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Effects of microwave power and microwave irradiation time on pretreatment efficiency and characteristics of corn stover using combination of steam explosion and microwave irradiation (SE–MI) pretreatment

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HIGHLIGHTS

- Effects of microwave power (MP) and time (MT) on SE–MI process were investigated.
- Enzymatic hydrolysis yield and sugar yield increased with MP and MT rising.
- The maximum total sugar yield was 72.1 g/100 g glucose and xylose in feedstock.
- Microwave effect was important to biomass decrystallization in SE–MI process.
- Low MP and short MT were favorable for SE–MI process considering energy consumption.

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ABSTRACT

The effects of microwave power and microwave irradiation time on pretreatment efficiency and characteristics of corn stover were investigated based on a new process named combination of steam explosion and microwave irradiation (SE–MI) pretreatment. Results showed that with microwave power and microwave irradiation time increasing, glucose and xylose that released into hydrolyzate, as well as enzymatic hydrolysis yields and sugar yields of glucose and xylose were all slightly increased after SE–MI pretreatment. The maximum sugar yield was 72.1 g per 100 g glucose and xylose in feedstock, achieved at 540 W microwave power and 5 min microwave irradiation time. XRD analysis showed that the crystallinity of biomass was 15.6–19.9% lower for SE–MI pretreatment with microwave effect than that without microwave effect. However, low microwave power and short microwave irradiation time were favorable for SE–MI pretreatment considering energy consumption.

1. Introduction

Sustainable production of economically viable biofuels, such as ethanol, from lignocellulosic biomass is one of the most suitable alternatives to fossil fuels. The bioconversion process for bioethanol production from lignocellusic biomass typically involves three steps of pretreatment, hydrolysis and fermentation (Ewanick et al., 2007). Pretreatment is an important procedure for practical cellulose conversion processes, which is required to alter the structure of cellulosic biomass to make cellulose be more accessible to the enzymes that convert the carbohydrate polymers into fermentable sugars. Pretreatment has been viewed as one of the most expensive processing steps in cellulosic biomass-to-fermentable sugars conversion, and also has great potential for improvement of efficiency and lowering of cost through research and development (Mosier et al., 2005).

Steam explosion (SE) is recognized as one of efficient pretreatment methods. In the SE process without additional chemicals added, raw material is exposed to pressurized steam followed by a sharp pressure release resulting in substantial breakdown of the lignocellulosic structure, hydrolysis of the hemicellulosic fraction, depolymerization of the lignin components and defibration. Therefore, the accessibility of the cellulose components to degradation by enzymes is greatly increased (Cara et al., 2008). Impregnation with sulfuric acid of lignocellulosic feedstock previous to steam explosion pretreatment has been shown to improve the enzymatic digestibility of pretreated materials and the recovery of hemicellulosic sugars (Cullis et al., 2004; Ewanick et al., 2007; Linde et al., 2008). Steam explosion has been employed on a variety of cellulosic feedstock to prepare them for subsequent enzymatic hydrolysis and sugar fermentation (Ruiz et al., 2008). Compared with alternative pretreatment methods, the advantages of steam

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