Characterization of Biochar from Fast Pyrolysis and Gasification Systems

Study Overview
Biochar is the solid carbon and ash product from the thermochemical processing of biomass that is used as a soil amendment to improve soil fertility and sequester carbon. Here, chars from the fast pyrolysis and gasification of switchgrass and corn stover were characterized by a variety of physical and chemical methods. For comparison, chars from the slow pyrolysis of the same feedstocks and a commercial hardwood charcoals were also characterized.

Char Composition & Physical Properties

<table>
<thead>
<tr>
<th>Char</th>
<th>Fixed C (%)</th>
<th>Volatiles (%)</th>
<th>Ash (%)</th>
<th>C (%)</th>
<th>H (%)</th>
<th>N (%)</th>
<th>K (%)</th>
<th>LV (%)</th>
<th>LV (%)</th>
<th>HHV (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass</td>
<td>75.0</td>
<td>25.0</td>
<td>1.5</td>
<td>69.4</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>26.5</td>
<td>41.4</td>
<td>14.3</td>
</tr>
<tr>
<td>Slow Pyrolysis</td>
<td>75.5</td>
<td>24.0</td>
<td>0.5</td>
<td>70.6</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>26.0</td>
<td>41.6</td>
<td>14.3</td>
</tr>
<tr>
<td>Fast Pyrolysis</td>
<td>75.7</td>
<td>23.3</td>
<td>0.3</td>
<td>71.3</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>26.2</td>
<td>41.7</td>
<td>14.3</td>
</tr>
<tr>
<td>Gasification</td>
<td>75.9</td>
<td>23.1</td>
<td>0.2</td>
<td>71.5</td>
<td>0.8</td>
<td>0.0</td>
<td>0.0</td>
<td>26.1</td>
<td>41.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Slow Stover</td>
<td>75.5</td>
<td>24.0</td>
<td>0.5</td>
<td>70.6</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>26.0</td>
<td>41.6</td>
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</tr>
</tbody>
</table>

Char Uses
- Combustion
- Fuel
- Power
- Gasification
- Water Purification
- Gas Purification
- Site Remediation
- Soil Amendment
- Carbon Sequestration

Biochar in the Soil
Increases:
- Nutrient Availability
- Carbon Exchange Capacity
- Microbial Activity
- Soil Organic Matter
- Water Retention
- Crop Yields

Decreases:
- Fertilizer Needs
- Greenhouse Gas Emissions
- Nutrient Leaching
- Erosion

Chars Characterized in This Study

Conclusions
- Chars from fast pyrolysis and gasification are physically and chemically different from traditional hardwood charcoals and chars prepared from herbaceous feedstocks by slow pyrolysis. The types of carbon present appear to depend on process temperature and reaction time. None of the chars contained a detectable amount of only partially pyrolyzed biomass.
- Fast pyrolysis and gasification chars should be included in biochar trials. Their wider range of properties and reaction conditions will offer insight on how to engineer desirable biochars. The structural features of fast pyrolysis char, namely the oxygen-containing surface functional groups that make the char more hydrophilic and contribute to its carbon exchange capacity, suggest favorable properties in this application. Co-production of biochar and bioenergy may prove to be a more cost-effective and resource efficient use of biomass crops and crop residues.
- Switchgrass and corn stover chars have high silica ash content and low surface area, and therefore, will present challenges to traditional char applications such as combustion or activation; the best use of switchgrass and corn stover chars may be soil application depending on the economic circumstances and the local soil properties. These chars are significantly alkaline and are therefore most likely best suited for application to acid (low pH) rather than alkaline (high pH) soils.

Acknowledgements
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