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Zeolite filled polyimide membranes for dehydration of isopropanol through pervaporation process

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ABSTRACT

Six mixed matrix membranes (MMMs) were prepared using zeolites of 4A and ZSM-5 incorporated in polyimide of Matrimid 5218. Effects of filler type on membrane morphology and pervaporation performance of MMMs were investigated using isopropanol dehydration. In addition, effects of operating temperature (30, 40, 50, and 60 °C), feed water concentration (10, 20, 30, and 40 wt.%) and permeate side pressure (0 and 15 torr) on pervaporation performance were studied. Scanning electron microscopy (SEM) analysis showed there were good adhesion between the fillers and the polymer matrix. Zeolite 4A has a better contact with the polymer phase and thereby nearly no void is formed in the MMM structure. Pervaporation were performed based on L16 array of Taguchi method for design of experiments. The results showed that the best separation condition is achieved at temperature, feed water concentration, and permeate pressure of 30 °C, 10 wt.% water and 0 torr, respectively. Selectivities of zeolites 4A and ZSM-5 filled MMMs were calculated as 8991 and 3904 compared with 1276 measured for the neat Matrimid 5218 membrane. Permeation rates of the zeolite 4A and ZSM-5 filled MMMs and the neat polymeric membrane were found to be 0.018, 0.016, and 0.013 kg/m^2 h, respectively.

Keywords: Mixed matrix membrane; Pervaporation; Matrimid 5218; Isopropanol; Dehydration

1. Introduction

Regarding pervaporation (PV), many researchers groups have focused on membrane development for various mixtures at different feed concentrations and tried to understand separation mechanisms (Okumus et al., 2003; Patil and Aminabhavi, 2008). There have been many attempts and investigations to develop homogeneous or heterogeneous polymeric membranes (asymmetric, composite or mixed-matrix) with high performance. Addition of adsorptive fillers to the membrane matrix to make mixed matrix membranes (MMMs) has been investigated since 1987 (Shanley, 1994). Mixed matrix materials comprising molecular sieve entities embedded in polymer matrixes can economically increase membrane permselectivity and equivalent productivity compared to existing membrane materials (Aroon et al., 2010). These materials combine processability of the polymer phase with superior transport properties of the molecular sieving phase, thereby resulting in the best of both materials (Ismail et al., 2009; Mahajan et al., 2002). Recently, interest has been focused on novel polymer–zeolite MMM, because the interaction of materials in the membrane matrix and the shape-selective catalytic properties of zeolites can favor permselective separations (Qiao et al., 2006). Gao and Yue (1994) investigated the addition of zeolites 3A, 4A, 5A and 13X (NaX) zeolites into PVA and cross-linked them at 160–200 °C for the pervaporation dehydration of different alcohols. The PVA-13X membrane exhibited higher flux but lower separation factor than PVA-A-type zeolite systems where was attributed to the larger pore size of 13X. Because of the smallest pore size of zeolite 3A, the PVA-3A system had the highest separation factor among the MMMs. Jia and Peinemann (1991) studied the permeation of various gases using a membrane composed of poly (dimethylsiloxane) (PDMS), which is a rubbery polymer, and silicalite-1, a hydrophobic zeolite. In their study, only a couple of very high zeolite loadings were

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