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Effects of sodium carbonate pretreatment on the chemical compositions and enzymatic saccharification of rice straw

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HIGHLIGHTS

- Mild alkaline media (sodium carbonate) is used for pretreatment.
- Sodium carbonate is cheap and can be easily recovered.
- Rice straw is feasible to be pretreated in mild conditions.
- Pretreated solids show significant delignification while keep most carbohydrates.
- The highest total sugar recovery of pretreated solid is above 70%.

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ABSTRACT

The effects of sodium carbonate (Na_2CO_3) pretreatment on the chemical compositions and enzymatic saccharification of rice straw were investigated. The enzymatic digestibility of rice straw is enhanced after pretreatment since pretreated solids show significant delignification with high sugar availability. During pretreatment, an increasing temperature and Na_2CO_3 charge leads to enhanced delignification, whereas an increased degradation of polysaccharides as well, of which xylan acts more susceptible than glucan. The sugar recovery of enzymatic hydrolysis goes up rapidly with the total titratable alkali (TTA) increasing from 0% to 8%, and then it reaches a plateau. The highest sugar recovery of rice straw after pretreatment, 71.7%, 73.2%, and 76.1% for total sugar, glucan, and xylan, respectively, is obtained at 140 °C, TTA 8% and cellulase loading of 20 FPU/g-cellulose. In this condition, the corresponding delignification ratio of pretreated solid is 41.8%, while 95% of glucan and 76% of xylan are conserved.

1. Introduction

The inevitable depletion of fossil fuels and the growing concerns over the environmental impact have led to an increasing interest in exploring alternative, sustainable energy sources (Sun and Cheng, 2002). Bioethanol, which can be obtained via the bioconversion of large-scale, renewable feedstock, is widely regarded as an efficient alternative for gasoline well suited to transportation (Wyman, 2007). Lignocellulosic biomass is particularly promising because these materials are sufficiently abundant and generate very low net greenhouse gas emissions, as well as its dramatic economic, strategic and infrastructure advantages (Galbe and Zacchi, 2007; Kumar et al., 2009; Wyman, 1999).

Biomass is composed of cellulose (40–50%), hemicellulose (25–35%) and lignin (15–20%) (Gray et al., 2006). Cellulose and hemicellulose can be broken down into their component monomeric sugars which are then subjected to fermentation into ethanol for recovery (Wyman, 2007). However, in natural plants, cellulose is protected and sheathed by lignin and hemicellulose, and lignin can also be covalently linked to carbohydrates, which make cellulose difficult to access by cellulase enzymes (Gray et al., 2006; Mosier et al., 2005; Sun and Cheng, 2002). Generally, the theoretical maximum glucan conversion yield of lignocelluloses directly

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