Introduction

Our current energy crisis has forced industry to invest in research of alternative fuels. Biofuels from catalytic sources have proven to be a viable contender in the race for the best new energy source; however, the production methods are not always the most eco-efficient (i.e., limiting the use of known hazardous chemicals, production of byproducts and wastes, and reliance on energy input). Here, we examine feedstocks and stake-of-the-art cellulose processing that satisfies the Principles of Green Chemistry and could be used as a model for industries interested in new approaches for synthesizing bioethanol. Lastly, we suggest which downstream use of bioethanol would be the most eco-effective and the most economic by considering both environmental health ramifications and cost differences of producing biofuels vs. bioethanol.

Proposed Strategy for Cellulosic Bioethanol Production

1. Harvesting (Soil improving - pest-deterrent)
2. Planting of Feedstock (Short Rotation Crops - nutrient-needy)
3. Pre-treatment
   - AFEX (c) Processing of Biomass
   - Chemical Hydrolysis (Olig. Glc)
   - Enzymatic Hydrolysis with AFEX Pretreatment (Olig. Xyl)
   - Phosphoric Acid Microwave Hydrolysis (Olig. Xyl)
4. Fermentation
   - S. cerevisiae
5. Fermentable Sugars
   - Ethanol
6. Biofuel
   - Ethanol (gal)
   - Bioethanol: Eco-Efficient Processing & Eco-Effective Downstream Use
7. Bioethanol
   - Econ. Value of Ethylene Derived from Cellulosic Bioethanol
8. Economic Value of Cellulosic Bioethanol as a Liquid Fuel

Economic Value of Cellulosic Bioethanol as a Liquid Fuel

<table>
<thead>
<tr>
<th>Technology</th>
<th>Glucose (kg)</th>
<th>Ethanol (kg)</th>
<th>Ethanol (gal)</th>
<th>Gasoline Equivalent (Energy Density in gal)</th>
<th>Price of Equivalent Gasoline Produced ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzymatic Hydrolysis with AFEX Pretreatment</td>
<td>347</td>
<td>159</td>
<td>53</td>
<td>33</td>
<td>$132</td>
</tr>
<tr>
<td>Concentrated Sulfuric Acid Saccharification</td>
<td>347</td>
<td>156</td>
<td>52</td>
<td>32</td>
<td>$128</td>
</tr>
<tr>
<td>Phosphoric Acid Microwave Hydrolysis</td>
<td>165-297</td>
<td>74-134</td>
<td>20-45</td>
<td>16-28</td>
<td>$64-112</td>
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<tr>
<td>Dilute Sulfuric Acid Saccharification</td>
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<td>4</td>
<td>35</td>
<td>22</td>
<td>$88</td>
</tr>
</tbody>
</table>

This table shows the yield of bioethanol from 1000 kg of plant material from the four different hydrolysis techniques. The quantity of ethanol produced is also displayed as the energy equivalent gallons of gasoline to facilitate comparison. The final column shows the value of the bioethanol produced from each process for use as a liquid fuel at $4.00/gal.

Economic Value of Ethylene Derived from Cellulosic Bioethanol

<table>
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<tr>
<th>Technology</th>
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<th>Ethanol (gal)</th>
<th>Value of Ethylene ($)</th>
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<td>Phosphoric Acid Microwave Hydrolysis</td>
<td>165-297</td>
<td>78-140</td>
<td>44-80</td>
<td>$45-82</td>
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<tr>
<td>Dilute Sulfuric Acid Saccharification</td>
<td>231</td>
<td>109</td>
<td>62</td>
<td>$64</td>
</tr>
</tbody>
</table>

This table shows the yield of ethylene from 1000 kg of plant material. Bioethanol derived ethylene could be a viable alternative feedstock to petrochemical derived plastics. With the AFEX/Enzyme technology, the value of ethylene produced by each process is shown in the final column using an ethylene price of $1.05/kg.

Recommendation

- Current biofuel production raises several environmental concerns for fertile land with food production, increases pollution from fertilizers and pesticides, and threatens biodiversity. On the process side, it is energy intensive and yields are low. We recommend two ways to overcome these key issues by using (1) Low-Input-High-density as feedstock for bioethanol production, and (2) enzymatic hydrolysis with AFEX pre-treatment.
- Bioethanol can currently act as an additive to gasoline but is far less efficient than the petroleum-derived compounds. It can act as a biofuel for cars and other vehicles. Bioethanol is produced from biomass, which is a renewable and sustainable source of plastics, which may help industries build reputations as green and sustainable companies.

Key References