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Small-pore zeolite and zeotype membranes for CO_2 capture and sequestration – A review

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A R T I C L E I N F O

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A B S T R A C T

The increasing anthropological CO_2 emission prompts an urgent solution for better carbon extraction technologies from CO_2 point sources. Likewise, natural gas processes require similar CO_2 capture technologies for natural gas refining and biogas upgrading. Recently, the number of studies in CO_2 removal processes using zeolite and zeotype membranes has been increasing. Zeolite frameworks having micropores composed of 8 T-atoms are of particular interest since they have similar pore sizes to the kinetic diameter of light gases. Exploration of the newer small-pore zeolite framework such as CHA, DDR, AEI, LTA, and ERI give many options for the preparation of high-performance zeolite/zeotype membrane for CO_2 removal and or CO_2 capture. Herein, up-to-date small-pore zeolite/zeotype membranes are reviewed, and the prospects of these membranes are also discussed.

1. Introduction

Anthropological carbon dioxide (CO_2) emission is the primary greenhouse gas contributing to global warming of more than 1°C higher compared to the pre-industrial level [1]. For this reason, carbon capture and sequestration (CCS) became one of the most reliable options for mitigating climate change demonstrated worldwide [2]. However, the most mature CO_2 capture technology, amine-based processes, are limited by the high chemical and energy requirements for regeneration of the amine sorbents (3.5 GJ per ton of CO_2 for mono-ethanolamine and 2.17 GJ per ton of CO_2 for amine blend [1]). In contrast, membrane gas separation shows superiority in terms of straight-forward-process, low-cost, low-energy, and low-chemical requirements [3]. Membrane technology has emerged as a solution to the problem as it delivers superior performance in many separation processes [4-8], including gas separation [9-11]. Membrane technology application in gas separation eliminates the need for liquid and solid sorbents, reducing energy requirements and operating costs. Furthermore, the membrane's compact modular arrangement promotes commercial development [12-14]. Membrane gas separation removes contactor-based problems such as flooding and weeping while being flexible for retrofitting into existing industries [15]. The membrane for gas separation can be prepared from polymer and inorganic materials. However, the polymeric membranes' chemical, thermal, and mechanical resistance are considerably weaker compared to inorganic membranes. Pristine polymeric membranes tend to have problems such as plasticization and degradation [16,17]. In addition, the separation performance of polymeric membranes in gas separation is limited by the permeability versus selectivity trade-off [18]. Today, many emerging inorganic membranes with unique properties, i.e., zeolitic-imidazolate-framework, metal-, carbon-, and ceramic-based membranes, are increasingly popular [19,20]. Ceramic-based membranes, including silica-, alumina-, zeolite-, and zeotype-based membranes, are especially noteworthy since they are continuously studied and recorded in a large amount of literature.

Zeolites and zeotype membranes are thermally stable (up to 800°C [21–23]). It is also advantageous that some zeolite and zeotype properties, such as pore size, crystal size, morphology, orientation, and/or chemical constituent, can be fine-tuned to match the desired application

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