SENIOR CAPSTONE/ SENIOR DESIGN EXPERIENCE 2024

SOY-BASED BIODIESEL MANUFACTURING

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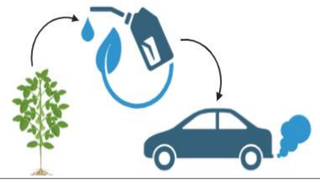
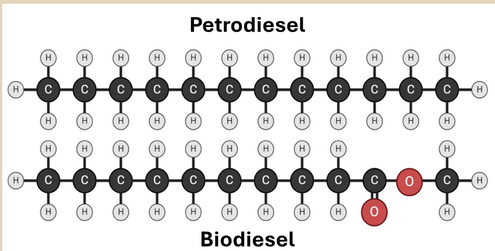
Objective

Formulate a production process or mechanism that will provide renewable energy sources for existing diesel engines to respond to the increasing impact of climate change, air pollution, and a rapidly diminishing supply of fossil fuels.

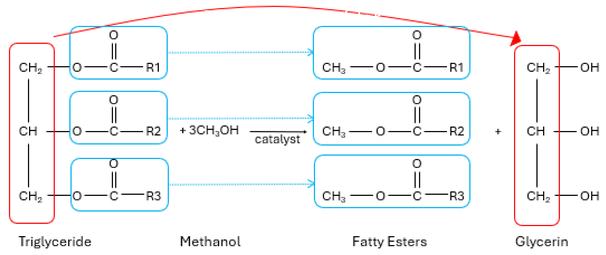


Biodiesel Background

- Biodiesel is synthesized via transesterification, where an alcohol, catalyzed by a strong base or acid, cleaves each fatty ester group from a triglyceride, resulting in biodiesel and leaving the glycerin backbone
- U.S. diesel-powered vehicles comprise 1.8% of personal vehicles or 2 million households.
- U.S. average gasoline usage is 422 gallons per year, opening a vast market for alternative liquid fuels as fossil fuels dwindle.

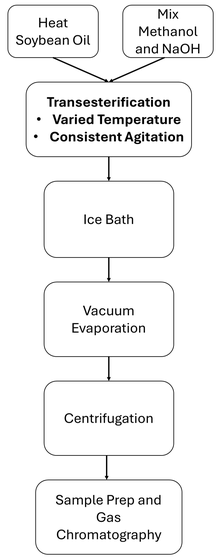


Comparison of Chemical Structure between Petrodiesel and Biodiesel



Chemical Mechanism of Transesterification

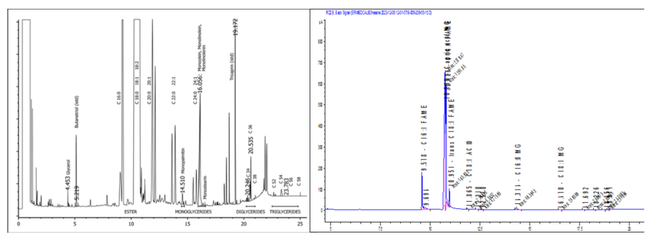
Experimental Results and Product Refocusing



- Small-scale biodiesel production used to analyze different transesterification temperatures (45°C and 55 °C)
- No significant difference in conversion, which is inconsistent with the literature
- Likely due to continued reaction

Mechanism and Build Complexity Beyond Scope

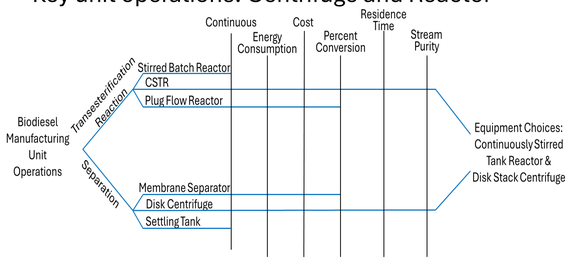
~~Small Scale Automated Biodiesel Reactor~~
Commercial Biodiesel Manufacturing



Comparison of ASTM Chromatograph for biodiesel quality with soy-based laboratory-formulated biodiesel

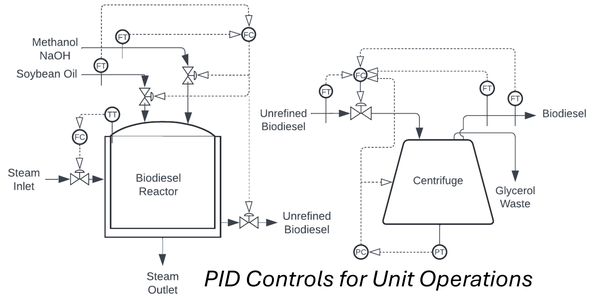
Biodiesel Process Design

- Continuous production rate of 10,000 gal/hr producing 80M gal/year (5% of US consumption)
- Key unit operations: Centrifuge and Reactor

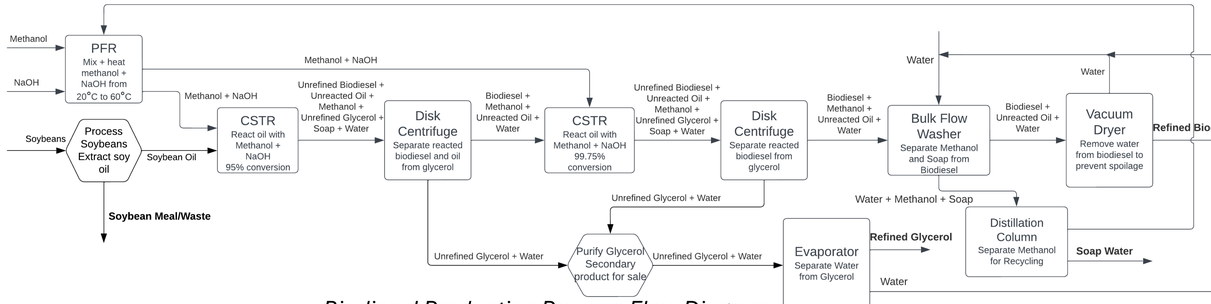


Morphological Analysis for Unit Operation Machine Choice

- CSTR: 2-stage design operated at 60 °C
  - Each stage achieving 95% conversion
- Disk Stack Centrifuge: nozzle discharge for high throughput
  - Immediately following CSTR to limit reverse reaction
- Process optimization modeled in MATLAB to choose equipment size and calculate mass balances through the chemical reaction
- Process controls implemented on CSTR and Centrifuge monitor and adjust flow rate for efficiency and pressure for safety



PID Controls for Unit Operations



Biodiesel Production Process Flow Diagram

Business Plan

Annual Biodiesel Production (gal)	80,000,000
Annual Operating Hours (hr)	8000
Percent of Market Consumption	5 %
Purchased Equipment	$935,700
Total Capital Investment	$5,548,700
Equipment Salvage Value	$416,152
Material Cost ($/gal product)	$3.99
Labor Cost ($/gal product)	$0.04
Breakeven Sell Point ($/gal)	**$4.92**

Our Production: 5%
Main Competitor (REM): 27%
Remaining Market

Future Work

Re-Examine Original Topic
- Investigate small-scale automated biodiesel reactors for individual home use.

Sustainability
- Roof solar panels
- Circular economy recycling of thermal energy

Value-Added Product Processing
- Purify glycerol and soap waste streams for re-sale

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