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Pretreatment as the crucial step for a cellulosic ethanol biorefinery: Testing the efficiency of wet explosion on different types of biomass

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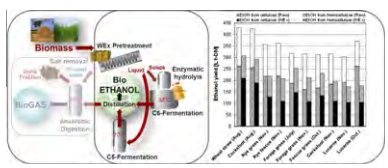
HIGHLIGHTS

- ▶ Modified wet explosion pretreatment was applied to lignocellulosic biomass samples.
- ▶ The efficiency of the pretreatment and enzymatic hydrolysis was investigated.
- ▶ The pretreatment efficiency for biomass of different composition was identified.
- ▶ Two biomass samples showed a potential of around 300 L bioethanol/ton-DM.

GRAPHICAL ABSTRACT



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ABSTRACT

The efficiency of wet explosion applied as modified dilute acid pretreatment at previously identified reference conditions (150 °C, 0.3% H_2SO_4, 15 min) was investigated on lucerne, ryegrass, fescue grass, cocksfoot grass, rye fescue, forage grass, and wheat straw in order to identify their potential as feedstock for cellulosic bioethanol production.

After pretreatment, cellulose recovery was more than 95% for all biomass while enzymatic convertibility of cellulose ranged from 40% to 80%. Lower enzymatic conversion of cellulose was correlated with higher lignin content of the biomass. Hemicellulose recovery was 81–91% with a final pentose yield of 65–85%. Cocksfoot grass and wheat straw had the highest bioethanol potential of 292 and 308 L/ton DM, respectively. Overall efficiencies were higher than 68% for cocksfoot grass harvested in August, fescue grass, wheat straw, and forage grass while efficiencies were lower than 61% for the other tested biomass resources, making further adjustment of the process parameters necessary.

1. Introduction

Lignocellulosic plant biomass is regarded as potential feedstock for sustainable production of biobased products including biofuels. However, due to the resistant lignocellulosic structure the utilization of cellulosic sugars to produce valuable biobased products faces significant technical challenges and its success depends largely upon the physical and chemical properties of the biomass type and pretreatment methods applied to it (Himmel et al., 1997). Pretreatment is among the most costly steps in the biochemical conversion of lignocellulosic biomass, accounting for up to 40% of the total processing cost (Lynd, 1996; Percival Zhang et al., 2009). Various thermal and chemical pretreatment methods as well as combinations of both have been proposed to make lignocellulosic biomass susceptible to enzymatic and microbial conversion (Galbe and Zacchi, 2002; Hendriks and Zeeman, 2009). Effective pretreatment of lignocellulosic biomass is characterized by a reduction in particle size, increase in surface area (porosity), disruption of cellulose crystallinity, hemicellulose disruption, and lignin redistribution without the formation of degradation products that inhibit the microbial activities during ethanol fermentation (Mosier et al., 2005; Karimi et al., 2006).

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