An integrated lignin biorefinery: Scaling-up lignin depolymerization technology for biofuels and chemicals
Kouris, P.; Oevering, H.; Boot, M.D.; Hensen, E.J.M.

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Lignin RICHES (Resins Chemicals Fuels)

Lignin is one of the major components of lignocellulosic biomass, constituting 15-30% of the weight and approximately 40% of the energy content depending on the source. Currently, the lignin produced in 2G bio-ethanol plants is mainly used for on-side energy production. At Eindhoven University of Technology a method was explored to depolymerize lignin in super critical ethanol with cheap non-noble catalysts to produce a mixture of monomeric aromatics. The product might be applied directly as a bio marine fuel, or as a source for chemical building blocks (Resins), octane boosters or biofuels when blended with gasolines. The primary goal for pilot activities is to produce Lignin Crude Oil (LCO) from lignin with a viscosity spec < 800 cSt at 40 °C, on a ton scale and to collect information for designing a demo plant with the aim of having an economically viable process.

Scale-up reactions

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Lignin:Ethanol ratio (w/v)</th>
<th>Monomer Yield (wt%)</th>
<th>LCO viscosity (cSt at 40°C)</th>
<th>Ethanol conversion (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (no cat)</td>
<td>1:40</td>
<td>1</td>
<td>&gt;1000</td>
<td>4</td>
</tr>
<tr>
<td>240</td>
<td>1:40</td>
<td>11</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>280</td>
<td>1:40</td>
<td>3</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>340</td>
<td>1:40</td>
<td>11</td>
<td>5,5</td>
<td>53</td>
</tr>
<tr>
<td>340</td>
<td>1:30</td>
<td>14</td>
<td>3,3</td>
<td>46</td>
</tr>
</tbody>
</table>

Lignin: EtOH + catalyst CuMgAlOx

Kinemetric viscosity of LCO over different reaction temperatures (red line: maximum viscosity limit)

Design Challenges

- Process complexity
- Batch vs continuous
- Operating window
- Lignin / catalyst loading
- Ethanol conversion
- Reactor design
- Catalyst regeneration
- Separation steps
- Ethanol concentration in LCO
- Ethanol losses in the process

Approach

- Experimental data input for process design
- Mass & energy balances for all process streams
- Perform techno-economical study
- Optimize the most feasible process routes

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TU/e technology

- Sulfur-free marine fuel
- Fuel boosters
- Resins
- Phenols