Preparation of silica hybrid membranes for high temperature gas separation

Mikihiro Nomura*, Keita Momma, Yoshio Negishi, Emi Matsuyama, Sayuka Kimura

Department of Applied Chemistry, Shibaura Institute of Technology, Tegosu, Koto-ku, Tokyo 135-8548, Japan
Tel. +81 358598160; Fax +81 358598160; email: Lscathy@shibaura-it.ac.jp

Received 23 July 2009; Accepted 25 November 2009

ABSTRACT

A molecular sieve silica hybrid membrane was successfully prepared by using a counter diffusion chemical vapor deposition (CVD) method. Propyltrimethoxysilane (PrTMOS) was employed for a silica precursor. O₃ was used as an oxidizer. Effects of deposition temperatures on permeation properties through the silica membranes were investigated. H₂ (0.29 nm), N₂ (0.36 nm) and SF₆ (0.55 nm) permeances were measured at the deposited temperatures through the membranes. H₂/N₂ permeances ratios decreased sharply with increasing the deposition temperatures from 200°C to 400°C. In addition, H₂ permeance through the membrane deposited at 400°C was very high (4.6×10⁻⁷ mol m⁻² s⁻¹ Pa⁻¹) with a low H₂/N₂ permeances ratio (3.4). This shows that silica was not deposited at 400°C due to O₃ decomposition at the high temperature deposition. On the other hand, N₂/SF₆ permeances ratios increased with increasing the deposition temperatures up to 320°C. The maximum value of N₂/SF₆ permeances ratio was 110 at 320°C deposition. This is much larger than that of Knudsen diffusion separation (2.3). According to the kinetic diameters of N₂ and SF₆, the pore sizes of the membrane were estimated at about 0.5 nm. These results show that the pore size of silica membranes can be controlled by changing the deposition temperatures. The decomposition reactions of propyl groups on silica hybrid materials were also investigated by TG and IR measurements. Propyl groups on silica hybrid materials decomposed at around 300°C and 400°C. Decomposition at around 300°C was C₃H₇ removal from the surface to remain methyl groups on the surface. Thus, we conclude that the high selective membrane deposited at 320°C was a silica hybrid membrane having methyl groups in the silica deposition.

Keywords: Silica hybrid membrane; Counter diffusion CVD; Pore size control

* Corresponding author.