Note

Application of Inorganic Membrane to Separation of Benzene and Cyclohexane with Supported Liquid Membranes Using Ionic Liquids

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Abstract

Application of inorganic membrane (Shirasu porous glass, SPG) to separation of benzene and cyclohexane with supported liquid membranes using ionic liquids, based on 1-alkyl-3-methyl-imidazolium was examined. Ionic liquids were stably kept in pores of a SPG support and benzene selectivity permeated the membranes as well as a polymeric membrane. Apparent diffusivities in the membrane using SPG were almost the same as those with the polymeric membrane.

Key words: liquid membrane, ionic liquid, inorganic membrane, benzene, cyclohexane, SPG

1 Introduction

In our previous papers, application of supported liquid membranes (SLMs) based on ionic liquids to separation of organic compounds and antibiotics were examined and we found that SLMs based on ionic liquids gave extremely stable membranes [1-4]. In these studies and most studies concerning SLMs, the membrane supports are polymeric [5]. However polymeric SLMs are more sensitive to temperature, pH, chemical environment and physical stress [6,7]. Although ceramic supported membranes have potential to overcome the above difficulties, there are a few studies of ceramic supported membrane based on conventional organic solvents [6,7] and no studies of those based on ionic liquids. In this study, we examine whether inorganic membrane can be utilized the SLMs based on ionic liquids. We raise the separation of benzene and cyclohexane as a model system which was previously reported using a polymeric SLM based on ionic liquids [1]. Shirasu porous glass (SPG) membranes, which have found many applications [8], were used as a ceramic support.

2 Experimental

Imidazolium-based ionic liquids, the hexafluorophosphates of 1-*n*-butyl- or 1-*n*-hexyl imidazolium, [C₄mim][PF₆] and [C₆mim][PF₆] were prepared as described in the previous paper[2]. The membrane materials were a hydrophilic polyvinylidene fluoride (PVDF, Millipore) with a pore size of 0.45 μm and Shirasu porous glass (SPG, SPG techno) with a pore size of 0.4 μm . The thickness of PVDF and SPG membranes were 150 μm and 766 μm , respectively. PVDF or SPG was impregnated with ionic liquid as described in the previous papers [1-3]. A membrane with an effective area, *A*, of 25 cm² (PVDF) or 2.25 cm² (SPG) was fixed in the apparatus. 50 ml of benzene and 50 ml of cyclohexane were added into the feed phase and 100 ml of hexadecane was poured into the receiving phase at 30 °C. The stirring speed of the magnetic bar in each cell was controlled at 300 rpm.

Samples in receiving phase were withdrawn at regular time intervals. Then the concentrations of benzene and cyclohexane in receiving phase were measured by gas chromatography.

3 Results and Discussion

Figure 1 shows time courses of the concentrations of benzene and cyclohexane in the receiving phase under the condition where $[C_6mim][PF_6]$ and SPG are used at 30 °C. The weight loss of ionic liquid supported in the membrane after the experiment was not observed. From these results, it was found that ionic liquids were stably kept in pores of a SPG support and benzene selectivity permeated the membranes as well as a polymeric membrane. As described in the previous papers [1-3], from the experimental data the overall mass transfer coefficients, k , and selectivity, S , were evaluated and shown in Fig. 2. From Fig. 2, permeation rates with SPG were lower than those of PVDF because of thicker membrane of SPG, suggesting that the controlling step of the permeation is the diffusion process through the membrane. Apparent diffusivities, D , through the membranes were calculated as products of the overall mass transfer coefficients and membrane thickness, and listed in Table 1. Apparent diffusivities were controlled by the affinity of permeants and ionic liquids [1,2], suggesting that the permeation obeys the sorption-diffusion model. And effect of support on the permeation was found to be small. As a consequence, it is possible to use SPG membrane as a support of liquid membrane.

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Fig.1 Time course of concentration in receiving phase. Ionic liquid; $[C_6mim][PF_6]$, Support; SPG

Fig.2 Effect of membranes on overall mass transfer coefficients and selectivity

Table 1 Apparent diffusivities

	$10^{10}D_{Bz}[m^2/h]$	$10^{10}D_{Cx}[m^2/h]$
C4,PVDF	792	84
C6,PVDF	894	135
C4,SPG	827	77
C6,SPG	881	107

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