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ORIGINAL PAPER

Effect of flow-rate on ethanol separation in membrane distillation process‡

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The separation of diluted ethanol solutions and fermentation broths by membrane distillation was investigated. The influence of stream flow-rate on the ethanol flux was studied. An evaluation of the process conditions on the separation degree of ethanol was performed with the application of hydrophobic capillary membranes composed of polypropylene. By removing the alcohol via membrane distillation, it is possible to achieve a higher content of ethanol in the permeate than that in the broth. The enrichment coefficient amounted to 4–6.5, and decreased with an increase of the ethanol concentration in the broth. It was found that the flow-rate affects the value of the enrichment coefficient. A positive influence of carbon dioxide on the ethanol transport through the capillary membrane was observed. The evolution of CO_2 bubbles from the broth increases the stream turbulence, probably enhancing the alcohol concentration in the layer adjacent to the membrane surface.

Keywords: membrane distillation, bioreactor, ethanol fermentation

Introduction

Applications of biotechnology to the production of energy from renewable biomass are currently being realised on a large scale in industrial installations. The production of biofuels, both biodiesel and bioethanol, has been intensively developed (Demirbas, 2007; Kolesárová et al., 2011; Ponton, 2009). Although the implementation of environmentally friendly technologies is supported by legislation, it is also important for new technologies utilising biomass to be cheaper than the traditional solutions (Ponton, 2009).

The technologies of bioethanol production currently in use are largely based on the fermentation of renewable feedstocks by means of yeast or bacteria (Bai et al., 2008; Demirbas, 2007; Sassner et al., 2008). Ethanol fermentation from renewable feedstock using *Saccharomyces cerevisiae* is regarded as both a substrate- and product-inhibited process, so the fermentation is traditionally conducted in batch reactors, resulting in a solution containing 5–12 mass % ethanol. A higher concentration of ethanol in the broth can be achieved in the bioreactors with recycling of the cells (Gyamerah & Glover, 1996; Maiorella et al., 1984). Continuous fermentation is more attractive than the batch process due to its higher productivity, better process control, and improved yields (Choi et al., 2009; Park et al., 1999). The challenge resides in effective removal from the broth of the metabolites produced by the yeast.

The majority of proposed configurations are based on ethanol separation combined with fermentation and the ethanol removal is carried out by different methods, including the coupling of various unit operations with the fermentation, or performing simultaneous processes favouring the in situ removal of ethanol from the culture broth (Cardona & Sánchez, 2007).

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