeolite membranes synthesis in static conditions

References

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