Enzyme recovery and fouling mitigation by ultrasound-enhanced ultrafiltration

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ABSTRACT

The development of second-generation biofuels from cellulosic/lignocellulosic biomass has advantages from energy and environmental aspects, but the overall cost of the process is mainly dependent on the cost of the enzymes. Enzyme recovery and recycling is one of the most important and effective means of increasing the efficiency of enzymatic hydrolysis processes by lowering the enzyme costs. The primary objective of this study was to investigate the possibilities of enzyme recovery by membrane separation. Ultrafiltration (UF) membranes with various cut-off values and materials were used to recycle cellulase and cellobiase in model solutions and cellulosic hydrolysates. The membrane separation process was followed by determination of the flux, and its efficiency of it was measured via sugar and protein retention, and the resistances were also calculated. A polyether-sulfone membrane with a cut-off value of 5 kDa, (PES5) operated at 26.8 L m⁻² h⁻¹ with 87.3% protein rejection while a thin-film membrane with a cut-off value of 4 kDa (TF4) operated at 26.3 L m⁻² h⁻¹ with 92.4% of protein rejection, allowing the free transmission of glucose. Large differences were measured between the distributions of various kinds of resistances for the PES5 and TF4 membranes; 65% of the total resistance was due to the fouling mechanism in the case of the PES5 membrane, whereas the fouling resistance amounted to only 41% for TF4 membrane. Ultrasound (US) treatment during the UF of a hydrolysate increased the flux and changed the proportions of fouling resistance and the gel resistance.

Keywords: Enzyme recovery; Biofuels; Cellulosic biomass; Ultrasound; Membrane separation

1. Introduction

From the aspect of the production of ethanol as an alternative fuel, cellulosic biomass is of great potential as an abundant renewable energy source [1]. Cellulosic material is converted to ethanol in a two-step process: the hydrolysis of cellulose to fermentable reducing sugar, and the fermentation of the reducing sugar to alcohol. The hydrolysis step usually involves enzymatic hydrolysis processes by lowering the enzyme costs. The primary objective of this study was to investigate the possibilities of enzyme recovery by membrane separation. Ultrafiltration (UF) membranes with various cut-off values and materials were used to recycle cellulase and cellobiase in model solutions and cellulosic hydrolysates. The membrane separation process was followed by determination of the flux, and its efficiency of it was measured via sugar and protein retention, and the resistances were also calculated. A polyether-sulfone membrane with a cut-off value of 5 kDa, (PES5) operated at 26.8 L m⁻² h⁻¹ with 87.3% protein rejection while a thin-film membrane with a cut-off value of 4 kDa (TF4) operated at 26.3 L m⁻² h⁻¹ with 92.4% of protein rejection, allowing the free transmission of glucose. Large differences were measured between the distributions of various kinds of resistances for the PES5 and TF4 membranes; 65% of the total resistance was due to the fouling mechanism in the case of the PES5 membrane, whereas the fouling resistance amounted to only 41% for TF4 membrane. Ultrasound (US) treatment during the UF of a hydrolysate increased the flux and changed the proportions of fouling resistance and the gel resistance.

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