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Preparation of silica hybrid membranes for high temperature gas separation

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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. O_3 was used as an oxidizer. Effects of deposition temperatures on permeation properties through the silica membranes were investigated. H_2 (0.29 nm), N_2 (0.36 nm) and SF6 (0.55 nm) permeances were measured at the deposited temperatures through the membranes. H_2/N_2 permeances ratios decreased sharply with increasing the deposition temperatures from 200°C to 400°C. In addition, H_2 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 H_2/N_2 permeances ratio (3.4). This shows that silica was not deposited at 400°C due to O_3 decomposition at the high temperature deposition. On the other hand,N_2/SF_6 permeances ratios increased with increasing the deposition temperatures up to 320°C. The maximum value of N_2/SF_6 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 N_2 and SF_6, 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 C_2H_4 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

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