SUGAR PRODUCTION BY ENZYMATIC HYDROLYSIS OF SUGARCANE BAGASSE

Alfredo Eduardo Maiorano
Industrial Biotechnology Laboratory / Bionanomanufacturing Center / Institute for Technological Research (IPT)
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Figure 1. Steam explosion equipment

The search for renewable materials to replace fossil resources has received considerable attention in recent years. Biomass has been regarded as of great potential to provide energy, chemicals and materials. One important aspect in this field is the industrial use of agroresidues, which would boost production without involving the expansion of the agricultural area. Sugarcane bagasse is a promising lignocellulosic material for such application since it has a high concentration of carbohydrates and is already available at sugar mills in significant quantities. However, the compact structure of the lignocellulosic matrix hinders the hydrolysis of cellulose into fermentable sugars. Thus, a pretreatment step is necessary to improve cellulose accessibility. The aim of this work was the evaluation of the enzymatic hydrolysis of sugar cane bagasse submitted to steam explosion pretreatment to produce sugars. These sugars can be used as substrate for the production of chemicals by biotechnological routes. The effects of steam explosion, alkaline delignification and enzymatic hydrolysis parameters were studied in detail. This research project was carried out jointly by Oxiteno Co and IPT.

In the steam explosion pretreatment, different reaction times were tested for different temperatures and the results were analyzed in relation to: the composition of pretreated bagasse and the corresponding hemicellulosic hydrolysate; the susceptibility of pretreated bagasse to hydrolysis by a cellulolytic complex selected as a model; and the benefits achieved by the delignification process. At the best condition of 220 °C for 9 min, large quantities of pretreated bagasse were produced to study the kinetics of the enzymatic hydrolysis in pilot scale reactor of about 40 L. The effects of the cellulase complex, substrate/cellulase ratio, stirring, degree of delignification and process design were evaluated in relation to both the sugar recovery and the obtained hydrolysis yields.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The objective of pretreatment is to destroy the recalcitrant structure of cellulosic biomass to make the cellulose fibers more accessible to enzymatic hydrolysis. As more drastic the conditions of pretreatment, more significant has been the loss of cellulose and the higher the damages to the fiber structure, causing the folding thereof. The best condition of pretreatment by steam explosion reduced the hemicellulose content of up to 90 % and the yield of glucose obtained in the enzymatic hydrolysis was 76.3 %.

Delignification with NaOH and H_2O_2/NaOH has also been applied in order to improve the enzymatic hydrolysis yield. The results showed that the NaOH concentration has a greater effect than temperature on the lignin solubilization and on enzymatic hydrolysis yield increasing. With bagasse pretreated and delignified was possible to reduce the lignin content of approximately 53% and yield of glucose in the enzymatic hydrolysis was 89.3 %.

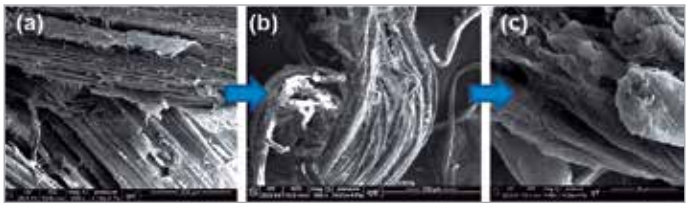

Figure 2. Bagasse Scanning Electron Microscopy (SEM): (a) fresh, (b) pre-treated to 18bar / 9min and (c) pre-treated and delignified with NaOH

Enzymatic hydrolysis of cellulose was performed by commercial cellulolytic enzymes. In the conditions tested the agitation speed had no significant effect on the enzymatic hydrolysis yield. Substrate concentration and enzyme load are important process parameters for the overall economy of the enzymatic hydrolysis. At 10% bagasse concentration resulted high enzymatic hydrolysis yield and high glucose concentrations in the medium. Higher substrate concentrations resulted in lower the rate and the yield of the hydrolysis. Furthermore, a large increase in power is required for stirring the bagasse suspension. Batch enzymatic hydrolysis was modified to fed-batch mode to solve the problems, however no significant effects were observed. Substrate inhibition depends on the substrate/enzyme ratio. This parameter had great influence in the process. Increasing the load of cellulases in the process, increased the yield and rate of the hydrolysis. The best enzyme/substrate ratio was 30 FPU/g, but would significantly increase the cost of the process.

MAIN PUBLICATIONS

Ota EM, Saad MBW, Silva EM, Porgete DS, Venceslau, RAMOS LP, RODRIGUES MFA, Maiorano AE. 2013. Efeito da deslignificação e da composição do complexo celulolítico na hidrólise enzimática de bagaço de cana pré-tratado por explosão a vapor. *XIX Simpósio Nacional de Bioprocessos, Foz do Iguaçu, Brasil, Anais em CD.*

Alfredo Eduardo Maiorano

Instituto de Pesquisas Tecnológicas (IPT)
Laboratório de Biotecnologia Industrial
Núcleo de Bionanomanufatura
Av. Prof. Almeida Prado, 532 – Butantã
CEP 05508-901 – São Paulo, SP – Brasil

+55-11-3767-4315
maiorano@ipt.br