Freshman Mini Project
Biofuel Process & Sustainability

Biofuels Synthesis from Waste Cooking Oil

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Biofuels Process & Sustainability

Biodiesel Synthesis from Waste Cooking Oil & Use of Glycerol By-product for Soap Production
Motivation

Expose freshman students to the latest changes in society

Respond to our reliance on non-renewable fossil fuels that have rapidly depleted, causing negative impacts on our environment
Objective:
To learn two very important aspects in **Bioeconomy**:
1) the production of biofuels and
2) the sustainability issues related to how biofuels are produced and utilized
Chemistry Behind Biodiesel Synthesis

- Molecular weight calculation of oil
- Basis for mass balance calculations
- Organic chemistry
- Catalyzed reaction (Sodium methoxide)

Pictorial representation of transesterification reaction of WCO (triglyceride) into biodiesel.

Transesterification of triglycerides to form biodiesel
Mass Balance

Compare Theoretical vs. Experimental Mass Balance

Mass Input:
- Waste Cooking Oil: 200g
- Methanol: 55mL
- NaOH catalyst: 2.0g

Process Conditions:
- Heat to 65°C
- Stirring rate: 450 rpm
- Reaction time: 60 min

Energy

Transesterified product (biodiesel + glycerin)

Methyl Ester Output
- Total mass: ___ g
- Composition (wt%)
  - Methyl Ester
  - Methanol
  - Soap
  - Catalyst
  - Water

Glycerol Output
- Total mass: ___ g
- Composition (wt%)
  - Glycerol
  - Methanol
  - Soap
  - Catalyst
  - Water

Ignite Change. Go Nova.

Villanova University
Energy Balance

Evaluate process energy efficiency

\[ \eta = \frac{\text{Energy required by process}}{\text{Energy supplied for process}} \times 100\% \]

Reaction process conditions:
- Reaction temperature: 65°C
- Reaction time: 60 mins (after 65°C is reached)
- Stirring speed: 450 rpm

Watt meter for power usage measurement

Infrared thermometer for temperature measurement
Energy Transfer

Evaluate process quality through experimental data analysis

Temperature (°C) and Energy Usage (kJ) Profiles
during Biodiesel Synthesis vs. Time (min)

Transient State Analysis

\[ Q = m \cdot C_p \cdot \Delta T \]

Where:
- \( Q \) Heat required in Joules
- \( m \) Mass in grams
- \( C_p \) Specific heat in Joules/gram
- \( \Delta T \) Final temperature – initial temperature in °C

Heat Loss by Convection

\[ Q_{convection} = h \cdot A \cdot \Delta T \]

where:
- \( Q \) Heat loss in Joules
- \( h \) Heat transfer coefficient \( \left( \frac{J}{S \cdot m^2 \cdot ^\circ C} \right) \) or \( \left( \frac{W}{m^2 \cdot K} \right) \)
- \( A \) Surface area of heat being transferred
- \( \Delta T \) Surface temperature – environment temperature in °C
Experiments

Biodiesel synthesis setup

Titration setup
Experiments

Mass balance setup

Soap production setup
Learned Skills: Technical & Non-Technical

- Mathematics i.e. understanding the use of mathematical correlations to explain engineering concepts
- Biofuels synthesis - chemistry
- Concept of mass and energy balances
- Concept of heat transfer
- Concept of sustainability
- Data collection and analysis
- Technical report writing

- Teamwork – conflict resolution, communication, delegating responsibilities
- Project & time management
- Leadership
- People skills
- Oral presentation skills
Student-run Villanova Biodiesel Program

- Biodiesel processing facility in ChE Dept., 3200 gallons WCO capacity
- 6000 gallons waste cooking oil (WCO) from VU Services every year!
- Biodiesel used by Villanova Facility Services
- Program to be run as a business enterprise
- Learn technical, business/entrepreneurial aspects in processing WCO to marketable products.
- Program seeking more student participations
Questions? Contact:

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WE WANT YOU!