Strategies to rapid preparation of CHA-type zeolite via interzeolite transformation of FAU to CHA

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Motivation

Zeolite membranes are classified in the category of inorganic membranes which are capable of operating at high temperatures and pressures. CHA-type (Chabazite) zeolite with a pore width of 3.72 Å has received much attention in the past decade, because of desirable properties including higher porosity, uniform pore structure with sizes in the molecular range and hence they have wide applications in several fields e.g. as catalysts in the conversion of methanol to ethylene, as a molecular sieve in gas separation and lastly as an ion exchanger. For instance, one of the most important uses of CHA-type zeolite is CO_2 capture from natural gas, flue gas, biogas and syngas. In this circumstance, the adsorption based separation process plays a significant role in CO_2 capture. This work describes a new approach to the fabrication of CHA-type zeolite membranes using a cost-effective method to reduce energy consumption during the hydrothermal process.

Experimental

In a conventional method for synthesizing CHA-type zeolite using interzeolite transformation, potassium hydroxide was dissolved into deionized water and then FAU zeolite was added to the solution. The obtained mixture was stirred for 24 h and subsequently was transferred into the autoclave for the hydrothermal reaction and maintained for 96 h at 95 °C. But in the present method, to fabrication of CHA-type zeolite, the FAU-type zeolite in addition to the same amount of distilled water and potassium hydroxide were thoroughly mixed in planetary mill for 1 - 2 h. The as-mixed alkaline solution was sonicated for 30 minutes and poured into the teflon-lined stainless steel autoclave and the hydrothermal reaction carried out at 120 °C for 18 h. The collected zeolite crystals and the membranes after hydrothermal reaction were recovered by washing several times until the pH value was reached to 7. Finally, the samples were dried at 70°C overnight.

The membranes obtained in this study will be characterized by XRD to discover the phases, by SEM to find out the size and morphology of zeolite crystals and by single gas permeation measurements in order to pore and channel structure and separation properties. In addition, the particle size after the hydrothermal reaction will be analyzed by dynamic light scattering.

Results

The results of X-ray diffraction showed that the zeolite crystals are single phase without any impurities. Also, the crystal morphology indicated the growth mechanism during the synthesis process. In one hand, these results verified that the present method has higher crystallinity and fewer defect that provides better expectations. On the other hand, short-time synthesis limits negative effects such as uncontrollable changes in physical or chemical properties during the hydrothermal reaction. Also, the ultrasound waves generate periodical compression and it reduces the probability of microstructural imperfections.

The outcomes of gas separation and leakage tests based on gas permeance and kinetic diameter of molecules express the efficiency of membranes.

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