Hydrothermal Liquefaction for Processing Municipal Solid Waste without Separation

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1. Municipal Solid Waste specifically plastics pose a grave danger to the environment. Current sustainable technologies like recycling are limited by the need for separation of solid waste.

2. Biomass components of municipal solid waste have been previously broken down to bio-oil using Hydrothermal Liquefaction.[1]

3. Preliminary work from our lab has suggested that plastics as well are converted to oil using Hydrothermal Liquefaction. High yields and heating values (HHV) were obtained.

Hypothesis: Hydrothermal Liquefaction provides a solution for utilizing Municipal Solid Waste to obtain oil and useful other by-products in an economically sustainable manner.

This Study

Municipal Solid Waste Composition[2]

(262 million tons) in 2015

Food 15%

Paper 30%

Yard trimmings 15%

Other vegetation 15%

Wood 6%

Rubber and Leather 3%

Plastic 13%

Goss 3%

Trash 9%

83% of Municipal Solid waste contains carbonaceous components that can be converted to oil using Hydrothermal Liquefaction

Objectives:

• Studying synergistic effects in mixtures of municipal solid waste using model compounds

• Explore the possibility of extracting recyclable components from HTL products[4]

Methods

Model Compounds:

1. Cellulose (Paper, Food)
2. Starch (Food)
3. Soy Protein (Food)
4. Stearic Acid (Food)
5. Polypropylene (Plastic)
6. Polyethylene Terphthalate (Plastic)
7. Polystyrene (Plastic)
8. Polycarbonate (Plastic)

Hydrothermal Liquefaction

• Water

Oil Product

Aqueous Phase

Solid residue

Gas Products

11ml reactor

Sand bath

Extraction set up

Binary mixture extracted

Results and Discussion

<table>
<thead>
<tr>
<th>Waste</th>
<th>Heating value of Oil from HTL (Mg/kg)</th>
<th>Oil Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food waste</td>
<td>35.8</td>
<td>45.3[3]</td>
</tr>
<tr>
<td>Paper</td>
<td>32.3</td>
<td>5.1[1]</td>
</tr>
<tr>
<td>Wood</td>
<td>34.3</td>
<td>27.5[5]</td>
</tr>
<tr>
<td>Plastic waste</td>
<td>41.12</td>
<td>60.1</td>
</tr>
</tbody>
</table>

• Biomass accounts for 60% of total MSW but provides bio-oil that has lower yield and heating values.

• Plastics account for only 13% of total MSW but provides higher yield and HHV values comparable to gasoline

• Better quality of oil produced

• Higher quantity of oil produced

• Reduce the use of catalyst and the need for upgradation

Commercialization

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost ($/gallon)</th>
<th>Commercial Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil from HTL process</td>
<td>4.38 [4]</td>
<td>3</td>
</tr>
<tr>
<td>Commercial Gasoline</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Conclusions

✓ Addition of plastic to biomass increases the net oil yield obtained by 101.67% (experimental vs. calculated) at 300 °C. This is attributed to significant synergistic interactions between plastic and biomass components.

✓ Value addition from the HTL co-products is expected to improve the process’ sustainability and economically viability