PRETREATMENT OF SUGARCANE BAGASSE TO ACID OR ENZYMATIC HYDROLYSIS APPLYING THE ADVANCED OXIDATION PROCESS BY IONIZING RADIATION TO ETHANOL BIOFUEL PRODUCTION

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Figure 1. Sugarcane bagasse irradiation in batch system at the Electron Beam Accelerator in the Nuclear and Energy Research Institute, IPEN. (Photo Jesus Carlos/Imagemlatina)

The main objective of the project is to study the cleavage of lignocellulosic material from sugarcane bagasse using ionizing radiation from an industrial electron beam accelerator, in order to make easier the cellulose hydrolysis and the fermentation of their sugars to ethanol biofuel production. Sugarcane bagasse generally contain up to 45% glucose polymer cellulose, much of which is in a crystalline structure, 40% hemicelluloses, an amorphous polymer usually composed of xylose, arabinose, galactose, glucose, and mannose and 20% lignin, which cannot be easily separated into readily usable components due to their recalcitrant nature. The main difficulty to produce ethanol biofuel from this biomass is to break cellulose down into starches and sugars suitable for fermentation. The reactive species generated by the interaction of ionizing radiation with water (oxidant OH radical and redutants e-aq, and H radical) reveal as a very efficient way for the organic compounds oxidation in simple molecules and to enhance the processes of lignocellulosic enzymatic or chemical attack as well as the direct fermentation. The radiation effects on cellulose properties have been studied extensively, and the results have shown a decreasing of the polymerization degree and an increasing of the carbonyl content. Although this subject has been studied before, the sugarcane bagasse usually used were dehydrated or very old, and, in most cases, the cellulose was separated from bagasse before the radiation processing. In the present study it was used bagasse samples collect directly from the sugarcane mill. These samples have about 50% of humidity and the ionizing radiation does not change this parameter, which is a positive point for combination with enzymatic or chemical hydrolysis. The main challenge is to obtain the desirable effects applying doses as low as necessary to get some break in the polysaccharides, and at the same time to avoid the glucose loosing due to uncontrolled degradation of cellulose and hemicelluloses.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The irradiation of the sugarcane bagasse was carried out using Electron Beam Accelerator from Radiation Dynamics Inc., USA, with 1.5 MeV, and 37 kW from Radiation Technology Center of IPEN. It was applied absorbed doses from 5 to 200 kGy and then the bagasse samples were characterized by analysis of lignin, hemicelluloses and cellulose using standard methods. The enzymatic hydrolysis were done in the Sugarcane Technology Center, using a commercial Trichoderma reesei cellulase preparation (Celluclast 1.5 L), kindly supplied by Novozymes (Bagsvaerd, Denmark), with 5 FPU/g of cellulase and Beta-glycosidase 0.5% (p/p). The electron beam processing changed the sugarcane bagasse structure and composition and also caused some lignin and cellulose cleavage without loosing of sugar, with absorbed doses from 5 to 100 kGy. The conversion rate of cellulose to glucose increased from 8% to 14%, and from 6% to 18% in the Assay A and B, respectively. These represent 75% and 300% of yield after irradiation with 20 kGy of absorbed dose. There was a break in the lignin structure with doses lower than 50 kGy which was observed by the increasing of 20% of low molecular mass carbohydrates. Glucose and arabinose were liberated by the total cleavage of cellulose and hemicelluloses, respectively, when absorbed doses higher than 100 kGy were applied. The decreasing in the conversion rate above 30 kGy could be caused by the enzyme inhibition by some compounds e.g. furfural and 5-hydroxyl-methyl-furfural (HMF) that are formed during the saccharification of lignocelluloses polysaccharides and by the degradation of glucose. All the publications found in the literature are based on results obtained for doses higher than 200 kGy, that become the technology not feasible economically. The most important contribution of this study is the demonstration of promissory results with lower doses.

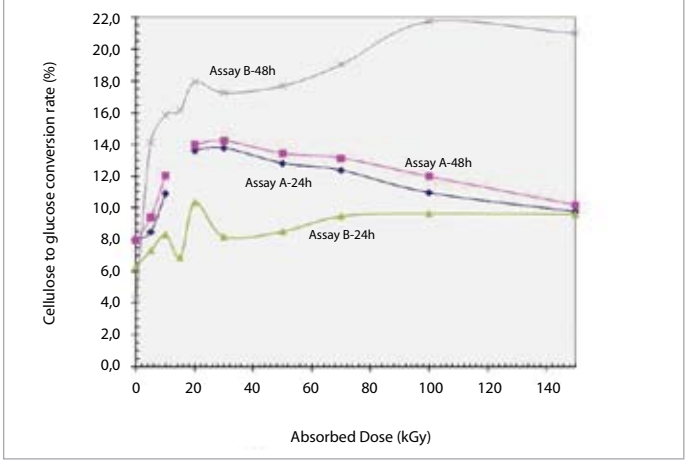

Figure 2. Conversion rate of cellulose to glucose in sugarcane bagasse samples from Assay A and B, related to the absorbed doses after irradiation at the Electron Beam Accelerator and enzymatic hydrolysis (24 and 48h)

MAIN PUBLICATIONS

Ribeiro MA, Cardoso VM, Mori MN, Finguerut J, Galvao CMA, Duarte CL. Electron beam processing of sugarcane bagasse to enzymatic cellulose hydrolysis. International Nuclear Atlantic Conference (INAC2009), Rio de Janeiro, BR, 27 Sept. to 2 Oct. 2009.

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