Fermentation of rice bran hydrolysate to ethanol using *Zymomonas mobilis* biofilm immobilization on DEAE-cellulose

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ABSTRACT

Background: The major challenges associated with the fermentation of lignocellulosic hydrolysates are the reduction in the operating cost and minimizing the complexity of the process. *Zymomonas mobilis* biofilm has been emerged to resolve these complexities. Biofilm has been reported to tolerate to the toxic inhibitors and easily manipulated toward the cell recycle through the cell immobilization.

Results: *Z. mobilis* ZM4 and TISTR 551 were able to develop biofilms on DEAE cellulose under the differences in the morphologies. *Z. mobilis* ZM4 developed homogeneous biofilm that brought DEAE fiber to be crosslinking, while *Z. mobilis* TISTR 551 developed heterogeneous biofilm in which crosslinking was not observed. Ethanol production under batch and repeated batch fermentation of rice bran hydrolysate containing toxic inhibitors were compared between these two biofilms. TISTR 551 biofilm produced the maximum yield (YFS) of 0.43 ± 0.09 g ethanol/g glucose (83.89% theoretical yield). However the repeated batch could not be proceeded due to the bacterial detachment. *Z. mobilis* ZM4 biofilm produced the maximum yield (YFS) of 0.177 ± 0.05 g ethanol/g glucose (34.74% theoretical yield) in the batch culture and the biofilm remained intact to proceed along the repeated batch. The highest ethanol yield (YFS) in the repeated batch of *Z. mobilis* ZM4 was 0.354 ± 0.07 g ethanol/g glucose (69.51% theoretical yield).

Conclusions: Homogeneous biofilm structure of *Z. mobilis* provided more recycle beneficial over the heterogeneous biofilm structure for the ethanol production from lignocellulosic hydrolysate.

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1. Introduction

Lignocellulosic biomass (LCB) is an abundant, renewable source of carbohydrates for microbial conversion to value added chemicals and fuels. One of the future prospects is to use lignocellulosic materials for the production of bioethanol and bring the production toward the industrial scale production [1,2]. However, a challenge for the fermentation of lignocellulosic material is the recalcitrance of biomass to breakdown. Pretreatments with either chemical or physic-chemical lead to the production of fermentable sugars together with other toxic by-products [3]. Dilute acid hydrolysis with high temperature is the most cost effective method that has been extensively performed for the pretreatment of lignocellulosic materials. However, relatively high concentrations of inhibitory compounds are formed during the process including furfural hydroxymethylfurfural (HMF), acetic acid, formic acid, levulinic acids and vanillin [4]. These toxic inhibitors are found to have negative effects over microbial growth, metabolism and ethanol production of many ethanologenic microorganisms [5,6,7].

These problems were previously overcome by removing the inhibitors or utilizing inhibitor tolerant microorganisms however, these required extra equipment and time leading to increased production costs [8,9].

Rice bran is an abundant by-product from rice production which can be served as a low cost attractive feedstock for the production of bioethanol [10,11]. Pure rice bran that was dilute acid pretreated enzyme saccharification has been reported as an effective substrate for ethanol production by *Zymomonas mobilis* biofilm. *Z. mobilis* biofilm has illustrated its potential for ethanol production from rice bran hydrolysate than free cells by representing higher survival, higher metabolic maintenance and higher ethanol yield when it is exposed to the toxic inhibitors [12]. Therefore, using biofilm as a biocatalyst represented its feasibility for ethanol production from lignocellulosic material which could lead to the reduction in the operating costs of bioethanol and minimizing the complexity of the process.

Biofilm represents a natural form of cell immobilization by the microbial adsorption or self immobilization on the solid support which is further applicable as biofilm reactor to produce various value added products [13,14,15,16,17,18,19]. The natural process of biofilm formation can be simply constructed and the process of immobilization is economical. Immobilization of microbial cells in the reactor has been found to eliminate the problem of inhibition caused...

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