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Pervaporation separation of toluene/n-heptane mixtures using a MSE-modified membrane: Effects of operating conditions

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ABSTRACT

In this work, separation of toluene/n-heptane mixtures via pervaporation using a composite membrane was investigated. Effects of operating conditions such as feed temperature, feed composition and downstream pressure on the membrane performance were studied. Experimental results were obtained at different feed compositions (10–40 wt.%), operating temperatures (25–85 °C) and downstream pressures (2–32 mbar g). The membrane selectivity for toluene was found to be greater than that for n-heptane. According to the results, it was observed that increasing toluene concentration in the feed and operating temperature enhance the membrane swelling and increase the polymeric chain mobility. Therefore, feed concentration and temperature have the same effects on toluene selectivity and permeation flux of the membrane. Permeation flux increases and toluene selectivity decreases with increasing feed concentration and temperature. In contrary, the membrane performance enhances with decreasing downstream pressure. It was found out that for a feed with 10 wt.% of toluene, at a temperature of 85 °C and a downstream pressure of 2 mbar g, the highest PSI value of 18.371 kg/m^2 h (in which permeation flux = 4.610 kg/m^2 h and toluene selectivity = 4.985) is achieved.

Keywords: Pervaporation; Toluene/n-Heptane mixtures; Operating conditions; MSE-modified composite membrane

1. Introduction

Separation of hydrocarbons from various liquid mixtures is an important objective of chemical and petrochemical industries from economical and environmental point of view. Usually, such a separation is carried out by energy consuming processes, like azeotropic distillation, extractive distillation and solvent extraction, as the most important ones (Schwarz and Malsch, 2005). In the recent years, separation of organic/organic mixtures using membrane separation technologies has been investigated extensively, and pervaporation (PV) is now considered as a basic unit operation for separation of these mixtures. In this technique, separation is achieved by preferential sorption and diffusion of one component through a dense membrane under reduced pressure due to the chemical potential difference across the membrane. The separation performance is mostly affected by chemical properties of the membrane material as well as its interaction with the permeating species (Ray and Ray, 2008; Smitha et al., 2004).

Aromatic/aliphatic hydrocarbon mixtures are categorized as a major branch of organic/organic mixtures. Separation of these mixtures was first investigated 25 years ago, in the frame of a European project (Smitha et al., 2004). Aromatics are valuable intermediates in chemical industries. Although their content in crude oil does not exceed a few percent, naphtha is their principal source. There are common aromatic/aliphatic mixtures that can be separated by PV process such as benzene/cyclohexane (Garcia Villaluenga and Tabe-Mohammadi, 2000; Yildirim et al., 2008), benzene/iso-octane (Mandal and Bhattacharya, 2008), toluene/iso-octane (Matsui and Paul, 2003; Xu et al., 2003) and benzene/n-hexane (Wang et al., 2002). One of the aromatic/aliphatic mixtures studied

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