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Comparison of the impact of ionic liquid pretreatment on recalcitrance of agave bagasse and switchgrass

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HIGHLIGHTS

- ▶ Assessment of the potential of agave bagasse as a biofuel feedstock using ionic liquid (IL) pretreatment.
- ▶ The total sugar yield was higher for agave bagasse (AGB) than for switchgrass (SWG).
- ▶ The initial enzymatic hydrolysis rate was lower for AGB than for SWG.
- ▶ Pretreatment resulted in higher delignification for AGB (45.5%) than for SWG (38.4%).
- ▶ XRD patterns showed highly crystalline peaks for AGB which decreased with pretreatment.

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ABSTRACT

Lignocellulose represents a sustainable source of carbon for transformation into biofuels. Effective biomass to sugar conversion strategies are needed to lower processing cost without degradation of polysaccharides. Since ionic liquids (ILs) are excellent solvents for pretreatment/dissolution of biomass, IL pretreatment was carried out on agave bagasse (AGB-byproduct of tequila industry) and digestibility and sugar yield was compared with that obtained with switchgrass (SWG). The IL pretreatment was conducted using ([C2mim][OAc]) at 120 and 160 °C for 3 h and 15% biomass loading. While pretreatment using [C2mim][OAc] was very effective in improving the digestibility of both feedstocks, IL pretreatment at 160 °C resulted in higher delignification for AGB (45.5%) than for SWG (38.4%) when compared to 120 °C (AGB-16.6%, SWG-8.2%), formation of a highly amorphous cellulose structure and a significant enhancement of enzyme kinetics. These results highlight the potential of AGB as a biofuel feedstock that can produce high sugar yields with IL pretreatment.

1. Introduction

Lignocellulosic feedstocks, such as agricultural and forest residues, industrial and municipal wastes, and dedicated bioenergy crops, by virtue of their high carbohydrate content, hold tremendous potential for large-scale bioethanol production (Banerjee et al., 2010). However, lignocellulosic biomass is highly recalcitrant to breakdown and offers limited accessibility to enzymes or microorganisms. Pretreatment, by disrupting the biomass (Zhu et al., 2008), is an essential prerequisite to make biomass accessible to enzymes that liberate fermentable sugars. An effective pretreatment must meet the following requirements: (1) improve subsequent biomass hydrolysis to liberate fermentable sugars, (2) avoid significant degradation or loss of carbohydrates, and (3) avoid the formation of byproducts that are inhibitory to the subsequent hydrolysis and fermentation processes (Kumar et al., 2009).

Several pretreatment technologies are currently employed to overcome the recalcitrance of lignocellulose, increase hydrolysis efficiency and improve the yields of monomeric sugars. For example, some ionic liquids (ILs) containing anions of chloride, formate, acetate or alkylphosphonate and organic cations can completely dissolve microcrystalline cellulose (Dadi et al., 2006). Some of these ILs also have positive attributes such as low volatility, nonflammability, and high thermal stability, thus making IL pretreatment potentially benign to the environment when compared to pretreatments that use acids, bases, or organic solvents. Once dissolved, cellulose can be easily recovered by the addition of an anti-solvent (Singh et al., 2009; Sun et al., 2009).

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