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Preparation of hydrophobic silica membranes supported on alumina hollow fibers for pervaporation applications

Authors : Ami Okabe, Daisuke Gondo, Akira Ogawa, Yasuhisa Hasegawa, Koichi Sato, Sadao Araki, Hideki Yamamoto

Abstract : Membrane separation draws attention as the energy-saving technology. Pervaporation (PV) uses hydrophobic ceramic membranes to separate organic compounds from industrial wastewaters. PV makes it possible to separate organic compounds from azeotropic mixtures and from aqueous solutions. For the PV separation of low concentrations of organics from aqueous solutions, hydrophobic ceramic membranes are expected to have high separation performance compared with that of conventional hydrophilic membranes. Membrane separation performance is evaluated based on the pervaporation separation index (PSI), which depends on both the separation factor and the permeate flux. Ingenuity is required to increase the PSI such that the permeate flux increases without reducing the separation factor or to increase the separation factor without reducing the flux. A thin separation layer without defects and pinholes is required. In addition, it is known that the flux can be increased without reducing the separation factor by reducing the diffusion resistance of the membrane support. In a previous study, we prepared hydrophobic silica membranes by a molecular templating sol−gel method using cetyltrimethylammonium bromide (CTAB) to form pores suitable for permitting the passage of organic compounds through the membrane. We separated low-concentration organics from aqueous solutions by PV using these membranes. In the present study, hydrophobic silica membranes were prepared on a porous alumina hollow fiber support that is thinner than the previously used alumina support. Ethyl acetate (EA) is used in large industrial quantities, so it was selected as the organic substance to be separated. Hydrophobic silica membranes were prepared by dip-coating porous alumina supports with a □-alumina interlayer into a silica sol containing CTAB and vinyltrimethoxysilane (VTMS) as the silica precursor. Membrane thickness increases with the lifting speed of the sol in the dip-coating process. Different thicknesses of the γ-alumina layer were prepared by dip-coating the support into a boehmite sol at different lifting speeds (0.5, 1, 3, and 5 mm s-1). Silica layers were subsequently formed by dip-coating using an immersion time of 60 s and lifting speed of 1 mm s-1. PV measurements of the EA (5 wt.%)/water system were carried out using VTMS hydrophobic silica membranes prepared on □-alumina layers of different thicknesses. Water and EA flux showed substantially constant value despite of the change of the lifting speed to form the γ-alumina interlayer. All prepared hydrophobic silica membranes showed the higher PSI compared with the hydrophobic membranes using the previous alumina support of hollow fiber.

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