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Pretreatment of sugarcane bagasse with $NH_4OH–H_2O_2$ and ionic liquid for efficient hydrolysis and bioethanol production

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HIGHLIGHTS

- ▶ An efficient pretreatment method using $NH_4OH–H_2O_2$ and ionic liquid (IL) was developed for the recovery of cellulose from sugarcane bagasse (SCB).
- ▶ [Amim]Cl reduced the crystallinity index of SCB.
- ▶ The pretreatment did not have a negative effect on subsequent bioethanol fermentation.

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ABSTRACT

An efficient pretreatment method using $NH_4OH–H_2O_2$ and ionic liquid (IL) was developed for the recovery of cellulose from sugarcane bagasse (SCB). The regenerated SCB from the combined pretreatment exhibited significantly enhanced enzymatic digestibility with an efficiency of 91.4% after 12 h of hydrolysis, which was 64% higher than the efficiency observed for the regenerated SCB after the individual $NH_4OH–H_2O_2$ pretreatment. 1-Allyl-3-methylimidazolium chloride ([Amim]Cl) dissolved the cellulose from the $NH_4OH–H_2O_2$–pretreated SCB, and the crystallinity index (CrI) detected by X-ray diffraction (XRD) was reduced by 42%. The recycled and fresh [Amim]Cl demonstrated the same performance on the pretreatment of SCB for the enhancement of enzymatic digestibility. The regenerated SCB was subsequently used in simultaneous saccharification and co-fermentation (SScF) for bioethanol production by cellulase and yeast. The pretreatment did not have a negative effect on bioethanol fermentation, and an ethanol yield of 0.42 g/g was achieved with a corresponding fermentation efficiency of 94.5%.

1. Introduction

The rapidly growing demand for energy, a dwindling and unstable supply of petroleum, and the emergence of global warming from the use of fossil fuels have rekindled a strong interest in pursuing alternative and renewable energy sources (Nguyen et al., 2010; Beukes and Pletschke, 2010). Lignocellulosic biomass and crop wastes have been considered as potential sustainable feedstocks for energy production. One of the major lignocellulosic materials considered for bioethanol production in tropical countries is sugarcane bagasse (SCB), which is the fibrous residue remaining after extracting the juice from sugarcane in the sugar production process. More than 70% of SCB consists of hydrolysable carbohydrates that can yield fermentable sugars for the production of value-added bioproducts (Paiva and Frollini, 2001). It is estimated that approximately 100 million dry tons of SCB are produced globally every year. Although most of the SCB is burned to produce steam power, there is still a surplus of this material that can be used for bioethanol production (Pandy et al., 2000).

A major issue in the conversion of lignocellulosic materials into biofuel is overcoming biomass recalcitrance through pretreatment while still maintaining green and energy-efficient processing. Several pretreatment methods, including chemical, physical and physico-chemical techniques have been reported, and several detailed review papers have been published (Mosier et al., 2005; Chang and Holtzapple, 2000). In general, regardless of the exact method used, the purpose of pretreatment is to alter or remove the lignin and/or hemicellulose, disrupt the crystallinity of the cellulose, and increase its porosity to make the cellulose more accessible to the enzymes, which significantly improves the hydrolysis of the cellulose (Sun and Cheng, 2002).

Recent studies showed that ionic liquids (ILs) could be used to dissolve cellulose from lignocellulosic biomasses such as corn stalks, wheat and wood (Nguyen et al., 2010; Li et al., 2010). ILs, which are known as "green solvents", are organic salts that usually melt below 100 °C. Compared with conventional pretreatment methods, pretreatments using ILs as cellulose solvents have several advantages. First, the application of ILs usually occurs at lower

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