Biomass conversion to produce value-added products from agricultural and forestry residues

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Biomass conversion to produce value-added products from agricultural and forestry residues

Mohammad M. Hossain, Ian M. Scott, Mark Sumarah, Ken Conn, Brian D. McGarvey, Franco Berruti, Cedric Briens

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Introduction

High value products from pyrolysis of biomass

• Traditional bubbling fluidized bed reactor:
  – Liquid is mixture of many products
  – Better selectivity is required for high value products

→ Use a batch Mechanically Fluidized Reactor (MFR)
Batch Mechanically Fluidized Reactor
Batch Mechanically Fluidized Reactor
Batch Mechanically Fluidized Reactor

• No need for:
  – Inert fluidization medium (e.g. sand)
  – Fluidization gas

• Can be used for batch pyrolysis:
  – Liquid cuts can be collected for different temperature ranges
Objective

Demonstration of batch MFR to obtain model compounds from plant biomass

Spent coffee ground

Tobacco leaf

Caffeine

Nicotine
Results: Spent coffee ground

Yield of bio-oil

<table>
<thead>
<tr>
<th>Temperature cut, °C</th>
<th>15°C/min</th>
<th>5°C/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient-130</td>
<td></td>
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<tr>
<td>130-180</td>
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<td>180-230</td>
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<tr>
<td>230-280</td>
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<td></td>
</tr>
</tbody>
</table>

15°C/min: Total bio-oil yield=50%

5°C/min: Total bio-oil yield=27%
Results: Spent coffee ground

Yield of caffeine = $\frac{\text{g caffeine in temperature cut}}{\text{g caffeine in biomass}}$

Spent coffee ground extract: 0.75 mg caffeine/g biomass

15°C/min: 96% recovered

5°C/min: 51% recovered
Results: Spent coffee ground

Purity of caffeine (mg caffeine/g bio-oil)

<table>
<thead>
<tr>
<th>Temperature cut, °C</th>
<th>Ambient-130</th>
<th>130-180</th>
<th>180-230</th>
<th>230-280</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg caffeine/g bio-oil</td>
<td>1.5</td>
<td>2.2</td>
<td>1.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>

- 15°C/min
- 5°C/min
Results: Tobacco leaf

Yield of bio-oil

15°C/min:
Total bio-oil yield=41%
Results: Tobacco leaf

Yield of nicotine = g nicotine in temperature cut / g nicotine in biomass

15°C/min: 94% recovery of nicotine
Results: Tobacco leaf

Purity of nicotine (g nicotine/g bio-oil) for different temperature cuts
Conclusions

• A faster heating rate is better to recover thermally sensitive products such as caffeine

• The batch MFR can:
  – Recover most of the compound originally in the biomass
  – Provide a liquid with a high concentration of desired product
Future work

Two dimensional Mechanically Fluidized Reactor (MFR)

Combine batch MFR with fractional condensation
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