CHEMICAL PROCESSING OF NON-CROP PLANTS FOR JET FUEL BLENDS PRODUCTION

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The use of Biofuels has been gaining in popularity over the past few years due to their ability to reduce the dependence on fossil fuels. Biofuels as a renewable energy source can be a viable option for sustaining long-term energy needs if they are managed efficiently.

We describe our initial efforts to exploit algae, halophytes and other non-crop plants to produce synthetics for fuel blends that can potentially be used as fuels for aviation and non-aerospace applications. Our efforts have been dedicated to crafting efficient extraction and refining processes in order to extract constituents from the plant material with the ultimate goal of determining the feasibility of producing biomass-based jet fuel from the refined extract. Two extraction methods have been developed based on comminution processes, and liquid-solid extraction techniques. Refining procedures such as chlorophyll removal and transesterification of triglycerides have been performed. Gas chromatography in tandem with mass spectroscopy is currently being utilized in order to qualitatively determine the individual components of the refined extract. We also briefly discuss and compare alternative methods to extract fuel-blending agents from alternative biofuels sources.

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Objective

- To determine the feasibility of producing jet fuel (C8-C16) from biomass (oils)
Manufacturing of Fuel

- Transesterification
  - Crude Methyl Esters
    - Fractionation distillation
    - Hydrogenation
  - Glycerine
- Hydrolysis
  - Glycerine
  - Esterification
    - Fractionation distillation
    - Hydrogenation
- Hydrogenation
  - Fractionation distillation
- Fuel
Manufacturing of Fuel

- Transesterification
  - Crude
  - Methyl Esters
- Hydrolysis
- Esterification
- Fractionation distillation
- Hydrogenation

- Oil
- Glycerine
- Fuel

- Hydrogenation
- Fractionation distillation
- Glycerine
Advantages of Methyl Esters

- Lower energy consumption
- Less expensive equipment
- Easier to distill-fractionate
- GC Analysis
Transesterification

\[
\begin{align*}
\text{Glyceride} & \quad + \quad \text{Alcohol} \\
& \quad \text{Catalyst} \\
\text{Esters} & \quad + \quad \text{Glycerol}
\end{align*}
\]
Methyl Ester from Vegetable Oils

- Canola Oil – large quantity of monounsaturated fatty acid chains
- Safflower Oil – large quantity of polyunsaturated fatty acid chains
- Coconut Oil – mostly unsaturated
Gas Chromatography of Biodiesel (Canola)

- Glycerol
- ISTD1
- Triglycerides
- Diglycerides
- Mono-glycerides
- ISTD2
Gas Chromatography of Biodiesel (Safflower)

- Glycerol
- ISTD1
- ISTD2
- Diglycerides
- Mono-glycerides
- Triglycerides
GC/MS Biodiesel (Canola)

C16:0

C18:0

C18:1

NL: 2.94E6
TIC MS data01_canola
GC/MS Biodiesel (Safflower)

RT: 15.00 - 23.00

C16:0
C18:1
C18:0
C18:2

Relative Abundance

Time (min)
GC/MS Biodiesel (Coconut)

- RT: 4.80 - 24.64
- C10:0
- C12:0
- C14:0
- C16:0
- C18:0
- C18:1
Research

- Feedstock – Halophytes and Algae
- Catalyst – future investigations
- Protocols – optimizing methods
## Methods

<table>
<thead>
<tr>
<th>Method 1</th>
<th>Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing</td>
<td>Freezing/Drying</td>
</tr>
<tr>
<td>Comminution</td>
<td>Comminution/Extraction</td>
</tr>
<tr>
<td>Drying (dry weight)</td>
<td>Filtration</td>
</tr>
<tr>
<td>Extraction (soxlet)</td>
<td>Drying</td>
</tr>
<tr>
<td>Drying</td>
<td></td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Plant Material</th>
<th>% Extracted</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sinapis</em> (Mustard Plant)</td>
<td>15.78</td>
<td>Hexanes</td>
</tr>
<tr>
<td>Tank Algae (unknown species)</td>
<td>8.56</td>
<td>Hexanes</td>
</tr>
<tr>
<td><em>Salicornia bigelovii europea</em></td>
<td>3.48</td>
<td>Isopropanol/Hexanes</td>
</tr>
<tr>
<td><em>Salicornia bigelovii europea</em> (germinating)</td>
<td>7.03</td>
<td>Isopropanol/Hexanes</td>
</tr>
</tbody>
</table>
Extracted and Non-Extracted Material
Chlorophyll Removal

- Dissolve in low molecular weight alcohols/water
- Column packed with bleaching clay
- Treatment with mineral acids
Transesterification

\[
\begin{align*}
\text{Glyceride} & \quad \text{Alcohol} \quad \text{Catalyst} \\
\text{CH}_2\text{O} - \text{C} - \text{R} & \quad + \quad \text{CH}_3\text{OH} \\
\text{CH}_2\text{O} - \text{C} - \text{R} & \quad \xrightarrow{\text{H}^+} \quad 3\text{CH}_2\text{O} - \text{C} - \text{R} \\
\text{CH}_2\text{OH} & \quad \text{CH}_3\text{OH} \quad \text{Glycerol}
\end{align*}
\]
Summary

- Conversion of vegetable oils into methyl ester
- Conversion methyl ester into jet fuel
- Extraction of lipids from halophytes and algae