Green Biodiesel
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Overview

- Biodiesel and its importance
- Comparison of biodiesel production processes
- Current and future research
Biodiesel Production

Source: European Biodiesel Board, National Biodiesel Board
US Biodiesel Production

In Millions of Gallons

*Projected estimate
Source: National Biodiesel Board estimates
Vegetable Oil Feedstocks

- Corn
- Soy
- Palm
- Cottonseed
- Canola
- Jatropha
- Algae
Biodiesel Chemistry

\[
\begin{align*}
\text{R-COOCCH}_2 + 3 \text{CH}_3\text{OH} & \xrightarrow{\text{catalyst}} 3 \text{R-COOCH}_3 + \text{CH}_2\text{OH} \\
\text{R-COOCCH}_2 + \text{CH}_2\text{OH}
\end{align*}
\]

Transesterification Reaction

- Veg. oil (fatty acids) + m(ethanol) > glycerol + biodiesel
- Reactants immiscible – reaction at interface
- Liquid catalyst versus solid catalyst
- Low pressure/temperature versus high press/ temp
Conventional Biodiesel Process

- Methanol
- Oils & Fats (multi-feedstock)
- Catalyst
- Pretreatment (optional)
- Transesterification
- Purification
- Methyl Esters (biodiesel)
- Glycerin
- Wastewater
Green Biodiesel Continuous Process Using Solid Catalysts

- Feedstocks (High and Low free fatty acid content)
- Ethanol
- Continuous Transesterification Process
  - Solid Metal Oxide Catalyst
  - High Quality Biodiesel
  - High Quality Glycerol
## Conventional vs. Green Comparison

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Green</th>
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<tbody>
<tr>
<td><strong>Process Type</strong></td>
<td>Batch</td>
<td>Continuous</td>
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<tr>
<td><strong>Catalyst Life</strong></td>
<td>Short (consumed)</td>
<td>Long</td>
</tr>
<tr>
<td><strong>Conversion Time</strong></td>
<td>100 minutes</td>
<td>10-20 minutes</td>
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<td><strong>Impurities (ASTM)</strong></td>
<td>Catalyst, soap, water, glycerol, glycerides</td>
<td>Glycerol, glycerides</td>
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<tr>
<td><strong>Pretreatment of Fatty Acid (waste oils)</strong></td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td><strong>Catalyst Mixing Unit</strong></td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td><strong>Distillation of Glycerol</strong></td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td><strong>Washing &amp; Wastewater</strong></td>
<td>Y</td>
<td>N</td>
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Continuous Packed-Bed Reactor

Schematic Diagram of Lab-Scale Reactor
Packed-Bed Reactor Results

![Graph showing biodiesel conversion (%)](image)

- **Biodiesel Conversion (%)**
- **Residence time (min)**

- TiO
- CaTiO₃
- MnO (20-35 mesh)
- MnO (+200 mesh)
- CaCO₃
Studies

- Rate Constant and Residence Time analysis of catalysts
- Longevity of Catalysts, Regeneration
- Feedstock impacts on product
- Catalytic hydration and hydrogenation
Full Scale Process Diagram

Major Equipment
1. Condenser (large flowrate)
2. Heat Exchanger (small flowrate)
3. Supercritical Fluid Reactor
4. Flash Drum
5. Liquid-Liquid Separator

ETHANOL

ETHANOL RECYCLE

VEGETABLE OIL

BIOETHANOL

BIOGAS

GLYCERINE

BIONITROGEN

BIOBENZIN

BIOETHANOL

BIOFUEL
Research and Development Timeline

- Test Catalysts and Reactor Conditions using Bench-scale reactor (4/07 - 10/07)
- Design of Commercial Reactor and Pilot Production Facility (6/07 - 1/08)
- Construction of Pilot Production Facility (3/08)
Summary

- Process accepts all feedstocks w/o pretreatment, producing no wastewater,
- **Pilot plant** planned for 2008
- Patent Applied For: June, 2007
- **Partners** to commercialize
INNOVATE

OR DIE!

A Personal Perspective on the Art of Innovation

Jack V. Matson