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Improved bioconversion of poplar by synergistic treatments with white-rot fungus *Trametes velutina* D10149 pretreatment and alkaline fractionation

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HIGHLIGHTS

- ▶ The subsequence alkaline fractionation further reduced the biomass recalcitrance.
- ▶ Biopretreatment showed little effect on the molecular weights of carbohydrates.
- ▶ White-rot fungal pretreatment altered the structure of lignin.
- ▶ The depolymerization of cellulose occurred at the C_1, C_4 and C_6 groups.

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ABSTRACT

Successive treatments with fungus and alkali were proposed to reduce the recalcitrance and improved the enzymatic digestibility of triploid poplar. Biopretreatment with *Trametes velutina* D10149 for 0, 4, 8, 12 and 16 weeks gradually degraded hemicelluloses and lignin, and improved the digestibility of cellulose from 4.0% to 19.5% with the increasing dry mass loss of lignocelluloses from 15.5% to 53.4%. Combining with alkaline fractionation, biopretreatment for 4 weeks significantly enhanced the availability of cellulose and achieved a maximum glucose yield (38.8% of the original cellulose) with a dry mass loss of 24.4%. The BET surface area of lignocelluloses increased from 1.7 to 10.6 m^2/g after combination of 8 weeks biopretreatment and alkaline fractionation. Moreover, alkaline fractionation removed amorphous and low molecular components, which incurred a higher crystalline index and narrower molecular weight distribution of residual carbohydrates in synergistically treated samples as compared to biopretreated samples.

1. Introduction

Worldwide demand for energy resurges the development of alternative energy that can displace fossil fuels. Lignocellulosic biomass has long been recognized as a potential sustainable source of mixed sugars for biofuels and biomaterials (Himmel et al., 2007). However, plant biomass evolves complex structure for resisting invaders, such as microorganisms and chemicals. The glucose polymer chains existing in crystalline cellulose makes the sugars hard to reach (Sanderson, 2011). In addition, lignin cross links with hemicelluloses and seals the carbohydrates, making physical barrier for enzymes access (Pérez et al., 2002). Therefore, lignocellulosic biomass requires aggressive pretreatment to increase the amenability of carbohydrates to enzymatic hydrolysis (Hendriks and Zeeman, 2009). Biological pretreatment with white rot fungi is attracting increasing attention due to its particular ability of disrupting the lignin-hemicellulose sheath, low energy input and environmental friendliness (Keller et al., 2003; Shi et al., 2009a,b; Yu et al., 2009). Recently, some studies applied microorganisms to enhance the saccharification efficiency of agricultural residues, such as cotton stalks, corn stover, cornstalks, and wheat straw (Dinis et al., 2009; Shi et al., 2009a,b; Wan and Li, 2010; Xu et al., 2010). However, the dry mass loss and long residence time make the biological pretreatment uneconomical. In this case, new biopretreatment is needed to improve its efficiency.

Alkaline fractionation has been implemented to break the rigid structure of lignocelluloses (Gould, 1984). It involves many types of reaction between the chemicals and functional groups in the

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