Slow Pyrolysis of Municipal Wastes
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Introduction
- Energy recovery from municipal wastes: Most of combustible materials in wastes are biodegradable (green house gas neutral)
- Energy recovery from wastes after segregation (material recovery) is a key part of energy policy as well as waste management.
- Incineration is dominant in industry but pyrolysis and gasification processes are also available.

Pyrolysis of Municipal Wastes
- Thermal decomposition into char, tar (liquid) and gas at elevated temperatures.
- Pyrolysis for energy conversion from waste/biomass: as a separate process for feedstock production or integrated process with gasification.
- Advantages
  - Storable feedstock (char and liquid) with various industrial purposes including energy recovery.
  - Compact process suitable for small scale applications complementary to incineration.

Research Advantages
- To provide fundamental data on pyrolysis products from key waste materials.
- To assess the use of pyrolysis for a fraction of waste materials that are not economically reused or recycled.

Material Characterisation
- Materials: Cardboard, Waste wood and Textile residues

<table>
<thead>
<tr>
<th>Properties</th>
<th>Waste wood</th>
<th>Cardboard</th>
<th>Textile Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (wt%)</td>
<td>8.9</td>
<td>10.8</td>
<td>12.2</td>
</tr>
<tr>
<td>Volatile matter (wt%)</td>
<td>71.7</td>
<td>76.0</td>
<td>78.0</td>
</tr>
<tr>
<td>Fixed carbon (wt%)</td>
<td>18.5</td>
<td>12.0</td>
<td>11.8</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.9</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Carbon (wt%)</td>
<td>44.0</td>
<td>41.7</td>
<td>43.3</td>
</tr>
<tr>
<td>Oxygen (wt%)</td>
<td>6.7</td>
<td>6.4</td>
<td>6.2</td>
</tr>
<tr>
<td>Hydrogen (wt%)</td>
<td>38.6</td>
<td>35.5</td>
<td>34.4</td>
</tr>
<tr>
<td>Gross calorific value (MJ/kg)</td>
<td>18.0</td>
<td>15.7</td>
<td>14.6</td>
</tr>
<tr>
<td>Van Krevelen diagram of char (C/H/O)</td>
<td>Van Krevelendiagram of char</td>
<td>Van Krevelendiagram of char</td>
<td>Van Krevelendiagram of char</td>
</tr>
<tr>
<td>Particle size and shape</td>
<td>20mm cubic</td>
<td>5x2x0.2mm</td>
<td>3x0.15mm</td>
</tr>
<tr>
<td>Bulk density of bed (kg/m³)</td>
<td>308</td>
<td>76</td>
<td>90</td>
</tr>
</tbody>
</table>

Experimental Methods
- Pyrolysis Reactor
  - Stainless steel reactor (ID 125mm x H 500mm) seated in a heated electrical furnace.
  - Provides more practical data, compared to tests with a very small amount of sample such as TGA.

Pyrolysis Conditions
- Final temperature: 350-700°C
- Heating rate: 10°C/min
- Nitrogen: 2 l/min
- Initial sample weight: ~200g
- 1hr at the final temperature

Characterisation of Products
- Standard fuel analyses (proximate, ultimate and calorific value) for raw material, char, liquids.
- Gas composition: CO/CO₂/O₂ analyser, GC-MS
- Char composition: Char: over 30MJ/kg-daf due to high carbon content.
- Liquid: 10-13 MJ/kg (containing large amount of water)
- Gas: typically 17 MJ/m³-dry for pyrolysis temperature of 700°C
- Calorific Value of Pyrolysis Products
- Van Krevelen diagram of char

Experimental Results: Pyrolysis Products
- Product Yield: approximately equal mass yields for each product
  - Char yield gradually decreases as pyrolysis temperature increases.
  - Liquid yield drops by effect of thermal cracking at high temperatures over 600°C.
  - Gas yield gradually increases as pyrolysis temperature increases.

Conclusions
- Pyrolysis for segregation residues can be a viable way of energy conversion complementary to incineration.
- Char from segregation residues having low ash contents is a good quality fuel for energy recovery.
- Liquids can be transported to and converted to energy in large-scale power plants.
- Gas can be directly consumed in order to provide energy required for pyrolysis.
- No significant benefits for pyrolysis at over 500°C

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More Information on SUWIC can be found at our websites: http://www.suwic.group.shef.ac.uk/