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# Using Composite Membrane Contactors with Polyamide Functional Layer for $Co_2$ Separation

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## Extended Abstract

Over the last decade, the increasing awareness and concern about environmental and health issues among the public have given rise to a range of new technological solutions in environmental engineering. As part of this change, considerable progress in membrane applications for flue gas treatment has been made, and new opportunities were created by developing high-performance membranes and modules designs. In particular, many researchers have widely studied the gas separation process using membrane contactors. The most explored gas separation process nowadays is capture of carbon dioxide ($CO_2$) capture from flue gas [1], sulphur oxide ($SO_2$) [2] and nitrogen oxides ($NO_x$) via gas absorption [3]. Membrane contactors are devices that allow a gaseous phase and a liquid phase to come into direct contact with each other, for mass transfer between the phases, with/without dispersing one phase into the other [4]. Some membrane contactors allow passing of the flue gas through the membrane pores and the gas becomes fine-bubbled, significantly increasing the effective contact area. The membrane technique can independently control the gas and liquid flow rate, avoiding solvent loss, bubble, channelling, entrainment and other operational problems [5]. In membrane contactors with functional polymer/ceramic layer, dispersion phenomena do not occur. Instead, diffusion or solution-diffusion or facilitated carries transfer the gas species from one phase to another [6]. Membrane contactors reduce the volume of equipment and offer a large interfacial area in non-dispersive contact across a membrane, leading to a decrease in the height of transfer unit values. Membrane contactors control a shape of fluid–fluid interface, in contrast to conventional separation equipment where the shape of the fluid–fluid contact is an accident of nature.

In this work, a thin film composite membrane with a polyamide functional layer (Toray, TM 710D) was used for the separation of $CO_2$ from the gas stream. Parts of these spiral membrane modules were tested as flat sheet membranes with an active area of 24 $cm^2$. Membrane thickness was 130 µm with functional polyamide layer having a thickness of about 500 nm. The testing bench used in this research consists of four main parts: gas mixture preparation system, a solvent loop with constant temperature, membrane module and gas concentration measurement system. The separation was measured for pure $CO_2$ and for the mixture of 15 vol.% $CO_2$ in nitrogen to simulate common flue gases. Demineralized water was chosen as an absorption solution before testing others $CO_2$ suitable solvents. The effects of several variables, such as gas flow rate, absorbent flow rate, gas pressure and cell internal geometry on the removal of $CO_2$ from flue gas, were investigated. The gas flow rate was kept at 50 $mL \cdot min^{-1}$ while the liquid flow rate was 3.23 $L \cdot min^{-1}$. It was found that the $CO_2$ removal efficiency increased with the increasing of gas pressure from 1 to 4 Barr for pure $CO_2$. The absorption flux was changing from 2.39 $\cdot 10^{-5}$ to 3.35 $\cdot 10^{-4}$ $mol \cdot m^{-2}\ s^{-1}$, and the removal efficiency changed from 0.2 to 2.2 % in the cell with mass transfer limitation due to porous steel support on the liquid side. The increase of gas pressure conditions has a slight effect on $CO_2$ removal efficiency, showing application prospects. Using the model solution of flue gases (15 vol.% $CO_2$ in Nitrogen), the absorption flux decrees to 4.48 $\cdot$ $10^{-5}$ $mol \cdot m^{-2}\ s^{-1}$. Absorption fluxes are comparable with membrane contactors for $SO_2$ and indicate that the membrane can be applied to $CO_2$ capture from the flue gas after optimization of hydrodynamic conditions in the contactor leading to higher removal efficiency.

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