Recovery of carbon dioxide by membrane separation

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Introduction

Carbon dioxide is a major gas among the green house gases such as methane, NO_x, SO_x, and CFC. The carbon dioxide is mainly produced from the power plant, cement plant and steel works, resulting from the industrialization. Nowadays, the separation and recovery of carbon dioxide are being studied by the several groups over the world. As the possible carbon dioxide removal techniques, chemical absorption, physical adsorption, cryogenic, membrane and hybrid methods have been considered. The conventional processes such as absorption and adsorption are, however, energy-intensive and the resulting equipment is rather large. Generally, membrane methods is known as the reducing energy consumption in the CO_2 separation and also make the entire system more compact than these conventional processes. In this study, the development of membrane technology to recover continuously carbon dioxide as high concentrated from stationary sources is proposed. A results of our research works with highly efficient membranes such as water-swollen hydrogel(WSH) membranes, an improved hollow fiber membrane contactor and hybrid system (combination of hollow fiber membrane contactor with absorption process) are summarized.

Results and Discussion

1. Separation of carbon dioxide by water-swollen hydrogel (WSH) membrane

WSH membranes for the gas separation were prepared by dip-coating asymmetric porous polyetherimide(PEI) supports with poly(vinyl alcohol) (PVA)-glutaraldehyde(GA), followed by the crosslinking of the coating layer by solution crosslinking method. In the solution crosslinking method, dry nascent WSH membranes were crosslinked by immersion for 10 min. at 40℃ in crosslinking solutions(isopropylalcohol/ water/HCl = 90/9/1 in wt.%). The coating layer with different blend composition (PVA/GA=1/0.04, 0.06, 0.08, 0.10, 0.12 mol.%) were characterized with differential scanning calorimetry (DSC) and the determination of their water swelling ratio. The thickness of coating layer and supporter of WSH membranes were 0.8-1.2㎛ and 180-200㎛, respectively. The separation performances of the WSH membranes were measured with a vacuum mode of downstream using a mass flow meter and gas chromatograph. A WSH membrane was swollen by water vapor contained in a feed gas. For the carbon dioxide separation

through the WSH membrane, a permeability of 10^5(cm^3/cm · sec · cmHg) and a CO_2/ N_2 separation factor of about 120 at room temperature were obtained. A small scale separation equipment(capacity : 0.05Nm^3/min.) using WSH membrane was prepared to separate carbon dioxide.

2. Study on the separation process using circulatory hollow fiber membrane contactor

Separation of CO_2 under different experimental conditions and computer simulation were carried out to optimize the operation condition. The CO_2 permeation rate increased as the flow rate of the absorbent through the circulatory hollow fiber membrane contactor increased. However, in the case of the mixture gas, CO_2 permeation rate increased but the selectivity decreased in a certain flow rate range. From the results of the efficiency of the recovery of CO_2 with different vacuum degree in the desorption module of the circulatory hollow fiber membrane contactor, it was found that the pressure and flow rate of absorbent in the desorption module affected seriously on the permeation rate of CO_2.

3. Development of hybrid system and study on the characteristics of carbon dioxide

To establish hybrid system consisting of hollow fiber membrane contactor and conventional absorption system and study on the efficiency of the CO_2 recovery using that hybrid system[Fig.1], polysulfone hollow fiber membrane module as a contactor was placed into the absorption unit of conventional absorption system that had a capacity of 1.2 Nm^3/h. To compare and analyze the separation efficiency of ours with that of conventional absorption system, CO_2 separation experiment was carried out, using MEA as an absorbent that has been used for the conventional absorption system and K_2CO_3 used for circulatory hollow fiber membrane contactor and the result was that the hybrid system developed in this project was appeared to be better and two times higher than conventional absorption system in the separation efficiency when K_2CO_3 was used.

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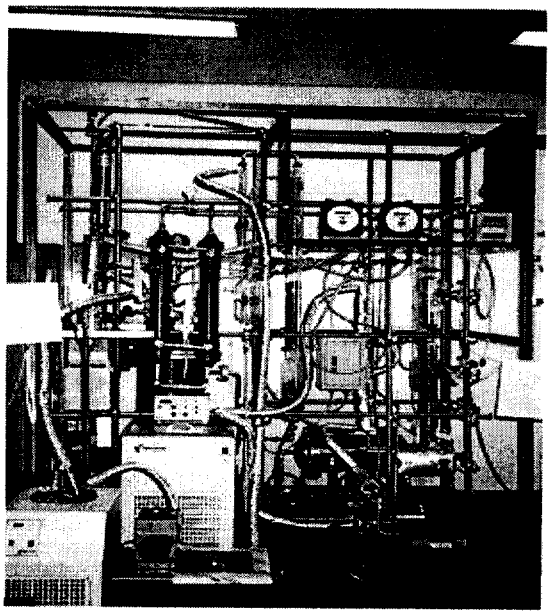

Fig. 1 Photograph of hybrid system