Evaluation of Acid and Enzymatic Hydrolysis of Hemicellulose Extracts Produced from Northeast Hardwood

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Evaluation of Acid and Enzymatic Hydrolysis of Hemicellulose Extracts Produced from Northeast Hardwood

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1. ABSTRACT
At the University of Maine, a hemicellulose pre-extraction technology is now being investigated to improve pulp yields, reduce organic and inorganic load for liquor recovery, and create a feed stream for the generation of new biomaterials.

In this study, we investigate 1. the extent of hemicellulose recovery by pre-extraction using green liquor pretreatment and 2. characterize the hydrolysis of the extract with respect to variable concentration via evaporation and comparing acid and enzymatic hydrolysis.

2. INTRODUCTION
Forest biomass is a promising resource for future biofuels and bioproducts. Biosurfactins in wood paper and chemicals is not as easy as making a single traditional paper product. Paper is made from the cellulose fraction of wood. Removing lignin and hemicellulose components through a liquid pre-extraction can enhance the quality of the pulp. Pre-extraction of hemicellulose by alkaline (Green Liquor) pretreatment produces a neutral-pH extract containing hemicellulose.

One near term option is to carefully pre-extract the hemicellulose before the main pulping step and then ferment it to bioethanol. A significant difference from other lignocellulosic biomass conversion processes is that the solid fraction has high value to make pulp and paper products and is thus not converted to liquids or boiler fuel.

3. PRE-EXTRACTION PROCESS
Rocking digester was loaded with 2 kg of chips and cooked. An effective Green Liquor of 3 % on chips was used for all cases with liquor to wood ratio of 4:1. This system was agitated (2 rpm) at 160 °C for 110 minutes yielding an H-factor of 800.

4. ACID AND ENZYME HYDROLYSIS OF EXTRACTS
The sulfuric acid hydrolysis was conducted with 10 mL hemicellulose extract at various concentration from 2 to 6 %. The temperature ranged from 100 to 160 °C. The residence time range from 2- to 258-min. All batch Acid hydrolysis experiments were performed using sealed Tubular Reactors (Figure 1). Temperatures of the vessel are adjusted in oil (Heat Transfer Fluid 550, Fisher, Pittsburgh, PA) heating/cooling baths.

The enzymes 3000 U/g xylanase from Trichoderma viride was tested with 10 mL working volume at various loadings from 0.4 to 4 %. The pH ranged from pH 1.5 to 6.0 in increments of one-half pH unit. The agitation (68 RPM), reaction time (96 hours), and temperature (40 °C) were constant. The pH was adjusted with 1 M NaOH or HCl.

5. CARBOHYDRATE ANALYSIS
Donex model HPAEC-PAD (LC30 Chromatography, Dionex Corp., Sunnyvale, CA) and Shimadzu model HPLC (LC-10AT Liquid Chromatogram, Shimadzu Corp., Kyoto, Japan) were used for determining the carbohydrates and decomposed products.

6. RESULTS AND DISCUSSION

![Figure 1. Schematic of Acid Hydrolysis Vessel Fitted with Swagelok](image)

Figure 1 shows the effect of xylanase loading on xylene yield at 60 °C. Figure 2 presents the effect of temperature on xylene yield at 4 % xylanase loading. Table 1 presents the chemical composition of the Northeast Mixed Hardwood on Dry Basis.

![Figure 2. Effect of Xylanase Loading on Xylene Yield at 60 °C](image)

![Figure 3. Effect of pH on Xylene Yield at 4 % xylanase loading](image)

![Figure 4. Effect of Residence Time on Xylene Yield at 4 % xylanase loading](image)

![Figure 5. Effect of Temperature on Xylene Yield at 4 % xylanase loading](image)

![Figure 6. Effect of Hydrolysis Time on Xylene Yield at 4 % xylanase loading](image)

![Figure 7. Effect of Acid Concentration on Xylene Yield at 4 % xylanase loading](image)

![Figure 8. Effect of Enzyme Concentration on Xylene Yield at 4 % xylanase loading](image)

Table 1 shows the chemical composition of the Northeast Mixed Hardwood on Dry Basis.

Table 2 presents the comparison of operating conditions at the highest xylene yield.

7. CONCLUSIONS
The maximum fermentable sugar yield from acid and enzyme hydrolysis of the extract was 0.91 g/100mL (95.5 %) and 0.76 g/100mL (80.1 %) respectively (Table 2). Attempts will be made to increase the sugar concentration in the hemicellulose extract so as to improve ethanol yield in the ethanol fermentation broth. It is conceivable that higher xylene yields may be achieved with optimal combination of temperature, acid (enzyme) concentration, pH, and reaction times.

8. ACKNOWLEDGEMENT
This work was funded by the National Science Foundation (EPSCoR, Contract #: 0554545 ).