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Pervaporation of ethanol from lignocellulosic fermentation broth

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HIGHLIGHTS

- Lignocellulosic ethanol pervaporation is reported for the first time in this study.
- Irreversible membrane fouling was observed using fermentation broths.
- All model lignocellulosic components decreased the total flux by 12–15%.
- Furfural permeates through the membrane and increases the total flux.

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ABSTRACT

Pervaporation can be applied in ethanol production from lignocellulosic biomass. Hydrophobic pervaporation, using a commercial PDMS membrane, was employed to concentrate the ethanol produced by fermentation of lignocellulosic hydrolysate. To our knowledge, this is the first report describing this. Pervaporation carried out with three different lignocellulosic fermentation broths reduced the membrane performance by 17–20% as compared to a base case containing only 3 wt.% ethanol in water. The membrane fouling caused by these fermentation broths was irreversible. Solutions containing model lignocellulosic components were tested during pervaporation at the same conditions. A total flux decrease of 12–15%, as compared to the base case, was observed for each component except for furfural. Catechol was found to be most fouling component whereas furfural permeated through the membrane and increased the total flux. The membrane selectivity increased in the presence of fermentation broth but remained unchanged for all selected components.

1. Introduction

Bioethanol is used as renewable transportation fuel (Mustafa, 2011). However, the bioethanol production process can still be improved a lot. Different alternatives, based on process design and process integration, have been suggested by researchers (Brethauer and Wyman, 2010; Cardona and Sánchez, 2007; Huang et al., 2008).

The cost and availability of the feedstock are crucial. The feedstock cost contributes 65–70% to the total ethanol production costs (Balat and Balat, 2009; Kazi et al., 2010). The current feedstocks used for bioethanol production are derivatives from food crops such as corn grain and sugar cane. However, these raw materials are insufficiently available to meet the increasing demand for fuels and their use raises major nutritional and ethical issues (Brethauer and Wyman, 2010; Mustafa, 2011). These facts lead to the quest for cheaper, abundant and non-food competitive feedstocks for bioethanol production. Lignocellulosic biomass, being renewable and abundant in nature, is an attractive option for the production of biofuel and is being explored by many researchers (Delgenes et al., 1996; Larsson et al., 2000; Mustafa, 2011). It mainly consists of all kinds of waste including agriculture residues, municipal solid waste, forest residues and paper waste. The use of lignocellulosic biomass will not only affect feedstock pretreatment and fermentation process of the ethanol production but also the downstream processing.

Ethanol recovery from fermentation broth is traditionally done by distillation. But for dilute ethanol streams (less than 5 wt.%), the high energy requirements in distillation (Madson and Lococo, 2000) has forced the study of more energy efficient technologies. Among these techniques, pervaporation has been studied by many researchers (Vane, 2008). To recover low concentrations of ethanol from fermentation, pervaporation may be economically more fea-

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