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Fabrication and characterization of organic pervaporation membranes to recover ethyl acetate of aqueous solutions

J. García-Ivars, M.I. Alcaina-Miranda*, M.I. Iborra-Clar, A. Iborra-Clar
Universidad Politécnica de Valencia, Spain

Introduction

Nowadays, there are many industries that employ organic solvents in their processes, generating wastewaters that cause serious environmental problems. These organic compounds are mainly volatile chemical products at room-temperature conditions (VOCs) which may involve health problems to humans [1]. To eliminate and recover these compounds traditional process as distillation is not a available alternative, principally for higher energy consume, low concentration or presence of azeotropes [2, 3] in the effluents. However emerging technologies as pervaporation (PV) and membrane distillation (DM) can be a very suitable alternatives, especially in the removal of volatile organic compounds (VOCs) from industrial wastewaters or contaminated groundwaters.

PV is a separation process in which minor components of a liquid mixture are preferentially transported by partial vaporization through a non-porous permselective membrane. During PV, the feed mixture is in direct contact with the membrane whereas permeate is removed in a vapor state from the opposite side into a vacuum and after is condensed [4]. For this reason, this application has a great interest in many industrial fields, for example, organic compounds dehydration, azeotropic mixtures separation, organic compounds recovery, etc.

Among PV process parameters documented here are process temperature, permeate pressure, feed concentration, and feed flow rate. The effects of these parameters on PV selectivity and permeation flux have been studied extensively and these studies have borne fruit in a better understanding of many aspects of PV processes. The challenge in implementing PV in practical operations lies in the further enhancement of membrane quality for specific VOCs as well as improved management and control of possible adverse hurdles coming from real systems.

In this work, we studied the development of a PV membrane to laboratory scale capable to recovery ethyl acetate (EA) from wastewater produced in paints and varnishes industries. The experiments were focused on the efficiency of laboratory an commercial investigated membranes used for the removal of EA from water. During the experiments, the following parameters characterizing system were determined: the separation factor (α) and the permeate flux (J) in the batch mode PV. The influence of the feed temperature and the initial content of EA in the feed were investigated. It was proved that two kinds of membranes were selective in the removal of EA from water. The selectivity and transport properties as well as the efficiency parameters were dependent strongly not only on the kind of the membrane and the kind of the separated feed mixture but also on the process parameters.

Methods

For this objective we have tested a self-made organophilic composite membrane prepared by cross-linking reactions between hydroxyl terminated polydimethylsiloxane (PDMS) and

polymethylhydrosiloxane with pendant hydride (PHMS) over polyethersulfone support obtained by phase inversion. Experimental PV membranes were tested joint a similar commercial organofilic PV (PERVAP-1060) supplied by Sulzer Chemtec Membrane Systems, in order to compare the both membranes behaviour. Experiments were carried out in a laboratory pilot plant (figure 1), provide with a membrane flat module (78cm^2 of effective area) using different feed concentration (1, 3 and 5 % EA-water mixtures) at different temperatures.
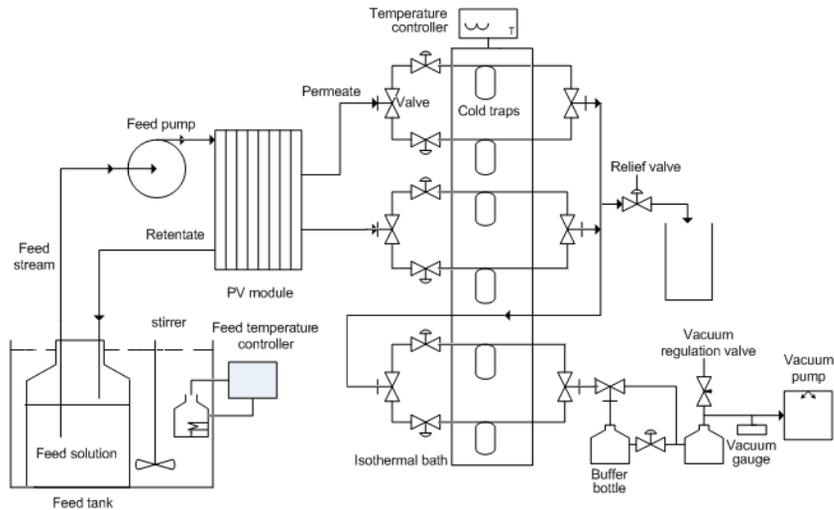

Figure 1. Schematic diagram of fabricated laboratory PV pilot plant.

In order to analyze the transport mechanism in PV processes, as well as the consequences suffered by the membranes for such process, the structural changes of the membranes above mentioned were studied through microscopic techniques, like scanning electron microscopy (SEM) and atomic force microscopy (AFM). Also, the performances of both membranes were systematically investigated by means of a refractometer to determine the selectivity factor (α) estimated by Eq. (1) and the total permeate flux (J). The partial flux was estimated by Eq. (2):

$$\alpha = \frac{\dfrac{y_{EA}}{1-y_{EA}}}{\dfrac{x_{EA}}{1-x_{EA}}} \quad \text{(Eq.1)} \qquad\qquad J_i = J \cdot y_{EA} \quad \text{(Eq.2)}$$

Where y_{EA} refers to the liquid fraction of EA in the permeate and x_{EA} refers to the liquid fraction of EA in the feed.

Results

The influence of two experimental parameters (feed solution temperature and solute concentration, EA) on the behaviour of the two PV membranes was tested, obtaining the evolution of the separation factor, total and partial permeate flux during all time of the process.

References

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