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Permeation of methanol/methyl-*t*-butyl ether mixtures through poly(ethylene-co-vinyl acetate) films

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Abstract

The permeation of methanol and methyl-*t*-butyl ether (MTBE) liquid mixtures through poly(ethylene-co-vinyl acetate) (EVAc) films of different compositions have been investigated. Experiments were performed by contacting the polymer film with a liquid mixture and removing the vapour on the other side with an inert gas flux, a set-up for a membrane process of pervaporation with sweeping gas. In the presence of the liquid mixture, the membranes swell to an extent that increases as the vinyl acetate content in the membrane or the MTBE in the liquid increase. This behaviour can be explained by two main factors: the crystalline content of the polymer and the distance between the polar solubility parameters of the liquid mixture and the centre point of the copolymer solubility sphere. The pervaporation results evidence a methanol higher permeability with low separation factors for all the membrane compositions and high fluxes, which increase with the membrane swelling. Very high flux values have been observed for the copolymer with the greatest vinyl acetate content at liquid composition close to the azeotropic one. In steady state conditions, the permeants showed a Fickian behaviour which allowed to evaluate the activation energy of the diffusion process through the membranes.

Keywords: Pervaporation; Methanol–MTBE; Poly(ethylene-co-vinyl acetate); EVAc membranes; Swelling

1. Introduction

Applications of polymeric membranes in separation processes have steadily increased over the years because of their low cost, easy maintenance and stability and because membrane processes are considered energy-saving compared to classical methods. The pervaporation process can be defined as a selective evaporation of a liquid mixture using a polymer film, or dense membrane, placed between the liquid and the gas phase. It can play an important role in the separation of volatile liquid mixtures when a very low concentration of one component or the presence of azeotropic compositions hinder a complete separation through distillation. The main applications of this technique are: the dehydration of organic solvents, the removal of organic solvents from aqueous solutions and the separation of organic solvent mixtures.

The separation of organic mixtures using pervaporation processes has been widely studied because of the importance of the separation processes in the chemical and petrochemical industries. The separation of aromatic/aliphatic [1], aromatic/cycloaliphatic [2], styrene/ethylbenzene [3] and alcohols [4] liquid mixtures has been recently reported.

The separation of methanol from methyl-*t*-butyl ether (MTBE) is an organic–organic separation whose economic importance has increased with the industrial production of octane enhancers. The distillation of methanol (bp 64.7 °C) and MTBE (bp 55.3 °C) mixtures involves the formation of a minimum-boiling azeotrope (bp 51.6 °C) with 14.3 wt.% methanol and some pervaporation processes have been proposed for this separation [5]. A combined process of distillation–pervaporation [6] might offer an industrial way to purify the MTBE but high fluxes through the membrane are required to efficiently couple the two separation methods.

The EVAc is a random copolymer of ethylene and vinyl acetate whose wide range of physical properties, which depend on the composition of the copolymer, allows it to be used in many fields. The polymer is extensively applied in both engineering and industrial fields because of its toughness, chemical resistance, flexibility, processability and

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