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Liquid hot water pretreatment of sugarcane bagasse and its comparison with chemical pretreatment methods for the sugar recovery and structural changes

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HIGHLIGHTS

- Liquid hot water process has no chemical addition but a good sugar recovery.
- Ultrastructural change of cell wall was observed for different pretreated samples.
- Lignin can migrate within and out of the cell wall in the hydrothermal pretreatment.
- A combined pretreatment with liquid hot water and aqueous ammonia was proposed.

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ABSTRACT

Liquid hot water (LHW), dilute hydrochloric acid (HCl) and dilute sodium hydroxide (NaOH) were applied to sugarcane bagasse (SB). Application of the same analytical methods and material balance approaches facilitated meaningful comparisons of glucose and xylose yields from combined pretreatment and enzymatic hydrolysis. All pretreatments enhanced sugar recovery from pretreatment and subsequent enzymatic hydrolysis substantially compared to untreated sugarcane bagasse. Adding Tween80 in the enzymatic hydrolysis process increased the conversion level of glucan/xylan by 0.3-fold, especially for the low pH pretreatment where more lignin was left in the solids. The total sugar recovery from sugarcane bagasse with the coupled operations of pretreatment and 72 h enzymatic digestion reached 71.6% for LHW process, 76.6% for HCl pretreatment and 77.3% for NaOH pretreatment. Different structural changes at the plant tissue, cellular, and cell wall levels might be responsible for the different enzymatic digestibility. Furthermore, a combined LHW and aqueous ammonia pretreatment was proposed to reduce energy input and enhance the sugar recovery.

1. Introduction

China is the third largest producer of sugarcane with 70 million tons, behind Brazil and India. The enormous sugar production in China generates huge amounts of bagasse, the fibrous waste product of the sugar refining industry. Take Guangxi province for example, more than 5.6 million tons of bagasse is produced every year. It is traditionally utilized for the animal feed, papermaking or combustion. Recently, sugarcane bagasse (SB) has been persistently receiving attention as a raw material for production of ethanol because of its prominent content of cellulose and hemicellulose (Dias et al., 2011; Macrelli et al., 2012; Shields and Boopathy, 2011).

Several processes are required in ethanol production from lignocellulosic material such as pretreatment, enzymatic hydrolysis, fermentation, and product separation/ distillation. The main bottlenecks so far include effective pretreatment techniques, cost-effective cellulase supply and the construction of strains to maximize ethanol yields and tolerance (Sarkar et al., 2012). An effective pretreatment can reduce the downstream pressure by making cellulose more accessible to the enzymes and minimize the formation of degradation products that inhibit the growth of fermentative microorganisms (Shen et al., 2012).

Diluted acid pretreatment remove hemicellulose components and expose cellulose for enzymatic digestion, and it is regarded as a promising method for industrial applications (Shi et al., 2011; Wyman et al., 2005a,b). Sulfuric acid is the most commonly used acid in pretreatment of sugarcane bagasse (Canilha et al., 2011; Zhao et al., 2012), but it has the disadvantages of high

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