Characterizing Sweetgum from Biomass to Bioethanol

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INTRODUCTION

The conversion of lignocellulosics into bioethanol remains a technically demanding process due to the complicated cell wall structure of lignocellulosics and their recalcitrant properties. The efficient processing of lignocellulosics into biofuels is contingent on the characterization of the chemical constituents of plant carbohydrates and lignin and their changes in structure throughout the process. This research program is directed at developing the fundamental knowledge needed to (1) describe the changes in biomass constituents during the overall conversion of plant polysaccharides into bioethanol and (2) optimize the overall process. New pretreatment strategies are also being developed.

RESEARCH OBJECTIVES

- Chemical characterization of the incoming feedstock
- Impact of pretreatment technologies on chemical structure and reactivity of biomass resources towards enzymatic hydrolysis
- Determination of reactive and unreactive components of pretreated biomass towards enzymatic hydrolysis
- Analysis of chemical constituents impacting fermentation of enzyme hydrolyzed biomass to bioethanol

PROCESS OVERVIEW

Biomass feedstock

- Widely prevalent hardwood species in South-Eastern US
- Used for lumber, veneer, plywood and pulpwood
- Bark-free Sweetgum chips obtained from chipping mill in Dewey Rose, GA.
- Chips stored at < -5 °C

Distribution map of Sweetgum

RESULTS

- Cellulose to glucose conversion yields for low enzyme dose experiments. 20 U cellulase; 40 U beta-glucosidase/g cellulose in 50 mM, pH 4.8 acetate buffer. Incubated at 45 °C and 150 rpm.

<table>
<thead>
<tr>
<th>Pretreatment</th>
<th>Klason lignin</th>
<th>Acid soluble lignin</th>
<th>Organosolv lignin</th>
<th>Lignin in effluent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>25.90</td>
<td>2.60</td>
<td>-</td>
<td>28.50</td>
<td></td>
</tr>
<tr>
<td>Organosolv (SA)</td>
<td>4.06</td>
<td>0.04</td>
<td>13.45</td>
<td>8.35</td>
<td>23.90</td>
</tr>
<tr>
<td>Organosolv (ClO2)</td>
<td>8.27</td>
<td>0.19</td>
<td>12.53</td>
<td>5.65</td>
<td>24.44</td>
</tr>
<tr>
<td>1.1 ClO2</td>
<td>16.07</td>
<td>0.06</td>
<td>-</td>
<td>9.28</td>
<td>25.21</td>
</tr>
</tbody>
</table>

Solid-state CP/MAS 13C NMR of extractive free Sweetgum

CONCLUSIONS

- On the basis of cellulose to glucose conversion, Organosolv (sulfuric acid), Organosolv (ClO2) and 1.1 ClO2 pretreatments were selected for detailed investigation.
- Main effects of pretreatments:
  - Decrease in ash content
  - Decrease in acid soluble and insoluble lignin
  - In the organosolv pretreatments, up to 50 % lignin recovered as Ethanol Organosolv Lignin which has potential commercial value
  - Increase in proportion of glucose in carbohydrates
  - Low furan (fermentation inhibitors) content in pretreatment liquids

Funding from Chevron is gratefully acknowledged.