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ORIGINAL PAPER

Pervaporation performance of surface-modified zeolite/PU mixed matrix membranes for separation of phenol from water

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Abstract Polyurethane (PU) is a kind of promising pervaporation membrane material and silica-rich zeolite is a potential modifier to PU, but the pristine zeolite particles suffer from the bad dispersion in the polymer. This work presents a new route to modify zeolite (ZSM-5) particles via bridging with isocyanate to prepare a membrane for the recovery of phenol from the water. Zeolite ZSM-5 particles were successfully grafted by TDI, β-cyclodextrin, and oleyl alcohol, consecutively. The corresponding zeolites filled PU membranes were prepared and characterized by FTIR, TGA and SEM techniques. The effects of the grafted structures on the pervaporation performances of the zeolites/PU membranes were investigated in the recovery of phenol from the water. The results showed that the modified ZSM-5 particles had a good dispersion in PU, while the pristine ones demonstrated an obvious sedimentation. The modified zeolite/polyurethane membranes achieved better comprehensive separation performance than the neat PU and pristine ZSM-5 modified PU membranes. Depending on the good affinity of the β-cyclodextrin to phenol, ZSM-5 particles grafted by toluene diisocyanate and β-cyclodextrin (ZSM-TC) showed the optimal separation performance with the flux of 46.03 kg μm m^{-2} h^{-1} and the separation factor of 15.64 for the 0.3 wt% aqueous phenol solution at 80 °C. With the increase in the zeolite loading from 5 to 25%, ZSM-5/PU membrane showed the decreased separation factor and flux comparing to the neat PU. However, ZSM-TC/PU membrane showed higher flux and better selectivity than the neat PU and pristine ZSM-5 filled PU membranes.

Keywords Pervaporation · ZSM-5 · Polyurethane · Modification · Membrane

Introduction

Phenol is a toxic and important chemical raw material that can be a refractory contaminant in the water resources and public health. The common methods to deal with phenolic wastewater include physical adsorption [1] and chemical degradation [2]. Comparatively, the physical method is more advantageous than the chemical one. The physical process is beneficial not only for the elimination of the toxic compound from the environment but also for the economic recovery of the valuable products.

The adsorption process is effective, but it often suffers from the limited feed concentration and adsorbent regeneration [3]. Physical technologies have been developed more. Electrocoagulation has been applied in upgrading the water quality. It has the advantage of removing the smallest colloidal particles and producing a relatively low amount of sludge [4]. The extraction of the phenol from phenolic wastewaters by supported liquid membrane showed the

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