



CAL POLY POMONA

Welcome to California State Polytechnic University, Pomona!

Green Technologies: Biodiesel Challenge

Safety Note: This challenge involves the use of some chemicals that could potentially be dangerous including potassium hydroxide and methanol. At all times during this challenge when handling these chemicals you should be wearing proper safety equipment including goggles and gloves. If you have questions regarding any safety precautions or hazardous materials do not hesitate to ask. Several faculty and staff from the Chemistry Department and Lyle Center will be present at ALL times. It is better to ask a question rather than risk placing your team in a dangerous situation.

Biodiesel Challenge:

In this challenge each team will work to produce Biodiesel fuel from two sources including Corn Oil and Sunflower Oil.

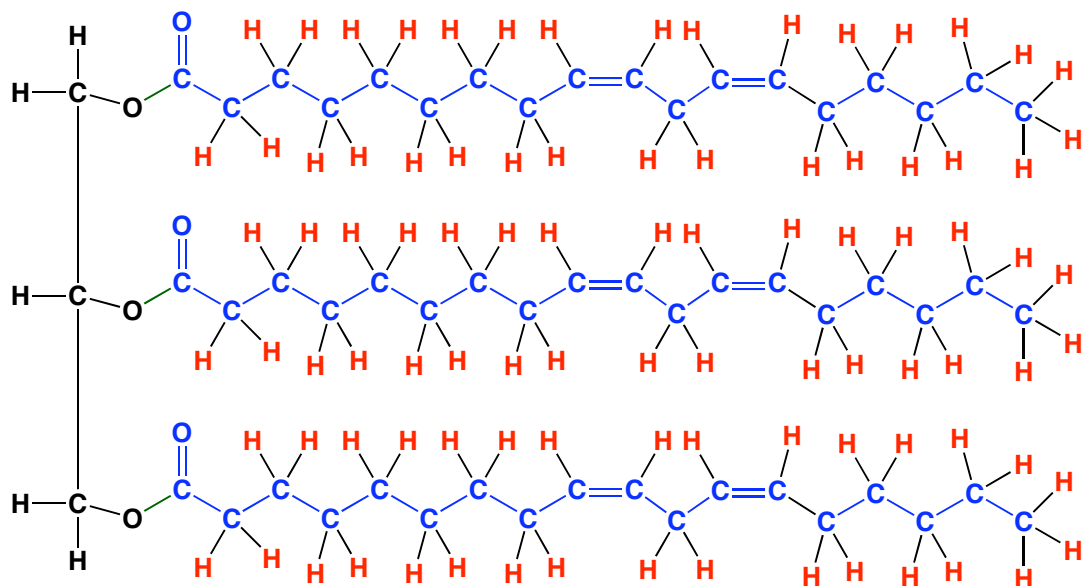
Your team will be judged based on the following criteria:

- a. Each team will be given 400 mL of corn oil, 200 mL of Methanol, and 2.6 grams of potassium hydroxide catalyst. Your team must work collaboratively to convert this oil to Biodiesel using a catalyst in a 3 hour time period. (During the conversion of oil to Biodiesel several separations and purifications must take place.)
- b. At the end of the 3-hour period, your teams will combine the Corn Biodiesel samples and the fuel will be dried to remove excess water that is used during the purifying process. The team will compare which group produced the largest amount of fuel.
- c. A small sample of your fuel will be used to analyze the overall purity of your fuel.
- d. Your team's purified Biodiesel from Corn Oil will be used to start a small diesel engine.
- e. All team members must be wearing safety materials during the Biodiesel synthesis and purification.
- f. The challenge will conclude with your team discussing and presenting the benefits, challenges, and obstacles facing the Biodiesel industry

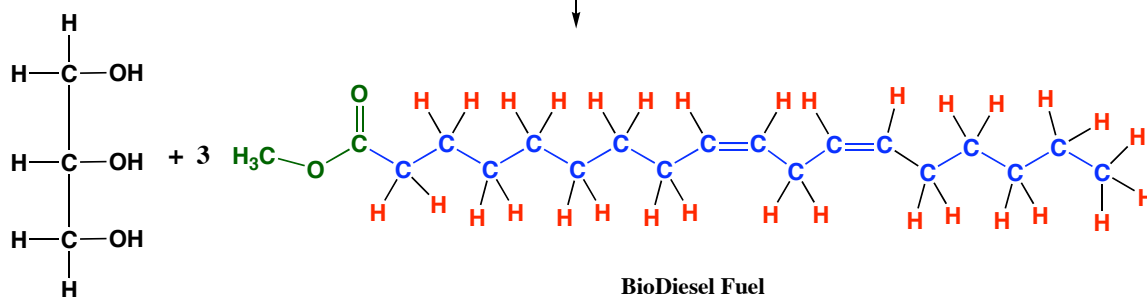
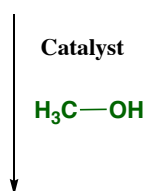
It would be a good idea to research:

- ✓ What is Diesel fuel and how it affects our environment when it is burned. (Including Density and Boiling Point)
- ✓ Definition of Biodiesel (including Density and Boiling Point)
- ✓ How is Biodiesel made and what are the byproducts produced during the chemical reaction? (density, appearance, and amounts of these byproducts)
- ✓ The advantages and disadvantages of using Land-based and Algae oils as an alternative fuel source.
- ✓ Impacts on global resources of using Biodiesel (Land-based or Algae) as an alternative fuel source.
- ✓ How is Biodiesel being utilized in the Inland Empire?
- ✓ What are the advantages of running a vehicle on a blend of regular petrodiesel and Biodiesel?

