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Effects of pretreatment factors on fermentable sugar production and enzymatic hydrolysis of mixed hardwood

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HIGHLIGHTS

- ▶ The pretreatment factors for fermentable sugar production differed by acid catalyst.
- ▶ pH was important to produce fermentable sugar in dicarboxylic acid pretreatment.
- ▶ Sulfuric acid pretreatment demanded a high reaction temperature than time or pH.

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ABSTRACT

The aim of this study was to investigate the effects of different acid catalysts and pretreatment factors on the hydrolysis of biomass compounds over a range of thermochemical pretreatments; maleic, oxalic, and sulfuric acids were each used under different pretreatment conditions. The most influential factor for fermentable sugar production in the dicarboxylic acid-pretreated mixed hardwood was pH. Reaction time was the next significant factor followed by reaction temperature. However, fermentable sugar production was more dependent on reaction temperature than time during sulfuric acid pretreatment, whereas the effect of acid concentration was considerably lower. Maleic acid pretreatment was very effective for attaining high glucose yields after enzymatic hydrolysis. The highest enzymatic hydrolysis yield was found following maleic acid pretreatment, which reached 95.56%. The trend in enzymatic hydrolysis yields that were detected concomitantly with pretreatment condition or type of acid catalyst was closely related to xylose production in the hydrolysate.

1. Introduction

The increase in energy consumption and consequent environmental problems has accelerated the development of alternative energy. Thus, much of the growth in bioethanol production is expected to come from next generation energy in the near future. Lignocellulosic biomass for ethanol production is advantageous because it is a renewable resource that consists of abundant carbohydrates. However, it is difficult to apply carbohydrate hydrolysis to produce fermentable sugars with a lignocellulosic biomass, because the biomass is highly recalcitrant (Yang and Wyman, 2008). Therefore, a pretreatment step is needed to make the cellulose more accessible to enzymes.

Various pretreatment methods have been used to overcome these restrictions such as dilute acids, steam explosion, organosolvent extraction, and biological treatment with white rot fungi (Ferraz et al., 2001; Lloyd and Wyman, 2005; Pan et al., 2005). In addition, supercritical water and ionic liquid treatments have been gaining interest because of their potential to effectively remove lignin and hemicellulose and decrease cellulose crystallinity (Uju et al., 2012; Weerachanchai et al., 2012). Among the pretreatment methods, a dilute acid pretreatment with sulfuric acid has been commonly used to hydrolyze hemicellulose. However, this method has several disadvantages, such as production of inhibitory products that can negatively affect the downstream process, corrosion of equipment, and difficulties recovering the sulfuric acid after pretreatment. Dicarboxylic acids such as oxalic, fumaric and maleic acids have been suggested as alternatives for sulfuric acid pretreatment to overcome these disadvantages (Mosier et al., 2002; Kootstra et al., 2009; Lee and Jeffries, 2011).

Dicarboxylic acids are sufficiently strong to catalyze hemicellulose hydrolysis, they are selective enough to avoid extensive cellulose degradation under mild conditions. These acids exhibit a higher catalytic efficiency for hydrolysis than sulfuric acid when applied under the same severity conditions (Mosier et al., 2001; Lee and Jeffries, 2011). In addition, xylose degradation is much

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