DEVELOPMENT OF MEMBRANE AND COLD-CONDENSATION PROCESS FOR REMOVAL AND RECOVERY OF VOLATILE ORGANIC COMPOUNDS

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ABSTRACT

Volatile organic compounds (VOC) cause air pollution problem and deterioration of atmosphere of petrochemical and fine chemical plants. Hybrid process of membrane and cold-condensation were developed and it effectively removed and recycled the VOC. Operation parameters of the process were optimized to attain high removal and recycle of VOC. Composite membranes for organic vapor separation were developed in this work by PDMS coating and plasma polymerization on polypropylene and polysulfone support membranes. PDMS and various silicone monomers were tested for several organic vapors such as benzene, toluene, TCE, and HCFC, which are produced in petrochemical and fine chemical industry and causes air pollution problems if are released to atmosphere. Composite membranes prepared in this work showed appreciable performance in terms of organic vapor removal and reuse. Performance variation of the membranes was correlated with their surface characteristics.

INTRODUCTION

Removal and recovery of VOC has been a big issue, and several methods to treat VOC have been developed so far, such as adsorption, combustion, condensation and membrane separation. Each method has its own characteristics and advantages over the others. Membrane technology, which has been successfully applied in seawater desalination and gas separation, is expected to provide an alterative to the conventional methods. If it is combined with other separation process such as cold condensation, it can achieve far better performance and secure the economical competitiveness. Gas separation with glassy membranes has emerged as a major application of membrane technology during the past 15 years. The current market for the membrane is approximately $150 million/year.
In order to prevent the air pollution and to reuse expensive organic materials, it is necessary to separate organic vapors from waste stream in petrochemical and fine chemical industry. Recovery of organic vapor has been under the scrutiny from both environmental and economic points of view. However, most existing techniques for vapor control have been so far proved to be unsatisfactory in terms of safety, performance, operating cost, and facility space.

EXPERIMENTAL

Membrane and cold-condensation system was designed and set up as shown in Fig. 1 System is composed of three units as shown in Fig. 1; condensation unit, membrane unit, concentration determination unit. Various operation conditions were applied to the system in order to optimize them, and several membranes from different process and different materials were tested. PDMS coating and plasma polymerization were used for composite membrane fabrication, silicone monomers were tested for their separation efficiency of organic compounds.

