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Sulfite (SPORL) pretreatment of switchgrass for enzymatic saccharification

D.S. Zhang [a], Q. Yang [a], J.Y. Zhu [a,b], X.J. Pan [a,*]

[a] Biological Systems Engineering, University of Wisconsin-Madison, 460 Henry Mall, Madison, WI 53706, United States
[b] USDA Forest Service, Forest Products Laboratory, 1 Gifford Pinchot Dr., Madison, WI 53726, United States

HIGHLIGHTS

- SPORL pretreatment of switchgrass was optimized by Response Surface Methodology.
- SPORL was compared with acid and alkali in pretreating switchgrass.
- Hemicellulose removal and lignin sulfonation in SPORL improved hydrolysability.
- SPORL pretreated switchgrass had better hydrolysability than DA and NaOH ones.
- Removing hemicellulose was more critical than lignin to SPORL substrate hydrolysis.

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ABSTRACT

SPORL (Sulfite Pretreatment to Overcome Recalcitrance of Lignocellulose) pretreatment was applied to switchgrass and optimized through an experimental design using Response Surface Methodology within the range of temperature (163–197 °C), time (3–37 min), sulfuric acid dosage (0.8–4.2% on switchgrass), and sodium sulfite dosage (0.6–7.4% on switchgrass). Performance of SPORL was compared with that of dilute acid (DA) and alkali (AL) in switchgrass pretreatment. Results indicated that SPORL pretreatment improved the digestibility of switchgrass through sufficiently removing hemicellulose, partially dissolving lignin, and reducing hydrophobicity of lignin by sulfonation. The removal of hemicellulose was more critical to substrate digestibility than the removal of lignin during SPORL pretreatment. SPORL pretreated switchgrass had better enzymatic digestibility than DA and AL pretreated ones. The SPORL pretreated switchgrass could be hydrolyzed by 83% within 48 h with 15 FPU (filter paper unit) cellulase and 30 CBU (cellobiose unit) β-glucosidase/g cellulose.

1. Introduction

Among the available energy crops for cellulosic ethanol production, switchgrass is a promising one because of its high productivity, low inputs, and positive environmental effects (Keshwani and Cheng, 2009). Switchgrass grows throughout North America because it is tolerant to heat, cold, and draught (Casler et al., 2007). Switchgrass provides habitat for grass birds and nesting birds (Roth et al., 2005) and wildlife (Dunn et al., 1993). Switchgrass has an extensive root system, and increases soil carbon storage by carbon sequestration effect (Bransby et al., 1998). It also improves surface water by reducing phosphorous and nitrogen in runoff (Sanderson et al., 2001) and removing herbicides (Mersie et al., 2006).

Physical and chemical pretreatment methods have been applied to switchgrass for cellulosic ethanol conversion. For example, physical pretreatment by grinding and milling (Bridgeman et al., 2007) and mechanical and thermal processing (Rijal et al., 2012) were used to improve enzymatic hydrolysis of switchgrass. AFEX pretreatment of switchgrass was investigated for optimum pretreatment conditions, and resulted in 6-fold improvement in enzymatic hydrolysis of pretreated switchgrass (Alizadeh et al., 2005). Dilute acid pretreatment of switchgrass was studied for optimal acid loading and pretreatment temperature (Chung et al., 2005; Dien et al., 2006). Lime pretreatment of switchgrass was conducted and combined with simultaneous saccharification and fermentation (Chang et al., 1997, 2001). Aqueous ammonium hydroxide pretreatment reduced about half lignin and hemicellulose content in switchgrass (Isci et al., 2008; Pryor et al., 2012). Microwave-alkali pretreatment of switchgrass was investigated for optimum processing condition, and achieves high yield of reducing carbohydrates (Hu and Wen, 2008). Organosolv was also an effective pretreatment for switchgrass by selectively removing lignin and hemicelluloses (Cateto et al., 2011; Cybulska et al., 2012).

SPORL (Sulfite Pretreatment to Overcome Recalcitrance of Lignocellulose) is a novel method recently developed for cellulosic ethanol production from lignocelluloses (Zhu et al., 2009). The

* Corresponding author. Tel.: +1 608 262 4951; fax: +1 608 262 1228.
E-mail address: xpan@wisc.edu (X.J. Pan).

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