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Influence of pretreatment with Fenton's reagent on biogas production and methane yield from lignocellulosic biomass

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HIGHLIGHTS

- ▶ In this study we investigated the chemical degradation of biomass.
- ▶ We determined the efficiency of the process by the hydrolysates composition.
- ▶ We found out that after Fenton's oxidation the delignification level is quite low.
- ▶ We concluded that chemical pretreatment makes the biogas production more efficient.

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ABSTRACT

Biomass from *Miscanthus giganteus*, *Sida hermaphrodita* and *Sorghum* Moensch was treated with Fenton's reagent for 2 hours under optimal conditions (pH = 3, mass ratio of [Fe^{2+}]:[H_2O_2] equals 1:25 for *Miscanthus* and *Sorghum* and 1:15 for *Sida*). The degrees of delignification were 30.3%, 62.3% and 48.1% for the three plant species, respectively. The volatile fatty acids concentration after chemical pretreatment was high enough for production of biogas with a high methane content. Combined chemical oxidation and enzymatic hydrolysis with cellulase and cellobiase led to glucose contents of above 4 g/L. Among the tested plants, the highest biogas production (25.2 Ndm^3/kg TS fed) with a 75% methane content was obtained with *Sorghum* Moensch. The results of the three-step process of biomass degradation show the necessity of applying a chemical pretreatment such as oxidation with Fenton's reagent. Moreover, the coagulation of residual Fe^{3+} ions is not required for high biogas production.

1. Introduction

Due to its chemical structure and relatively high energy value, green biomass can be utilized for liquid and gas fuel production (bioethanol, biogas), and for heat generation and electricity (da Costa Sousa et al., 2009; Wyman et al., 2005). The biomass is employed in anaerobic digestion, gasification, composting or combustion for energy production, and plantations with selected, high-energy plants have been established in many areas to satisfy local energy needs (Amon et al., 2007; Kacprzak et al., 2009).

The process of anaerobic degradation of green biomass in its classical version is currently the technology most commonly used (Amon et al., 2007). Low adverse environmental effects, high efficiency of biogas production and wide feasibility and selection of raw materials make this method very attractive (Kacprzak et al., 2009); however, the time required for the entire process, especially biological hydrolysis, make it necessary to find pretreatments that shorten the time required for fermentation (Appels et al., 2008; Mosier et al., 2005). Hence, chemical decomposition of biomaterials which leads to the transformation of high-molecular, polymeric structures of lignocellulosic materials into products easily biodegradable under anaerobic conditions are being investigated (Hendriks and Zeeman, 2009; Wyman et al., 2005).

Thermo-chemical pretreatments with diluted acids (Cara et al., 2008; Lenihan et al., 2010) or alkali (McIntosh and Vancov, 2010; Wang et al., 2010), biomass oxidation by hydrogen peroxide (Chen et al., 2008; Rabelo et al., 2008) or ozonation (Carballa et al., 2007; Weemaes et al., 2000) have already been studied. Each of these treatments leads to more or less degradation of hemi- and cellulosic structures and to the considerable delignification of the plant material. The intermediate products formed during such transformations are easily available for methanogenic microorganisms, and the disintegration of polymeric structures allows for more effective enzymatic hydrolysis.

Although the classic Fenton's reaction has been applied in the treatment of highly loaded industrial wastewater (De Heredia et al., 2001), utilization of landfill leachate (Kochany and

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