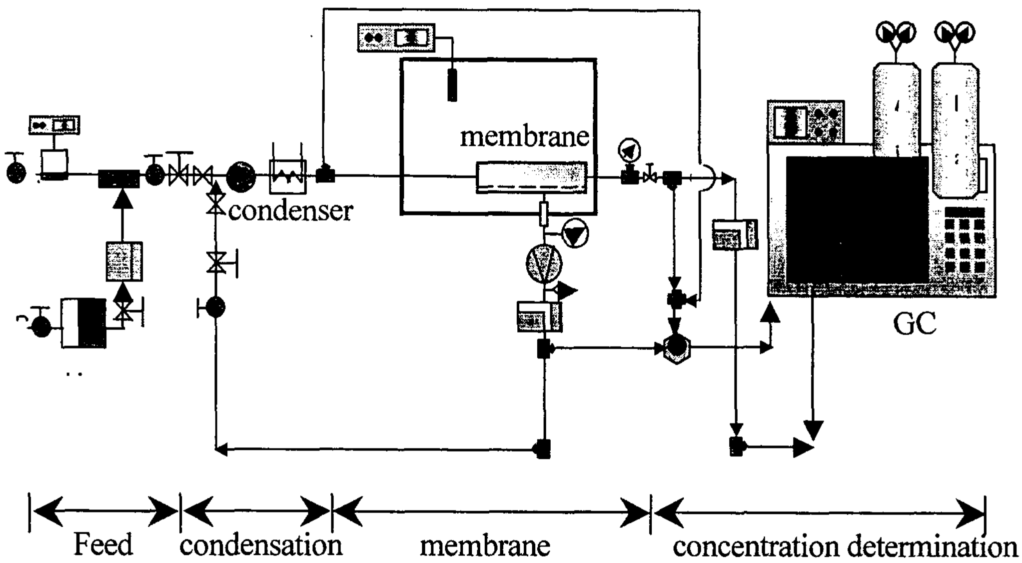

Fig. 1 A schematic diagram of membrane and cold-condensation system

For PDMS coating process polysulfones membrane are used as support material. Prepolymer (RTV655A) and crosslinking agent (RTV655B) was purchased form General Electric Co. to make coating solution by dissolving prepolymer and crosslinker in a 10/1 weight ratio in n-hexane. Total polymer concentration range was varied from 5 to 40 weight %. PDMS solution was pre-crosslinked for 4hr at room temperature under stirring condition. Prior to coating, the wet porous support were attached to a glass plate. Support plate was inclined to angle of 60 °, on which casting solution was poured. and the plate was put in a vertical position under the hood. The solvent was evaporated for 1hr at 100℃ in the vacuum oven to complete the crosslinking reaction.

Plasma polymerization makes pinhole-free, thin film composite membrane. Plasma polymerization for membrane preparation is a very promising field. The porous substrate used for plasma polymerization was porous polypropylene membrane. Monomers used for plasma polymerization were hexamethyldisiliane, hexamethyldisiloxane, and hexamethyldisilazane (Aldrich, 99.9%) and were used without further purification.

Plasma polymerization was performed in a radiofrequency (RF) powered plasma reactor. The reactoris 190mm ID, length 700mm pyrex reactor opened at both ends. The one end is connected to a monomer bottle through 1/4 in. tube with a metering valve. RF power supply (RFX 600 generator)and matching network (RTX-600) are connected to the reactor. The pressure in the reactor vessel was monitored with an MKS pressure transducer (MKS type 622) and a recorder.

Before plasma polymerization, Celgard substrate was placed inside the reactor, and the plasma polymerization system was evacuated for at least 1h below 30mTorr. The substrate was then treated with Ar plasma for 60min to eliminate water adsorbed on the surface of the reactor. Then, the monomer was introduced into the reactor with a controlled rate. After the steady state was reached, 10W RF power was supplied to the reactor, and plasma polymerization proceeded for a certain period

RESULTS AND DISCUSSION

Effects of operating temperature, operating pressure and feed concentration were examined as shown in Figs. 2 to 4..

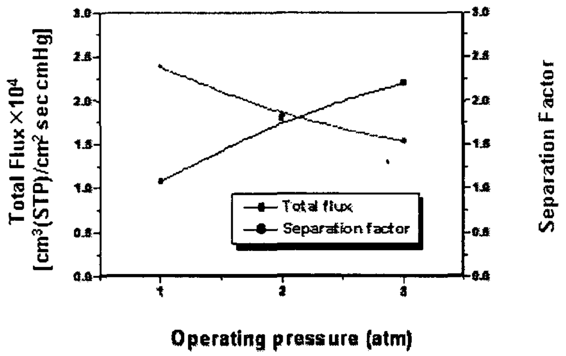

Fig. 2 Effect of Operating Pressure

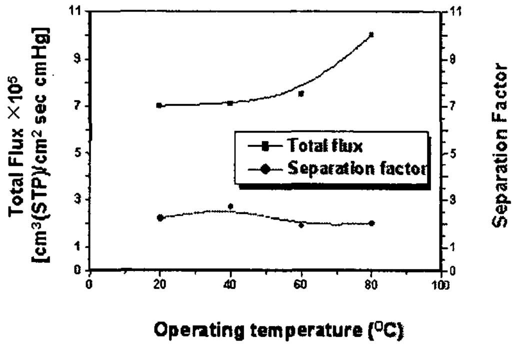

Fig. 3 Effect of Operating Temperaturee

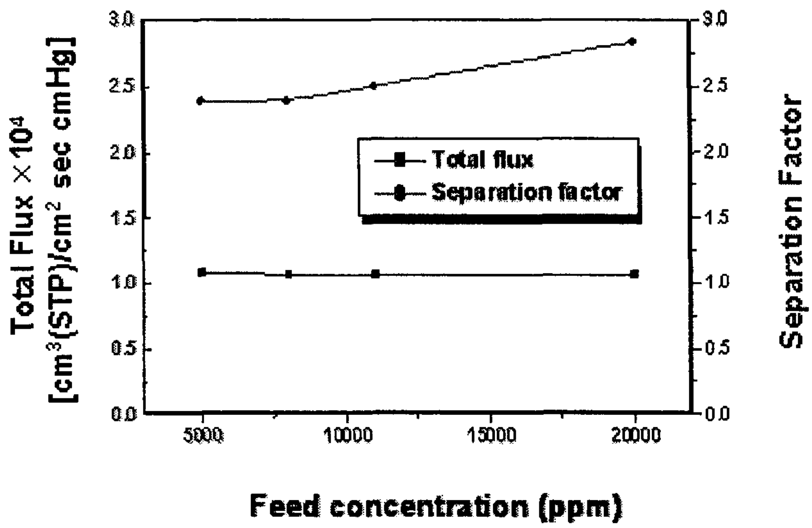

Fig. 4 Effect of Feed Concentration

We have tested several VOCs in this work as shown in Fig. 5, from which we could catch that separation factor of each VOC is directly related with its critical temperature.

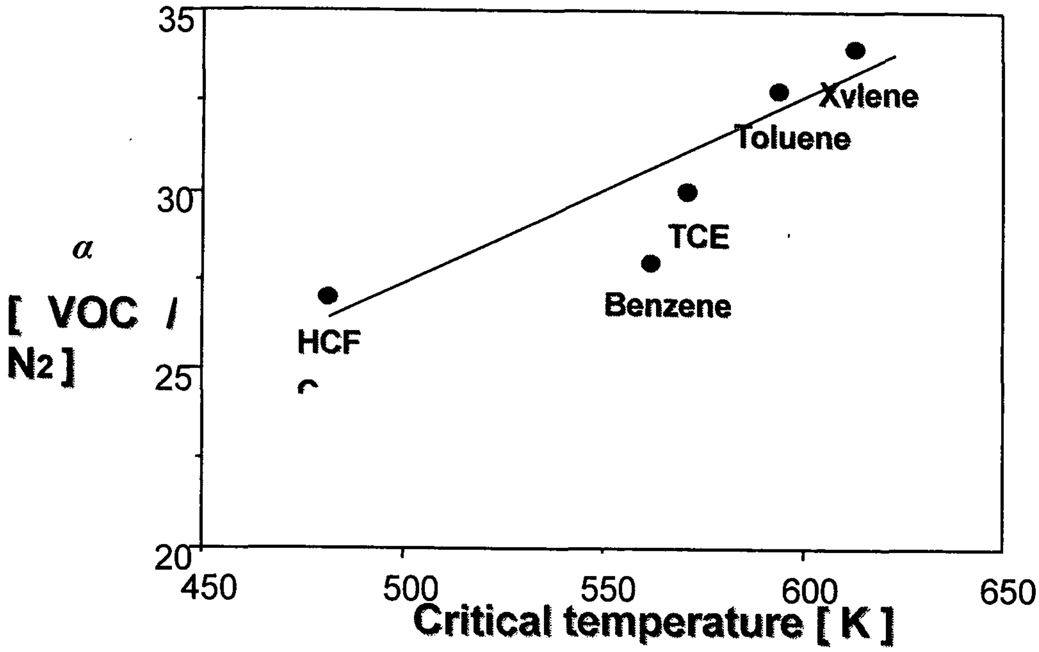

Fig. 4 Correlation of separation factor with critical temperature

REFERENCES

1 C.K. Yrom, S.H. Lee, H.Y. Song, J.M. Lee. Vaporpermeation of a series of VOCs/N2 mixtures through PDMS membrane. J Memb. Sci. 1989 (2002)

2. Xianshe Feng , S.Souriragan, F.Handan Tezel, Separation of Volatile Organic Compound/Nitrogen mixtures by polymeric membrane. *Ind. Eng. Chem. Res. 32(1993)*

3. Wool-Ik Sohn, Dong-Hyun Ryu, Sae-Joong Oh, Ja-Kyung Koo. A study on the development of composite membranes for theseparation of organic vapor. J. Memb. Sci. 175(2000)

4. I.F.J. Vankelecom, B. Moermans, G. Verschueren, P.A. Jacobs. Intrusion of PDMS top layer in porous support. J. Memb. Sci. 158(1999)

5. B. Bae, B-H. Chun, D. Kim. Surface characterization of microporous polypropylene membranes modified by plasma treatment. Polymer 42(2001)

6. A. Yamasaki, R.K. Tyagi, A.E. Fouda, T. Matsuura, K. Jonasson. Effect of gelation conditions on gas separation performance for asymmetric polysulfone membrane. J. Memb. Sci. 123(1997)