Pre-treatment of sugarcane bagasse using high-pressure CO_2-H_2O technology

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Introduction

The sustainable production of sugar-rich solutions from biomass is a key challenge in the conversion of lignocellulosic residues into biofuels or other valuable products. Most biomass processing approaches are characterized by low selectivity and sugar yield, need of chemical catalysts or still bench scale of the processes.[1] Recently, a new approach with high pressure CO_2-H_2O has been investigated and was demonstrated to be an interesting alternative to conventional technologies such as hot liquid water and acid-catalyzed technologies.[1,2]

Results and Discussion

In the present study high-pressure CO_2-H_2O pre-treatments of sugarcane bagasse followed by enzymatic hydrolysis were performed and the conversion into different monomers, oligomers and other degradation products such as HMF and furfural was analyzed. The optimal pre-treatment condition and its corresponding glucan and xylan conversion yields are depicted in Table 1.

Table 1. Glucan and xylan conversion yields (%) for sugarcane bagasse treated for 30 min at 180°C, and 60 bar of initial CO_2 pressure.

	Glucan	Xylan
Oligosaccharides (GOS, XOS)	4.6	32.7
Monomers (M) from pre-treatment	1.1	27.5
M from enzymatic hydrolysis	88.4	26.8
Hydroxymethylfurfural (HMF)	0.3	11.9
Total saccharide conversion	94.1	87.1

For the pre-treatment performed at 180 °C for 30 min and 60 bar of initial CO_2 pressure a total glucan to glucose yield of 94.1% and a glucan to glucose yield for the enzymatic hydrolysis of 94.0 % were obtained. These results are superior to those reported in the literature for pre-treatments with diluted sulphuric acid. For example Hsu et al. were only able to obtain a maximum glucan to glucose yield of 83% for rice straw using 1% (w/w) of sulphuric acid with a reaction time of 5 min at 180°C.[3] Sugar recovery from hemicellulose (xylan) was also high (87.1 %) with minimal formation of degradation products (11.9%). Additionally, the high-pressure CO_2-H_2O process proved to be very efficient and selective for xylan conversion into xylooligosaccharides (XOS), which can be an advantage as they are known for their prebiotic activity.[4] The integrated polysaccharide conversion to sugars in all forms was analysed and is shown in Figure 1.

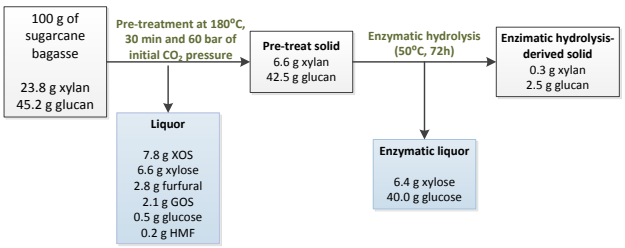

Figure 1. Overall mass balance of integrated polysaccharide conversion for high pressure CO_2-H_2O.

Conclusions

High pressure CO_2-H_2O technology is a viable alternative to hydrothermal and acid catalysed pre-treatment processes allowing carrying out processes at mild conditions, obtaining hemicellulose-rich solutions with low formation of degradation products and producing processed solids highly susceptible to enzymatic hydrolysis as well.

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