Background:



Triglyceride from Lipids in Oil



BioDiesel Fuel

Glycerol

General structure of Biodiesel

Triglycerides from algae and food sources such as olive, corn, and canola oils have similar structures. These compounds make up most of fats digested by humans. Triglycerides are formed from a single molecule of glycerol, combined with three fatty acids on each of the OH groups. Chain lengths of the fatty acids in naturally occurring triglycerides can be of varying lengths but 16, 18 and 20 carbons are the most common. Natural fatty acids found in plants and animals are typically composed only of even numbers of carbon atoms due to the way they are synthesized in the body.

Diesel Engines

The idea of using vegetable oil as a fuel source is as almost as old as the internal combustion engine itself. Rudolf Diesel presented the invention of a Diesel engine at the 1900 World's Fair in Paris. This engine ran exclusively on peanut oil. The diesel engine was eventually marketed to farmers who could grow their own fuel to power the engine. Later, in 1912, Rudolf Diesel commented to the Institution of Mechanical Engineers (of Great Britain): "One cannot predict what part these oils will play in the Colonies of the future. In any case, they make it certain that motor-power can still be produced from the heat of the sun, which is always available for agricultural purposes, even when all our natural stores of solid and liquid fuels are exhausted."

Using chemistry, in this challenge, triglycerides of canola oil and algae oil can be converted to Biodiesel that can power diesel engines in tractors, trucks, planes, and even trains. This is because the carbon chain lengths of Biodiesel (16-20 carbons) are very similar to that of regular diesel fuel (12-20 carbons). In this challenge you will convert the triglyceride of a regenerative source to fuel. Biodiesel is a methyl ester of the free fatty acids of a triglyceride or FAMES (Free Fatty Acid Methyl Esters). [shown above] The most common Biodiesel fuels are made from rapeseed or soy oil due to their low cost, availability, and efficiency.

Emissions:

Diesel (petrodiesel) that can be purchased from major gas stations comes from the oil of fossils that are found in the ground (fossil fuels). Petrodiesel is very similar to gasoline that powers the motors in most small cars. The main difference between these two types of fuels is the boiling point and the number of carbons in the fuel. Gasoline has a boiling point of 70 °C and contains a chain of 5-12 carbons (average of 8 carbons long). Petrodiesel is a much heavier oil that has a higher boiling point (150 °C) and contains a longer chain of 12-20 carbons (average of 16 carbons).

By comparison Biodiesel is a non-fossil fuel, cleaner burning alternative to petrodiesel. This is because triglycerides lack nitrogen and sulfur atoms that are often found in fossils that produce crude oil. When emitted in petrodiesel, the nitrogen atoms bind with oxygen to make nitrogen oxides (NO_x). These nitrogen oxides lead to surface-level smog that affects the quality of the air is inhaled. When sulfur is emitted as petrodiesel is burned in an engine, the sulfur atoms binds with oxygen atoms to make sulfur oxides (SO_x) that can lead to acid rain. The use of Biodiesel eliminates these particular harmful emissions. Diesel engines can be powered with 100% Biodiesel (B100) or even a mixture of Biodiesel and petrodiesel. B80 = (Fuel mixture containing 80% Biodiesel, 20% Petrodiesel) B50 = (Fuel Mixture containing 50% Biodiesel and 50% petrodiesel) In Orange County, at University of California, Irvine, a campus shuttle runs on B100 (100% Biodiesel). Many local campuses and companies that have large fleets of

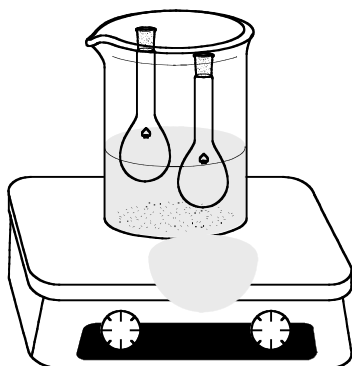
vehicles have also started investigating running their diesel engines on B20. Most importantly, even a small amount of Biodiesel in the blend of fuel with petrodiesel reduces the harmful emissions up to 50% in some cases. This causes the engines to burn cleaner sustainable fuels and even extends the lifetime of the engine due to the superior lubrication of Biodiesel compared with petrodiesel.

