Recycling “Paper Sludge” into Useful Carbon Products
A Progress Report

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- Definitions and Lab Operations
- Example Previous Waste Recycling Results
- Results of “Paper Sludge” Recycling
Definitions

“To recycle or not to recycle” – Life Cycle Analysis

Paper products are short-lived consumer materials

Newsprint
- mechanically made; lignin in pulp
- recycling v.s. “waste to energy” difference is small
- recycling reduces deforestation: total energy input reduced

Office paper
- chemically processed; most lignin removed; burning better than recycling; reduces fossil fuel use

Reference: Linda Gaines, MRS Bulletin, April 2012, pg. 333-338
Lab Operations

Determine % organic in “paper sludge”

High Pressure Reactor

“hydrogen” reagent
CO + H$_2$O or HCO$_2$Na
“thermal” paper degradation

Product Type Separation

Filter oil from solids
Solvent extraction
Distillation

Product Identification

Spectroscopy
Example Reactor Product Analysis Data

Input = 200 g. solid waste + 85 g. liquid

Volatiles vented from reactor
wt = 160 g. liquid
BTU/lb. = 18,500 ± 300

(5-30 wt motor oil = ~ 19,000 BTU)

Residue remaining in reactor
Wt. = 120 g.
BTU/lb = 18,000 ± 200

~ 75% gas/diesel HC’s
Reaction Time vs. Yield Data for Sewage Sludge
(Gentry) (Fast Heating and Cooling)

\[ T = 350^\circ \text{C}, \text{ initial CO pressure} = 300 \text{ psig}. \]

<table>
<thead>
<tr>
<th>Reaction Time</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 min.</td>
<td>38.6%</td>
</tr>
<tr>
<td>5 min.</td>
<td>22.2%</td>
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<tr>
<td>15 min.</td>
<td>17.3%</td>
</tr>
</tbody>
</table>

Typical Cracking Experiment Data for Oils from Waste Sludge
(Margosian)

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Temp.</th>
<th>Yield</th>
<th>Trapped Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durabeal 8A</td>
<td>500°C</td>
<td>0%</td>
<td>Same as Feed</td>
</tr>
<tr>
<td>Durabeal 8A</td>
<td>700</td>
<td>5-15%</td>
<td>Benzene, toluene, naphthalene</td>
</tr>
<tr>
<td>Filtrol 110</td>
<td>700</td>
<td>5-10%</td>
<td>Benzene, toluene, naphthalene</td>
</tr>
<tr>
<td>Durabeal 8A</td>
<td>600</td>
<td>55-55%</td>
<td>n-heptane, benzene, toluene</td>
</tr>
<tr>
<td>Durabeal 8A</td>
<td>600</td>
<td>80-85%</td>
<td>n-heptane, benzene, toluene</td>
</tr>
<tr>
<td>Filtrol 110</td>
<td>600</td>
<td>50-55%</td>
<td>n-heptane, benzene, toluène</td>
</tr>
<tr>
<td>Filtrol 110</td>
<td>600</td>
<td>65-70%</td>
<td>n-heptane, benzene, toluene</td>
</tr>
<tr>
<td>Durabeal 8A</td>
<td>600</td>
<td>85-90%</td>
<td>n-heptane, benzene, toluene</td>
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</tbody>
</table>
Current “Paper Sludge Conversion Results

Reactor at 300°C, 1400-1600 psi

100 gm Potsdam Paper Sludge (5 min)

Exp 18 | Weight (g)
---|---
Org Oil | 1.66
Aque | 31.28
Solid | 15.58

60% organic

50 gm Interface Sol’ns Sludge (60 min)

Exp 19 | Weight (g)
---|---
Org Oil | 3.16
Aque | 6.1
Solid | 34.82

30% organic

100 gm Interface Sol’ns Sludge (60 min)

Exp 20 | Weight (g)
---|---
Org Oil | 3.26
Aque | 15.36
Solid | 66.2

30% organic
Infrared Spectral Information