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Experimental investigation and mathematical modeling of CO_2 sequestration from CO_2/CH_4 gaseous mixture using MEA and TEA aqueous absorbents through polypropylene hollow fiber membrane contactor

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Abstract

In the current study, experimental and mathematical results of a counter-current contact between CO_2/CH_4 gaseous mixture and aqueous liquid absorbents (MEA and TEA) through a microporous polypropylene hollow fiber membrane contactor are presented to evaluate the sequestration percentage of CO_2 acidic pollutant from gaseous mixture. One of the aims of this paper is to experimentally and mathematically study the effects of gas flow rate, aqueous liquid absorbents' flow rate and also inlet CO_2 concentration on the removal efficiency of CO_2. In order to carry out this, a two dimensional mathematical model is developed to predict the experimental results. The experimental results show that MEA absorbent has higher superiority for efficient removal of CO_2 acidic gas compared to TEA absorbent. Based on the experimental results, the sequestration efficiency of CO_2 from gaseous mixture applying MEA and TEA aqueous absorbents is about 92 and 62 %, respectively. The simulated results of CO_2 sequestration in wide ranges of gas flow rate, inlet CO_2 concentration and liquid absorbents' flow rate demonstrate an excellent agreement with those of experimentally measured ones with average absolute relative errors (AAREs) of 4.3, 4.4 and 3.6 % for employing MEA and 6.9, 3.4 and 5.2 % for using TEA absorbents, respectively. Additionally, this article aims to study the influence of momentous operational parameters such as number of fibers, module length and also membrane porosity and tortuosity on the CO_2 separation efficiency. Based on the experimental and the numerical simulated results, increase in the gas flow rate, the membrane tortuosity and the CO_2 inlet concentration significantly deteriorates the sequestration efficiency of CO_2 while increment of the fibers counts, the membrane module length, the membrane porosity and the liquid flow rate positively encourages the CO_2 sequestration percentage.

Graphical abstract: