일반강연 I -8

Hexamethyldisiloxane의 플라즈마 중합에 의하여 제조된 복합막을 통한 공기중의 휘발성 유기물질의 분리에 관한 연구

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Separation of VOCs from Air through Composite Membranes Prepared by Plasma Polymerization of Hexamethyldisiloxane

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1. Introduction

Atmospheric discharge of VOC-contaminated streams in chemical plants and air streams from chemical processes poses a serious environmental problem and entails large financial losses. Such emissions may be reduced by i) adsorption process, ii) absorption process and iii) incineration process. These processes only forbids the air pollutions. Throughout the recent decade, another technique-membrane process has emerged. The separation and recovery of organic vapors by membrane process may have great economic potential. Most of the published research works on the separation of organic vapors from air were performed using silicon rubber membranes. However, it is very difficult to fabricate very thin membranes with less than 1 μm thickness. Plasma polymerization could be a good technique to generate a thin polymer film.

The objective of this work is to find out the optimum condition of plasma polymerization for producing VOC separation membrane. For the objective, composite membranes are prepared through plasma polymerization of hexamethyldisiloxane onto porous substrates under different conditions. The membrane is then subjected to the permeation of permanent gases and VOCs to find the correlations between the physical properties of the penetrant and permeability and selectivity.

2. Experiments

For the plasma polymerization, coil type tubular reactor was used, and 13.6 MHz radio frequency power was supplied into the reactor. Throughout the plasma polymerization, the power ratio was varied from 7.5 Watt/sccm to 13.3Watt/sccm by changing monomer flow rate in the range from 1.5 sccm to 3 sccm, under the power supply range between 2 Watts to 3 watts. Permeabilities of permanent gases such as oxygen, nitrogen, methane, and organic vapors of propane, butane, benzene, hexane and cyclohexane through the membranes were tested separately. The permselectivities of the VOCs over nitrogen were estimated by the ratio of VOCs permeabilities over the nitrogens permeability.

3. Results and Discussions

In the composite membranes, the permeability coefficients were dominated by the solubilities of the penetrants rather than diffusivities. Figure 1 shows the effect of critical temperatures of the penetrants on their permeabilities. From the figure, we can see that the permeabilities increased while the critical temperatures increased. The critical temperature is a measure of condensability and hence the solubility of the penetrant. That is, the permeability of the penetrant increased with its solubility, and the VOCs of benzene, n-hexane and cyclohexane with high solubilities showed higher permeabilities than the gases such as oxygen, nitrogen and methane. When the critical temperatures are similar each other, geometry of the penetrant also affected the permeability. From the figure, we can see that n-hexane which has straight chain structure showed higher permeability than cyclohexane which has circular structure.

Additionally, the decrease of the power ratio made considerable increase of the permselectivities of the VOCs toward nitrogen. Figure 2. shows the effects of power ratio on the permeslectivities of the VOCs over nitrogen. This behavior may be a result of the structural difference among the plasma films prepared with different power ratios. It is well known that plasma films which are prepared under low power ratio show the structure of low crosslinking density.

4. Conclusions

Through the plasma polymerized composite membranes, the permeability coefficient of the penetrant increased with its solubility, and the VOCs with higher solubilities showed higher permeabilities than the nitrogen with lower solubility. The power ratio played an important role in obtaining composite membranes with good separation characteristics. Membranes with higher permselectivities was obtained through plasma polymerization under the lower power ratio.

5. References

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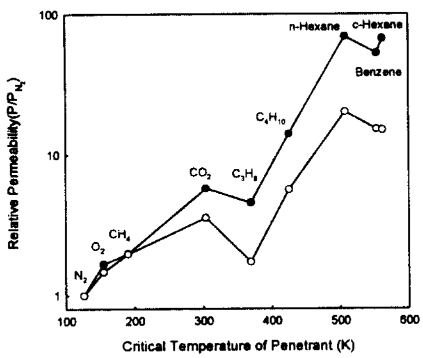

Figure 1. Effect of Critical Temperatures of Penetrants on Their Relative Permselectivities

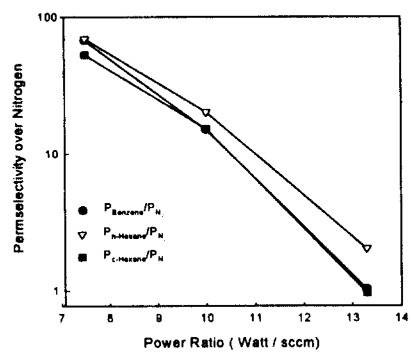

Figure 2. Effect of Power Ratio on The Permselectivities of VOCs over Nitrogen