Pervaporation of Ethyl acetate- Water Mixture through Sago/PVA Blend Membranes Cross-linked with Glutaraldehyde

Abdulhakim.M.Alamaria¹, a, Mohd.Ghazali.Mohd.Nawawi²,b, Zafifah.Zamrud³,c

¹,²,³ Faculty of Chemical Engineering, UniversitiTeknologi Malaysia, 81300 Skudai, Johor, Malaysia

a hakim792016@gmail.com, b ghazali@cheme.utm.my, c zafifah.zamrud@gmail.com

Abstract

Sago composite membrane possesses a microporous polysulfone substrate were prepared and tested for dehydration of ethyl acetate/water mixture. Sago composite membrane has been cross-linked successfully by glutaraldehyde. The membranes were characterized by Degree of swelling (DS) and scanning electron micrographs (SEM). Pervaporation of ethyl acetate –water mixture was conducted over a range of water concentration (1-4 wt %) in feed solution at varied temperature from 30°C to 60°C.

Keywords Sago starch: Pervaporation; Ethyl acetate; Polyvinyl alcohol; Composite Membrane;

Introduction

Pervaporation (PV) is a membrane separation process that has been studied intensively to separate alcohol/water mixture such as ethanol/water, iso-propanol/water and ethyl acetate/water [1-3]. The pervaporation process can be used to separate azeotropes, close-boiling mixtures, thermally sensitive compounds and remove species present in low concentrations. Two main advantages of pervaporation are no pollution and high production efficiency [4, 5]. The recovery of ethyl acetate from water by pervaporation process has received more attention over the years. Ethyl acetate is an important solvent, widely used in various manufacturing processes such as the production of drugs in the pharmaceutical industry. It also used in the chemical industry for manufacturing cleaning fluids, inks, coated paper and perfume. The application of ethyl acetate in industry increased from 200,000 tons in 2001 to 1000,000 tons in 2008. Ethyl acetate is produced by the esterification of acetic acid and ethanol with water as waste product. In addition, large quantities of amount of ethyl acetate are produced as waste from chemical and pharmaceutical industry processes. In general hydrophilic polymer materials with O-H groups are usually preferred membrane materials Extensive research has been carried out to develop environmentally friendly, starch-based polymers for renewable energy
applications. Sago starch is evidently a hydrophilic polymer, which is an interesting material to develop to remove water from alcohol. In this study an azeotrope forming mixture of ethyl acetate-water was separated using sago/PVA membrane. The effect of different operating conditions on the separation will be discussed in this work.

Materials

The sago starch used in this study was obtained from Malaysia; Hydrolyzed polyvinyl alcohol (86,000 MWt) 99-100% purity, Ethyl acetate (99% purity), N, N-dimethyformide (DMF) and glutaraldehyde were purchased from New Jersey USA. The sulfuric acid (99% purity) was obtained from Thailand, while acetone (C₃H₆O) was sourced from Taman Industry Rawang Selangor Malaysia and deionized water.

Methods

Membrane preparation

The preparation of Sago membrane started by dissolving 3wt% and 10wt% of sago and PVA respectively in hot water for 4 hours at 90°C. Than the solution were filtered to remove un-dissolved impurities. Sago and PVA were mixed by 50wt% of each one and stirred for 24 hours at 70°C. After that the solution were kept in the oven for another 24 hours at 70°C before start casting onto glass plate and dried in ambient air for 72 hr. The membrane was then cross-linked to achieve good selectivity and high permeation flux. Chemical cross-linked started by immersing the membrane in a chemical solution containing 0.5wt% sulfuric acid (H₂SO₄), 2.5wt% glutaraldehyde, 48wt% acetone and deionized water for 30 min. All films were immersed at room temperature. The films were removed and washed continuously with distilled water and immersed in distilled water for 7 h at room temperature to remove residual H₂SO₄. The membrane was then removed from distilled water and dried at room temperature for 24 h.

Characterization of the membrane

The membrane was characterized by Degree of swelling (DS) and scanning electron micrographs.
Results and discussion

Characterizations of the membrane

The surface morphology of cross-linked and non-cross-linked of sago/PVA bend membranes were studied using scanning electron microscopy and the resulting are presented in Fig.1. As we can see from the photographs it’s clear that the membranes are considered as dense membranes in this study. From the Fig.1 it is clearly observed that the chemical cross-linked membrane is roughness membrane while the non-cross-linked membrane usually smooth. Fig.2. shows the effect of degree of swelling on the cross-linked membrane, as we can see increasing in the GA solution content lead to decreasing in the degree of swelling from 50% at 2wt% of GA to 20% at 10wt% of GA.

Effect of feed temperature and concentration

At 5 wt% of GA solution content in the reaction solution, membrane had the best pervaporation in the separation of ethyl acetate –water mixture. This membrane was used for separation of ethyl acetate-water mixture over range of 1-4wt% of water in the solution and over range of 30°C-60°C of feed temperature. As we can see from fig.4A. increasing in the feed temperature leads to decreasing in the separation factor. Fig.4B. shows effect of feed temperature on the permeation flux and it’s clear that total flux increased by increasing in the feed temperature and concentration due to membrane swelling of the membrane.
Fig. 4 A,B. Effect of feed temperature and concentration on the pervaporation of ethyl acetate-water mixture.

Conclusion

Sago/PVA blend membrane were prepared and tested for pervaporation of ethyl acetate water mixture. Effects of glutaraldehyde cross-linked were investigated and the membranes were characterized using SEM and degree of swelling. The effect of feed temperature on the separation factor and permeation flux showed a good result as well as effect of feed composition. The membranes were very stable during the pervaporation work.

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References