A life cycle analysis on Bio-DME synthesis system considering biomass materials

Masashi Higo (E-mail: j7408625@ed.noda.tus.ac.jp), Kiyoshi Dowaki
Tokyo University of Science, Faculty of Science and Engineering, Department of Industrial Administration

1. Objective

This study focuses on Bio-DME (Biomass Di-methyl Ether) which is BTL (Biomass To Liquid). We executed process design of the Bio-DME production system. Especially, in order to estimate the variation of wood materials, seventeen species in Japan and Papua New Guinea (PNG) are selected.

- To investigate the differences of specific CO₂ emissions with variation of the materials, their moisture content, and transportation distances.
- To estimate energy intensities and specific CO₂ emissions, due to Bio-DME production performances and CO₂ inventories based on LCA methodology.

2. Wood Materials

<table>
<thead>
<tr>
<th>JAPAN</th>
<th>PNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. densiflora</td>
<td>C. japonica</td>
</tr>
<tr>
<td>C. mangium</td>
<td>C. equisetifolia</td>
</tr>
<tr>
<td>C. oligodon</td>
<td>E. deglupta</td>
</tr>
<tr>
<td>E. grandis</td>
<td>L. leucocephala</td>
</tr>
<tr>
<td>P. falcataria</td>
<td>P. aduncum</td>
</tr>
<tr>
<td>E. robusta</td>
<td></td>
</tr>
</tbody>
</table>

3. Process Design

- Ultimate analyses
- Gaseous yields in pyrolysis
- Reaction rate of char gasification

\[
\begin{align*}
   & C + H_2O \rightarrow CO + H_2 \\
   & C + CO_2 \rightarrow 2CO
\end{align*}
\]

4. Bio-DME LCA

- Pre-Processing
  - Transportation process
    - Transportation distance
      - JAPAN: 5°150km, PNG: 0°2.5km
    - Drying process
      - Initial moisture content: 20°~50%
- Energy Conversion Process
  - Gasification process
    - Liquefaction process
      - Oxidation agent: Air, Oxygen
      - Plant scale: 50 t/d (dry-base), operating time: 7200hr/yr
      - Synthesis condition: 240°C, 3MPa
- Fuel Transportation Process
  - Fuel transportation distance: JAPAN: 100km, PNG: 4,765km (one-way trip)

5. Results

- Production Efficiency
- Production Rate
- CO₂ emissions
  - JAPAN Case (17.8°~50.8g CO₂/MJ)
  - PNG Case (12.2°~56.7g CO₂/MJ)
- Uncertainty effect
  - Transportation distance (feed collection)
- Materials condition (moisture content)

6. Discussions

It is important to propose the appropriate materials for CO₂ emissions mitigation, and for Bio-DME production yield.

- CO₂ emissions regression on the specific CO₂ emission and the production yield of Bio-DME were estimated, base on analysis results.
  - JAPAN Case
    - Y_{DME} = 0.017Mat_{in} - 3.30Cont_{H} + 0.19
    - CO₂ = 142.27Y_{DME} - 17.7Mat_{in} + 72.1
    - CO₂ = 94.83Y_{DME} + 0.06
  - PNG Case
    - Y_{DME} = 0.021Mat_{in} - 1.33Cont_{H}
    - CO₂ = 105.76Y_{DME} + 50.2
    - CO₂ = 73.09Y_{DME}

7. Conclusions

- We analyzed the differences of the seventeen species for their performances and the specific CO₂ emissions in the Bio-DME production system.
- If the heating value, the hydrogen contents and the bulk densities of feeds are provided, the Bio-DME production yields and the CO₂ emissions would be able to be predicted.