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Pervaporation dehydration of ethylene glycol by NaA zeolite membranes

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ABSTRACT

Home-made NaA zeolite membranes were used for pervaporation dehydration of ethylene glycol (EG)/water mixtures. Hydrothermal stability of the membranes in pervaporation was investigated for industrial application purpose. The membranes exhibited good stability for water content of less than 20 wt.% at 100 °C. The reduction of operating temperature was effective to improve membrane stability for operating at high feed water content (e.g. 30 wt.%). The influence of feed water content and operating temperature on dehydration of EG was extensively investigated. A permeation flux of 4.03 kg m^{-2} h^{-1} with separation factor of >5000 was achieved at 120 °C for the separation of the solution with 20 wt.% water content. A pilot-scale pervaporation facility with membrane area of 3 m^2 was built up for dehydration of EG with the water content of 20 wt.%, which showed technical feasibility for industrial application.

Keywords: Ethylene glycol; NaA zeolite membranes; Pervaporation; Dehydration

1. Introduction

Ethylene glycol (EG) is one of the major chemicals, which can be used as precursors to polyester, non-volatile antifreeze, plasticizer, etc. The conventional synthesis route via hydrolysis of ethylene oxide uses excess water to improve EG yield, which requires an extra dehydration process to acquire pure product. Multistage evaporation and distillation are commonly employed for the dehydration, which are highly energy-consuming due to high boiling point of EG. In the past decades, pervaporation technique based on membrane separation has gained increasing attention in many chemical processes. Since only a small amount of permeate has to be vaporized, the separation process can save more energy compared with conventional separation techniques, such as distillation and adsorption (Lipnizki et al., 1999; Hinchliffe and Porter, 2000; van Hoof et al., 2004; Naidu and Malik, 2011). The separation efficiency of pervaporation mainly depends on sorption equilibrium and mobility of components through membrane channels, which is almost independent of vapor–liquid equilibrium associated with feed mixture. For EG dehydration, pervaporation has been considered as a promising technique with water content of less than 30 wt.% (Jehle et al., 1995).

Polymeric membranes have been investigated for dehydration of EG by several groups. Feng and Huang (1996) first demonstrated pervaporation dehydration of EG by using chitosan membranes. A permeation flux of 0.3 kg m^{-2} h^{-1} and the water content of >92 wt.% in permeate were achieved at 35 °C for the feed of 90 wt.% EG. Since then, various polymeric membranes were employed for dehydration of EG, such as surface crosslinked PVA membranes (Guo et al., 2007), poly (N,N-dimethylaminoethyl methacrylate)/polysulfone composite membranes (Du et al., 2008), chitosan-poly (vinyl alcohol) blend membranes (Hyder and Chen, 2009), chitosan coated zeolite filled regenerated cellulose membranes (Dogan and Hilmioglu, 2010), etc. Although continuous progress has been made on water selectivity for polymeric membranes, the achieved water fluxes were still modest for practical utilization. The low water flux is related with the inherent property of polymeric membrane material for water transportation and the strong interactions between

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