Conversion of Corn Oil to Biodiesel:

Part A: Catalyst Solution

1. Make detailed observations at each step of the procedure
2. Be sure you are wearing your lab goggles and gloves
3. Make detailed observations at each step of the procedure
4. Carefully add solid potassium hydroxide to a clean plastic bottle (This is a strong base be careful)
5. Label the bottle catalyst with a marker
6. Slowly add methanol to the catalyst bottle (Methanol is flammable at high temperatures)
7. Cap the bottle and gentle swirl the mixture to dissolve the solids
8. Slowly and carefully vent the bottle every 20 seconds
9. Close the cap and continue to swirl the mixture until all the solids have dissolved. Remember to vent the bottle every 20 seconds to release any pressure that may have accumulated in the bottle. (Be careful the bottle may heat up as the solids dissolve)

Part B Chemical Transformation



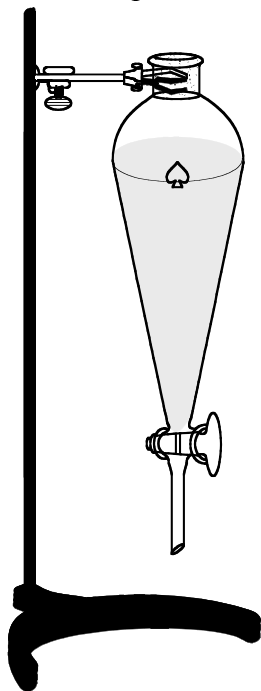
1. Make detailed observations at each step of the procedure
2. Be sure you are wearing your lab goggles and gloves
3. Measure 20 mL of Corn Oil in a conical tube
4. Add 10 mL of catalyst (methanol and potassium hydroxide) to the conical tube of oil.
5. Cap the conical tube
6. Shake the reaction tube for 20-30 seconds
7. Place the mixture in a hot water bath around 60 °C

[Note: You do not want the water to be boiling! The boiling point of water is 100 °C.]

8. Remove the tube from the water bath and **slowly and carefully unscrew** the lid of the tube to vent the system (**Careful the methanol could have become pressurized**)
9. After venting the system for a few seconds recap the tube
10. Repeat steps 5-9 until two layers form while the tube is resting in the hot water bath

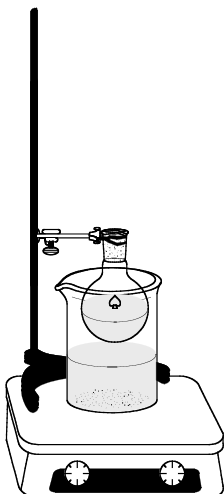
11. Once you determine the reaction has completed, pour the contents of your reaction tube into a 500 mL separatory funnel that is securely resting in a ring stand and has the drain valve the closed position.
12. Allow the reaction to rest and the layers to separate
13. If you have more starting Corn oil you can reuse the conical tube to begin another Corn Biodiesel transformation.

Part C: Separation and Purification (in a 500 mL separatory funnel)



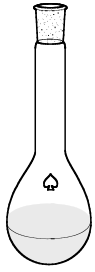
1. Once you have added the mixture to the funnel from Part A. Allow the layers to completely separate (What do you think are in these two layers?)
2. The byproducts can be drained into a clean plastic bottle (Label the bottle) (**Black sharpie Markers**)
3. Gently Spay the Biodiesel that is in the 500 mL separatory funnel with water
4. Allow the two layers to separate completely (Be patient) (Why are you doing this?)
5. Drain the water from the separatory funnel into a clean plastic bottle (Label the bottle)
6. Repeat this water washing procedure (steps 3-5) until the water layer is clear and no longer cloudy. (This will help increase the purity of your fuel)
7. Drain the Biodiesel into a clean bottle (Label the bottle)

Part D Drying Corn Biodiesel



1. With the help of Joelle Opotowsky or Dr. Page, transfer the Biodiesel to a 500 mL round bottom flask with a magnetic stir bar and heat it to 115 °C for 30-60 minutes (Why are you doing this?)
2. After 30 minutes transfer your Biodiesel to a graduated cylinder to make your final reading of how much fuel your team produced from Canola Oil.
3. Record your final result.

Part E Analytical testing



1. Place 5 mL of the purified Biodiesel in a glass vial using a pipette and take it to building 3 to be analyzed in the lab of Dr. Ahmadzadeh.

Part F Diesel Engine



1. With the help of your instructor place the remaining Biodiesel oil in the small diesel engine and attempt to start the system.

Lab Questions:

1. What is diesel fuel?
2. Please define a triglyceride and how they are used in our daily lives?
3. Please define Biodiesel?
4. What is B100, B80, and B20?
5. What would be the economic impact on global resources if Biodiesel were implemented as an alternative fuel?
6. What are the impurities or by-products produced while making Biodiesel?
7. What are some advantages of using Biodiesel produced from Algae oil?
8. How is Biodiesel less harmful in terms of emissions in comparison to petroleum-based fuels?
9. How can one test the quality of Biodiesel?
10. How can Biodiesel from land-based sources (like vegetable oil) be used to make fuel and not effect the global supply of food?
11. What are some limitations of expanding Biodiesel as an alternative fuel source?