Commercial Lignin: Co-product Of Cellulosic Sugar Production

“Not All Lignins Are Created Equal”

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Economically Deconstructing Biomass to Valuable Products

Biomass to Chemicals & Fuels

Renmatix Conversion Technology

Plantrose Process
Plantrose™ Process: A Flexible Platform

**WOODY BIOMASS**

**ENERGY GRASSES**

**AGRICULTURAL RESIDUES**

**WASTE SOURCES**

**C5 SUGAR**

**C6 SUGAR**

**LIGNIN**

**SUPERCritical WATER PLATFORM FOR BIOMASS CONVERSION**

ADDRESSABLE MARKET INCLUDES A WIDE VARIETY OF BIOMASS TYPES & DOWNSTREAM USES FOR SUGAR

C5 = 5 carbon sugar, eg. Xylose  
C6 = 6 carbon sugar, eg. Glucose
Strong Partnerships & Strategic JDAs

KEY INFLUENCER RECOGNITION
Biomass is More Than Carbohydrates, and Renmatix is More Than Sugar…

Example Dry Biomass Composition

- Lignin
- Hemicellulose
- Cellulose
- Other
Background On Lignin & Industry

**History**

- 2nd most abundant biological material on earth
  - Second only to cellulose
- Much maligned, often due to claiming capability, but ignoring cost
  - Like all markets, it needs to compete on a performance, quality, AND cost basis vs. the next best alternative
- Has actually been used for decades in industry

**Current Uses**

- Dispersants
- Viscosity Modifiers
- Binders

Has been researched for decades: first identified in 1959
Still understanding what it is today.
Lignin Structure - Hardwood

Source: European Beech, By Nimz, 1974
### Current Lignin Production Sources

<table>
<thead>
<tr>
<th>Sources of Lignin</th>
<th>Resulting Characteristics &amp; Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Kraft Pulping</td>
<td>• Contains sulfur</td>
</tr>
<tr>
<td>• Soda Pulping</td>
<td>- Smell, impacts application</td>
</tr>
<tr>
<td>- Mostly used on non-woody materials</td>
<td>- Chemical Reactivity affected</td>
</tr>
<tr>
<td>• Sulfite Pulping</td>
<td>• Degradation</td>
</tr>
<tr>
<td>• Organosolv Processing</td>
<td>- Molecular weight changes</td>
</tr>
<tr>
<td></td>
<td>• Monomer vs Oligomer vs Polymer</td>
</tr>
<tr>
<td></td>
<td>- Structure Changes</td>
</tr>
<tr>
<td></td>
<td>• Condensation</td>
</tr>
<tr>
<td></td>
<td>- Decreased solubility</td>
</tr>
<tr>
<td></td>
<td>• Additional costs can be incurred</td>
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</tbody>
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Impact of property, purity, reactivity changes are application dependent. Additional costs if trying to modify properties (cleanup, improved activity, etc.)
Lignin Markets Exist Today

Lignin Applications, Today & Tomorrow, Are Numerous

Source: Gosselink, 2011
If Property and Costs are Correct, Interesting Options Appear…

- THERMOPLASTICS
- EXTENDERS
- PHENOLIC REPLACEMENTS
- ADHESIVES
- CARBON FIBER
- VANILLIN
Lignin Markets Exist Today
Routes For New Markets Developing Rapidly

## Not All Lignins Are Created Equal: Renmatix Lignin Has Distinct Attributes

### Unique Process & Composition

- Has only seen water
- Highly functional
- Great macromolecule for broad market applications
- No protein or organism biomass in the lignin
- Effectively sulfur free
- Very low degradation
  - Compared our lignin to industry standard lignin, and structurally our lignin is less degraded (NMR)
- Low Price to produce

### Businesses DO Exist and Make Money on Lignin

- So, why do so many say “You can make anything except money…”
- Because, like all material plays:
  - You need a market
  - You need properties that the market wants/needs
  - You need a production cost that allows you to make money

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Our current business model assumes heating value only for lignin…. Incremental value for lignin further enhances Renmatix cost advantage
World Class Analytical, World Class Experts
World Class Analytical, World Class Experts
World Class Analytical, World Class Experts
DEMONSTRATION:
4x8 Panels with Renmatix Lignin Adhesive
Renmatix’s Clean Lignin Offers A Large Potential Production Cost Improvement With A Much More Functional Lignin

Significant Progress Made On Alternative Biomass And Lignin Efforts

Leaders in the space:
- Unique analytical capabilities
- Unique composition of matter
- World class lignin expertise
- Developed Production & Purification Processes For End Market Optionality

Renmatix does not need lignin to be the low cost cellulosic sugar provider
- Deep interest with industrial partners; adds value

POSITIVE RESULTS FROM 3rd PARTY TESTING OF RENMATIX LIGNIN IN MARKET APPLICATIONS
- Tested in applications at multiple scales
- Completed characterization for strength & mixability

Distinct Attributes Of Renmatix Lignin
ARE BRINGING THE MARKET TO US!