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BIOENERGY FROM LIGNOCELLULOSIC WASTES: PREATREATMENT, ENZYMATIC HYDROLYSIS AND ETHANOL PRODUCTIVITY

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Abstract

Biovalorization of wastes from wheat straw, and other plant materials which constitute a low-cost lignocellulosic biomass, into valuable compounds was studied. For bioethanol conversion there are mainly three processes involved: (i) pretreatment for hemicellulose removal from lignocellulosic biomass, (ii) hydrolysis of cellulose to produce reducing sugars, and (iii) fermentation of the sugars to ethanol using an ethanologenic microorganism. Waste biomass pre-treatments were applied: autohydrolysis and acid hydrolysis were compared. Enzymatic hydrolysis was studied using a commercial cellulase mixture (Celluclast 1.5 L and Novozym 188, Novozymes A/S, Denmark) at different conditions. The influence of different parameters such as temperature (35-60ºC), incubation time (1-7 days) and enzyme loading (10-15 FPU/g and 0.2-0.4 mL/g polysaccharides) during the hydrolysis process was evaluated. The optimisation criterion was the fermentable sugar yields, which were analysed by HPLC. The best results for the wheat straw hydrolysis were obtained for the enzymatic loading: Celluclast 10 FPU/g polysaccharides + Novozym 188, 0.2 ml/g polysaccharides at 55ºC for 48 h. These optimal saccharification conditions for wheat straw pretreated (WSP) allowed a final process yield of ~60% in hydrolisate sugar content. Other waste materials are also compared.

The potential for ethanol production by fermenting wheat straw hydrolisate (WSH) with two yeast strains of *S. cerevisiae* (strains F and K from our collection) and a bacterial strain of *Z. mobilis* (strain CP4 a gift from LO Ingram) was evaluated. Batch fermentation tests of the WSH showed an ethanol yield of 74%, 79% and 58%, respectively. Supplementing the WSH with peptone and/or yeast extract had no effect on yield for yeast fermentation. However, the ethanol production by *Z. mobilis* was highly increased when yeast extract was added to the hydrolisate, corresponding to an ethanol yield of 98%.

Moreover, further pretreatment optimization of lignocellulosic materials to remove lignin can significantly enhance the hydrolysis of cellulose improving the bioethanol yield and in addition the recovered lignin can also be converted into valuable compounds.

These results show that an integrated exploitation of these lignocellulosic wastes from agricultural production is economically possible and highly advantageous for energy and chemicals production.