Effects of PEG200 on the Properties and Performance of PVDF Membranes in the Separation of Methanol-Water Mixtures by Pervaporation

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ABSTRACT

The conventional process for methanol-water separation like distillation consumes about 60 % of total energy. As an alternative, researchers have developed a membrane-based separation process for alcohol-water mixtures separation. However, there is a big challenge for researches to separate alcohol-water aqueous mixtures using a polymeric membrane because of swelling. In the present work, the aim is to separate methanol from water by pervaporation using polymeric membranes made up of polyvinylidenefluroide (PVDF) and polyethylene glycol (PEG200) modified PVDF membranes. The membranes were characterized by thermogravimetry analysis (TGA), field emission scanning electron microscopy (FE-SEM), and Fourier-transform infrared spectroscopy (FTIR). A study on the process parameters such as temperature (35, 40, 45, 50, and 55 °C) and feed composition (20%, 30%, and 40% of methanol) was carried out for pure PVDF membrane. The pure PVDF membrane was modified by adding pore-forming agent PEG200, which results in increasing the porosity of the membrane. Due to an increase in porosity of the membrane, the hydrophilicity of the membrane was found to be increased. As a result, higher water flux was observed than methanol flux in the modified membrane. For the pure PVDF membrane, the total flux increased with an increase of methanol content in the feed. The PEG-modified membrane is more selective towards water than methanol, so the higher methanol selectivity was found in the pure PVDF membrane.

KEYWORDS: *Metal-organic frameworks, Pervaporation, Methanol-water mixture, Polymeric membrane.*

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1. INTRODUCTION

Conventional separation methods like extraction, distillation, filtration, condensation, evaporation, and crystallization consume about more than 60% of the total energy consumed in the chemical industry. Nowadays, membrane processes like ultrafiltration, microfiltration, reverse osmosis, gas separation, membrane distillation, pervaporation, etc., have been widely used in the industries to separate mixtures because of their environment-friendly and energy-efficient features[1]. Membrane material and its properties have a considerable impact on the performance and separation efficiency of the membrane. Some polymers, for example, polysulfone (PSf), cellulose acetate (CA), polyamide (PA), polydimethylsiloxane (PDMS), polyimide (PI), and polyvinylidene fluoride (PVDF) are widely used polymer materials in membrane preparation because of some distinctive advantages, mainly low operating cost and high processability[2]. A disadvantage of polymeric membranes is that they generally suffer between selectivity and permeability[3]. The polymer properties, such as structure stability, surface chemistry, and wettability, are essential for the separation of aqueous mixtures. Hydrophilic polymers such as poly(vinylalcohol) (PVA), polyacrylonitrile (PAN), and chitosan are often used because they especially allow water to permeate [4]. Hydrophobic polymers like PDMS, polyether-block-amide (PEBA), polybenzimidazole (PBI) are used to remove organic compounds from the aqueous streams[4]. Nanoparticles (NPs) are incorporated into polymeric material to alter the formation mechanism, pore structure, and composition of the membrane, thereby resulting in high-performance mixed-matrix membranes (MMMs) with better separation performance[3,5].

Some researchers have reported different membranes and their separation performance for methanol-water mixtures using pervaporation. Mohammadi et al.[6] studied methanol-water mixtures (0.3-3 wt% of methanol) separation using the PDMS membrane by pervaporation at 30°C. They obtained total flux and separation factor of 0.35-0.5×10-5 kg m^{-2} h^{-1} and 2-8, respectively. Li et al.[7] studied the separation of 5 wt% methanol-water mixture at 50°C using the ZIF-71/PDMS mixed matrix membrane. Also, they reported that after the addition of ZIF-71, the separation performance of the ZIF-71/PDMS membrane was enhanced in both separation factor and flux. Hu et al.[8] studied methanol-water separation (20-60 vol% of methanol) using hybrid PVA cross-linked with N-3-(trimethoxysilyl) propyl ethylenediamine (TMSPEDA) and HCHO solution. Based on experimental data, they reported that these mixed-matrix membranes have a practical application in the separation of methanol-water aqueous mixtures. Bano et al.[9] prepared sodium alginate (NaAlg)/PVA membranes for the separation of methanol-water aqueous mixtures. They reported that the morphology of the NaAlg/PVA membrane is more suitable for vapor permeation with a high separation factor of 160 for 80% methanol-water mixture.[9] Villegas et al.[10] studied methanol-water mixture separation (90 wt% methanol) using poly(3-hydroxybutyrate) (PHB) membrane. They reported that the PHB membrane is highly selective towards methanol than water at 40°C. Tang et al.[11] prepared a sulfonated polyphenylsulfone (PPSU) membrane and used for dehydration of C_1-C_4 alcohols. They