Carbon and nitrogen recovery by hydrothermal oxidation

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Hydrothermal oxidation

Biodegradation efficiency is low:
Proteolysis: 70%;
Fiber: 44%.

Fermenter

- Wastes 100%
- Filtrate 35-44%
- Gas 3-15%
- Sludge 25-40%
- MEC*
- CO₂

Carbon distribution

*MEC: Microbial electrolysis cell
Hydrothermal oxidation

<table>
<thead>
<tr>
<th>Filtrate</th>
<th>VFAs, soluble nitrogen, and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-44%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sludge</th>
<th>Cellulose, xylan, lignin, insoluble nitrogen, VFAs, and others.</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-40%</td>
<td></td>
</tr>
</tbody>
</table>

Continuous reactor → Batch reactor
### Continuous Reactor

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Residence time (s)</th>
<th>OER*</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>48, 58, 68</td>
<td>1</td>
</tr>
<tr>
<td>340</td>
<td>38, 48, 58</td>
<td>1.5</td>
</tr>
<tr>
<td>360</td>
<td>38, 48, 58</td>
<td>2</td>
</tr>
<tr>
<td>380</td>
<td>28, 38, 48</td>
<td>3</td>
</tr>
</tbody>
</table>

*Oxygen equivalence ratio

### Batch Reactor

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Residence time (s)</th>
<th>OER*</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>400</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>450</td>
<td>300</td>
<td>1.5</td>
</tr>
<tr>
<td>500</td>
<td>600</td>
<td>2</td>
</tr>
</tbody>
</table>
Sample analysis:

**Gas samples:**
- ◊ Micro-GC

**Liquid effluent:**
- ◊ TOC analyzer
- ◊ Elemental analyzer
- ◊ NANOCOLOR® kits
  - (ammonia, nitrite, nitrate)
- ◊ GC-MS
- ◊ GC-FID
  - (VFAs)
RESULTS – CARBON DISTRIBUTION

Total C input

*Carbon distribution*

- **Sludge**: 97.1% to CO2
- **Filtrate**: 68.2% to CO2

Acetic acid is the main residual for both feed.
Almost all converted into CO2, few cases with ethylene < 0.03 vol%
No solids produced.
Volatile fatty acids are main residuals for both feed, and acetic acid is one of the main compound.
RESULTS – NITROGEN DISTRIBUTION

Nitrogen

<table>
<thead>
<tr>
<th>Sludge</th>
<th>Organic nitrogen*</th>
<th>Ammonium</th>
</tr>
</thead>
<tbody>
<tr>
<td>898 mg/L</td>
<td>88.7 wt.%</td>
<td>11.3 wt.%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filtrate</th>
<th>Organic nitrogen*</th>
<th>Ammonium</th>
<th>Nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>246 mg/L</td>
<td>41 wt.%</td>
<td>59 wt.%</td>
<td>0.04 wt.%</td>
</tr>
</tbody>
</table>

898 mg/L     246 mg/L
Ammonia 35,2%  LOST N 63,6%
Nitrogen distribution

Low temperature

Ammonia
Nitrate
Nitrite

High temperature

N₂
NOx
CONCLUSION

– Temperature, residence time and OER all have positive correlation on carbon conversion.

– Nitrogen distribution varies with temperature. Temperature have to be precisely controlled to avoid conversion of nitrogen to gas phase.

– 400 °C, OER=2, >1MIN could be one of the optimized conditions for carbon and nitrogen recovery.
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