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Response surface optimization of corn stover pretreatment using dilute phosphoric acid for enzymatic hydrolysis and ethanol production

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HIGHLIGHTS

- ▶ Dilute phosphoric acid pretreatment of corn stover was optimized by RSM.
- ▶ Temperature, acid dose and time were independent variables for pretreatment.
- ▶ Total sugar yield from pretreated corn stover was 78% after enzymatic hydrolysis.
- ▶ Recombinant *Escherichia coli* FBR5 produced 0.49 ethanol/g sugar from undetoxified hydrolysate.

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ABSTRACT

Dilute H_3PO_4 (0.0–2.0%, v/v) was used to pretreat corn stover (10%, w/w) for conversion to ethanol. Pretreatment conditions were optimized for temperature, acid loading, and time using central composite design. Optimal pretreatment conditions were chosen to promote sugar yields following enzymatic digestion while minimizing formation of furans, which are potent inhibitors of fermentation. The maximum glucose yield (85%) was obtained after enzymatic hydrolysis of corn stover pretreated with 0.5% (v/v) acid at 180 °C for 15 min while highest yield for xylose (91.4%) was observed from corn stover pretreated with 1% (v/v) acid at 160 °C for 10 min. About 26.4 ± 0.1 g ethanol was produced per L by recombinant *Escherichia coli* strain FBR5 from 55.1 ± 1.0 g sugars generated from enzymatically hydrolyzed corn stover (10%, w/w) pretreated under a balanced optimized condition (161.81 °C, 0.78% acid, 9.78 min) where only 0.4 ± 0.0 g furfural and 0.1 ± 0.0 hydroxylmethyl furfural were produced.

1. Introduction

Developing sustainable transportation fuels is a global challenge (Savvanidou et al., 2010). Bioethanol is a renewable, biobased oxygenated fuel (Saha, 2004) and the current production of bioethanol is based on first generation conversion of starch and sugar based crops (Ajanovic, 2011; Fischer et al., 2010). In particular, the United States and Brazil have expanded corn and sugarcane cultivation, respectively, for production of fuel ethanol (Rathmann et al., 2010; Hoekman, 2009). Further growth in production will need to rely on exploiting other non-food and non-animal feed associated biomass (Hoekman, 2009; Uncu and Cekmecelioglu, 2011). Lignocellulosic biomass is the most abundant renewable carbohydrate source in the world and it is proposed to dominate the biofuel production in the future (Chen et al., 2012; Fischer et al., 2008). Low cost agricultural residues (corn stover, wheat straw, rice straw), agricultural processing byproducts (corn fiber, rice hulls, sugar cane bagasse) and energy crops (switchgrass, miscanthus) can be used for ethanol production (Saha and Cotta, 2010). One significant source of biomass is corn stover, which is especially abundant in the United States (Um et al., 2003).

Biological production of ethanol from lignocellulose requires that the biomass be pretreated prior to enzymatic hydrolysis for production of fermentable sugars (Saha et al., 2011a). Pretreatment is needed to provide accessibility to enzymes for the hydrolysis of cellulose and hemicellulose (Öhgren et al., 2005; Saha et al., 2011b). Various physical, chemical, and physicochemical methods

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