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Enzymatic conversion of steam exploded pine into fermentable sugars

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Lignocellulosic biomass (LC) is a highly available and low cost raw material that can be converted into biofuels and chemical products within the concept of a biorefinery. Due to its recalcitrant nature, it has to be efficiently deconstructed to alter the structure of the biomass prior to hydrolysis, in order to allow the enzymes to access the cellulose.

Steam explosion (SE) is one of the most successful and widely used techniques for pretreatment of LC. It consists of a hydrothermal treatment with a sudden depressurization that destroys the LC structure, solubilizing the hemicellulose, transforming the lignin and increasing the hydrolysis potential for cellulose. The process can also be optimized with the addition of an acid catalyst such as H_2SO_4. Acids are an essential addition when softwood (with a low potential for autohydrolysis), such as pine, has to be pretreated, which can also help to reduce the severity [1]. However, the quantity added has to be carefully evaluated, since it may lead to a higher production of enzymatic and fermentation inhibitors.

In this study, the production of fermentable sugars from pine wood residues through a SE pretreatment and enzymatic saccharification was studied. The equipment used was a continuous reactor with a processing capacity of 10 kg/h and a maximum working pressure of 15 bar. The feedstock used was a mix of sawdust and shavings from a pine sawmill. It was kiln dried at 40ºC and the particle size reduced in a hammermill (average of 7 mm). The experiments were carried out in duplicate with a residence time of 7.5 min. Three temperatures were evaluated: 180ºC, 190ºC and 200ºC. The 180ºC and 200ºC conditions were performed without and with the addition of 1% w/w dry solid H_2SO_4. The 190ºC condition was only evaluated with the addition of 0.5% w/w H_2SO_4. Previous to the pretreatment, the pine was soaked in water overnight to achieve an approximate moisture content of 30 wt.%. H_2SO_4 was mixed with the water for the catalyzed conditions. After the SE, the resulting slurry was processed in a filter press, separating the liquid fraction from the solid fraction. Both pretreatment liquor and pretreated eucalyptus were characterized following NREL protocols. The optimal pretreatment condition was determined based on the hydrolysis efficiency of the pretreated solid, using 2% solid content and enzyme Cellic Ctec2 (25 FPU/g glucan), after 72 h. After that, higher solid concentrations were studied to obtain greater fermentable sugars concentrations (25 FPU/g_{glucan}).

The best condition for the enzymatic saccharification was the most severe (200ºC, 1% w/w H_2SO_4), resulting in a saccharification efficiency of 65%. The highest glucose concentration achieved was 56.8 g/L for a 22% w/w solid content in 96 h with a saccharification efficiency of 57%. The results found in this study are promising for the valorization of pine residues for an industrial scale up.

References

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