学位論文概要

題目Production of glucose from agricultural waste using hydrothermal pretreatment and enzymatic hydrolysis: Study on enzymes, reaction medium, and effect of feedstock structural linkage
（水熱前処理と酵素加水分解を用いた農業残渣からのグルコース生産－酵素、反応媒体、原料構成物間結合の効果に関する研究）

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A pretreatment has been seen as a determinant factor in the production of glucose from lignocellulosic biomass such as agriculture wastes for bioethanol production. Because it will determine the amount of cellulose which subsequently determine the glucose produced in enzymatic hydrolysis and ethanol produced in fermentation. As such, the enzymatic hydrolysis essentially evaluates the effectiveness of pretreatment. Among various techniques, hydrothermal pretreatment uses water as the reaction medium so it has been seen as a safe and environmentally friendly process. To create a successful bioethanol production using this technology, the process should be designed effectively, efficiently and sustainably.

The most common technique of enzymatic hydrolysis is using enzyme cellulase complex with the addition of accessory ß-glucosidase to enhance the effectiveness. As consequence, the expression of this addition effect is required to select the optimum condition. In this study, a simple equation to express the accessory enzyme addition effect on cellulose hydrolysis using commercial cellulase complex was developed as discussed in Chapter 5. The highest glucose yield was obtained using the amount of cellulase and ß-glucosidase mixtures at 300 EGU: 300 PGPU, and the accessory enzyme addition was found to be less effective when being added to cellulase complex at above 150 PGPU.

Beside using the optimum condition of enzymatic hydrolysis, the water for reaction medium in hydrothermal pretreatment should not be used excessively. In addition, to enhance the reaction, commercial catalysts are commonly added. Thus, it is necessary to find an alternative for the reaction medium and commercial catalysts that is low cost and available onsite. In this study, the potential use of acidic and alkaline wastewater as the reaction medium for hydrothermal pretreatment of lignocellulosic biomass was evaluated as discussed in Chapter 6 and 7. The palm oil empty fruit bunch (EFB), rice straw, and rice husk were chosen as the feedstock while palm oil mill effluent (POME) and biodiesel wastewater (BDW) were chosen as reaction medium. It was found that suspended solid-removed-POME was a promising candidate to be used as reaction medium with glucose yield achieved similarly with the acid catalyst added-water at pH 4.

To understand the behavior of cellulose from lignocellulosic biomass in hydrothermal pretreatment, model compounds mixtures are often used in various studies. However, unlike in actual biomass, in model compound mixtures the structural cross-link of cellulose, hemicellulose and lignin is absent. The effect of this structural cross-link need to be clarified. Therefore, the behavior comparison between actual biomass with artificial mixtures in hydrothermal pretreatment was carried out as discussed in Chapter 8 and 9. The barriers of lignin and hemicellulose in structural form was found to be more significant compared to their presence in a “bare” form in the mixtures. The structural cross link in actual biomass clearly hindered the exposing of cellulose especially at temperature region of 150-180 °C. Lastly, the mechanism of lignocellulose biomass behavior in hydrothermal pretreatment was proposed which will be useful for designing a successful bioethanol production.