일반강연 2-5

이산화탄소 분리를 위한 중공사막 모듈에서의 물질전달 거동

전 명 석, 김 영 목, 이 규 호

한국화학연구소, 고분자소재부 분리소재연구실, 대전 305-606

On the Mass Transfer Behaviors in Hollcw-Fiber Membrane Modules for CO_2 Separation

Myung-Suk Chun, Young-Mok Kim, Kew-Ho Lee

Membranes and Separation Lab., Advanced Polymer Div.

Korea Research Institute of Chemical Technology, Taejon 305-606

High permeability, selectivity and stability are the basic properties also required for membrane gas separations. The CO_2 separation by liquid membranes has been developed as a new technique to improve the permeability and selectivity of polymeric membranes. Sirkar et al.(1) have attempted the *hollow-fiber contained liquid membrane* technique under four different operational modes, and permeation models have been proposed for all modes. Compared to a conventional liquid membrane, the diffusional resistance decreased by the work of Teramoto et al.(2), who referred to a *moving liquid membrane*. Recently, Shelekhin and Beckman (3) considered the possibility of combining absorption and membrane separation processes in one integrated system called a *membrane absorber*. Their analysis could be predicted effectively the performance of flat sheet membrane, however, there are restrictions for considering a flow effect.

The gas absorption rate is determined by both an interfacial area and a mass transfer coefficient. It can be easily understood that although the mass transfer coefficients in hollow fiber modules are smaller than in conventional contactors, the substantial increase of the interfacial area can result in a more efficient absorber (4). In order to predict a performance in the general system of hollow-fiber membrane absorber, a *gas-liquid mass transfer* should be investigated inevitably. The influence of liquid velocity on both a mass transfer and a performance will be described, and then compared with experimental results. A present study is attempted to provide the fundamentals for understanding aspects of promising a hollow-fiber membrane absorber.

Model developments

Depending on the interaction of the membrane material, either wetted (*hydrophilic*) or non-wetted (*hydrophobic*) membrane conditions may be realized (4). The liquid is flowing countercurrently to the gas flow through the tube side (lumen). The conditions of i) isothermal, ii) fully developed laminar flow, iii) no axial diffusion, and iv) Henry's law are assumed. The concentration profiles can be obtained from the general differential mass balance that describes *diffusion* and *convection*. As boundary conditions, the concentration profile is symmetric about the center of the tube, and constant at interface (4,5). With these conditions, this problem is then well described with the *Graetz-Lévèque solution.* The concentration profiles can be obtained numerically using a *finite difference* scheme, and tridiagonals are formulated according to the discretization. The calculation procedure is continued till a convergence is attained. The physical constants needed as parameters for computations are presented from literature information.

Experiments

Microporous hydrophobic Celgard polypropylene fibers were used, their characteristics are provided in Table 1. The CO_2 concentrations in gas inlet and outlet were measured by a HP 5890A gas chromatography using a TCD detector. MEA(mono-ethanolamine) solution was used as an absorbent. Details on the experimental setup will be presented.

Table 1 Dimension of hollow fiber modules

hollow-fiber				module		
type	ID (μm)	OD (μm)	porocity, %	type	contact length (cm)	volume (cm^3)
X-10	240	290	40	A	12.5	61.4
X-20	400	450	23	B	26	127.6

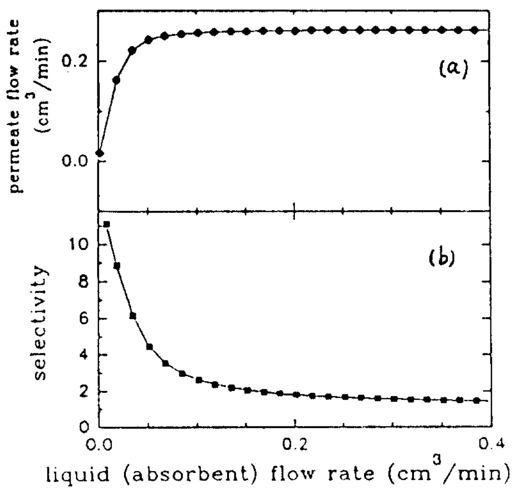

Fig.1. Predictions on the (a) permeate flow rate, and (b) selectivity of membrane absorber with variation of absorbent flow rates.

References

(1) Guha, A.K., Majumdar, S., and Sirkar, K.K., *I&EC Res.*, 31, 593 (1992).

(2) Teramoto, M., Matsuyama, H., Yamashiro, T., and Okamoto, S., *J. Membrane Sci.*, 45, 115 (1989).

(3) Shelekhen, A.B. and Beckman, I.N., *J. Membrane Sci.*, 73, 73 (1992).

(4) Kreulen, H., Smolders, C.A., Versteeg, G.F., and van Swaaij, W.P.M., *J. Membrane Sci.*, 78, 197 (1993), and 78, 217 (1993).

(5) Karoor, S. and Sirkar, K.K., *I&EC Res.*, 32, 674 (1993).