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Cellulose solvent- and organic solvent-based lignocellulose fractionation enabled efficient sugar release from a variety of lignocellulosic feedstocks

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HIGHLIGHTS

- ▶ COSLIF can effectively pretreat numerous feedstocks.
- ▶ Glucan digestibilities of most feedstocks were ~93% at a low cellulase loading.
- ▶ COSLIF could be regarded as feedstock-independent biomass pretreatment.
- ▶ Feedstock-independent fractionation would be vital to success of biorefineries.

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ABSTRACT

Developing feedstock-independent biomass pretreatment would be vital to second generation biorefineries that would fully utilize diverse non-food lignocellulosic biomass resources, decrease transportation costs of low energy density feedstock, and conserve natural biodiversity. Cellulose solvent- and organic solvent-based lignocellulose fractionation (COSLIF) was applied to a variety of feedstocks, including Miscanthus, poplar, their mixture, bagasse, wheat straw, and rice straw. Although non-pretreated biomass samples exhibited a large variation in enzymatic digestibility, the COSLIF-pretreated biomass samples exhibited similar high enzymatic glucan digestibilities and fast hydrolysis rates. Glucan digestibilities of most pretreated feedstocks were ~93% at five filter paper units per gram of glucan. The overall glucose and xylose yields for the Miscanthus:poplar mixture at a weight ratio of 1:2 were 93% and 85%, respectively. These results suggested that COSLIF could be regarded as a feedstock-independent pretreatment suitable for processing diverse feedstocks by adjusting pretreatment residence time only.

1. Introduction

The production of biofuels and value-added biochemicals from renewable abundant non-food lignocellulosic biomass would bring benefits to the environment, rural economy, and national security. Additionally, it would create a large number of new biomanufacturing jobs, which cannot be outsourced, because of high transportation costs for lower energy density biomass feedstocks as compared to crude oil, coal, and corn kernels (Judd et al., 2012; Zhang, 2011). The largest technical and economical obstacle to second generation biorefineries is cost-effective release of fermentable sugars from lignocellulosic biomass (Lynd et al., 2008; Rollin et al., 2011; Zhang, 2011).

Miscanthus x giganteus (briefly called Miscanthus) and *Populus nigra x Populus maximowiczii* (hybrid poplar) are regarded as promising bioenergy crops because they have high productivities and low requirements for plantation. Miscanthus is a perennial C4 grass, featuring a long production lifetime (e.g., 10–15 years) (Wang et al., 2010). Extensive trials in Europe result in an average biomass productivity, more than 30 dry metric tons per hectare per year with minimal agricultural inputs, much higher than an average yield of 10–15 tons per hectare per year of switchgrass (Heaton et al., 2004; Khanna et al., 2008; Miguez et al., 2009; Somerville et al., 2010). Poplar and their hybrids are fast-growing and short-rotation woody crops, which can be grown in marginal lands with a mean above-ground biomass productivity of ~14 dry metric tons per hectare per year (Sannigrahi et al., 2010). Since hybrid poplar has a wide spatial distribution in North America and Canada, it can be grown close to biorefineries. Moreover, woody biomass, such as poplar, has several advantages compared to agricultural

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