



Catalyzed modified clean fractionation of switchgrass

Iwona Cybulska^{a,*}, Grzegorz P. Brudecki^a, Brett R. Hankerson^a, James L. Julson^a, Hanwu Lei^b

^a Department of Agricultural and Biosystems Engineering, South Dakota State University, Brookings, SD 57007, USA

^b College of Engineering and Architecture, Washington State University, Richland, WA 99352, USA

HIGHLIGHTS

- ▶ Catalyzed modified clean fractionation of switchgrass was evaluated and optimized.
- ▶ Catalyzed modified clean fractionation resulted in high lignin and glucose recoveries.
- ▶ Recovered lignin contained low ash and high Klason lignin content.
- ▶ Obtained cellulose was highly fermentable.

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ABSTRACT

Switchgrass was used as a lignocellulosic feedstock for second generation ethanol production, after pretreatment using sulfuric acid-catalyzed modified clean fractionation based on NREL's (National Renewable Energy Laboratory) original procedure. Optimization of temperature, catalyst concentration and solvent composition was performed using Response Surface Methodology, and 59.03 ± 7.01% lignin recovery, 84.85 ± 1.34% glucose, and 44.11 ± 3.44% aqueous fraction xylose yields were obtained at 140.00 °C, 0.46% w/w catalyst concentration, 36.71% w/w ethyl acetate concentration, and 25.00% w/w ethanol concentration. The cellulose fraction did not inhibit the fermentation performance of *Saccharomyces cerevisiae* and resulted in an ethanol yield of 89.60 ± 2.1%.

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1. Introduction

Switchgrass is considered one of the most attractive potential lignocellulosic ethanol feedstocks due to its ubiquitousness and low growing costs (Pimentel and Patzek, 2005; Sanderson et al., 2006). The energy input for switchgrass production is about half as much as that of corn; however, as with every lignocellulosic material, switchgrass requires a pretreatment step prior to ethanol production, which increases the cost of the final product by about 20% when dilute-acid hydrolysis is performed (Pimentel and Patzek, 2005). Therefore, finding a pretreatment method which requires lower energy input, or creates other possible revenue sources, could improve the economics of the production of switchgrass-based ethanol.

The concept of biorefinery is based on the principle of utilizing the full potential of lignocellulosic biomass, making ethanol production only one of the branches of a biorefinery. Other potential products of lignocellulosic origin include furfural, phenolics, xyli-

tol, acetic acid, vanillin and many others and polymers such as phenolic resins, epoxy resins, polyurethane foams, nylon, and cellulose acetate (Kamm et al., 2006; Lora and Glasser, 2002; Pearl, 1967; Sarrouh et al., 2009).

In order to obtain value-added products in addition to ethanol, a pretreatment method must do more than just disrupt the lignocellulose structure to make it more susceptible to enzymatic digestion (Chandra et al., 2007). The first step that has to be applied in this concept is fractionation. One of the better known methods of fractionation, which has been practiced throughout the last century (in the pulp and paper industry) is organosolv treatment (Alvira et al., 2010; Taherzadeh and Karimi, 2008; Wyman, 1996).

There have been many alternatives of the organosolv process, each using different lignin solvents (e.g. alcohols, ketones, organic acids or esters) and processing conditions. The best known studies include projects like Lignol and ALCELL (developed in the 1970s) with application in the ethanol industry (Arato et al., 2005; Lora and Glasser, 2002; Pye and Lora, 1991). Lignin extracted in the organosolv process was found to be highly phenolic, and it had low molecular weight, which made it attractive for utilization in the production of chemicals (Arato et al., 2005). Another example

* Corresponding author. Tel.: +1 605 688 4710.

E-mail addresses: iwona.cybulska@sdstate.edu, iwonacybulska@op.pl (I. Cybulska).