Creating Biodiesel with Peanut nut oil

Research Question: Can we create a usable form of biodiesel using peanut oil?

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Environmental Systems and Societies

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Climate change is a controversial topic, especially today. Some people believe that climate change is a serious issue, while others don't even think it's real. There is a big difference between weather and climate, and many often confuse the two. Weather is the conditions in the air at a particular time, such as wind, rain, or temperature[1]. On the other hand, climate is the description of the long-term pattern of weather in a particular area[2]. Our planet's climate is varying faster now than any other point in history, mainly as a result of humans. Researchers from around the world have conducted thousands of studies documenting increases in temperature of the earth's surface. It has been found that the main cause of global warming is the burning of fossil fuels. Fossil fuels produce massive amounts of carbon dioxide when burned. These carbon emissions trap heat in the atmosphere which leads to the warming of the planet. [3] Scientists have been working on discovering new forms of energy to replace fossil fuels that are polluting our atmosphere. Many have begun looking into energy sources such as solar, wind and water. Another alternative form of fuel that is often overlooked in the news media is biodiesel.

Biodiesel is a renewable, clean-burning, diesel replacement that can be used in existing diesel engines without modification. Biodiesel is made from an increasingly diverse mix of resources such as recycled cooking oil, soybean oil, and animal fats[4]. Another important aspect of biodiesel is that most sources of it are carbon neutral. This means that whatever is being used to create the biodiesel is the same amount of energy

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[1] https://dictionary.cambridge.org/us/dictionary/english/weather
[2] https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html
[3] Denchak, Melissa. "Fossil Fuels: The Dirty Facts." *NRDC*, 16 July 2019, www.nrdc.org/stories/fossil-fuels-dirty-facts.
[4] https://www.biodiesel.org/what-is-biodiesel/biodiesel-basics

that is given off when the biodiesel is heated. When we are referring to biodiesel made from plants, they take in energy in the form of carbon dioxide during photosynthesis, but release that same amount of carbon dioxide off when the fuel is combusted.

I decided to investigate this topic because of how relevant it is in our society today. Many researchers believe that if we don't start combating the climate crisis head on in the next 20 to 30 years, we will see disastrous results. Some of the impacts of global warming have already started to show in certain regions. On the east coast of the US and the Caribbean are seeing more and stronger hurricanes than ever before. And in regions like Alaska, where glaciers have dominated most of the landscape for decades, they are melting away at an increasing and alarming rate. These impacts are the reason why many scientists are searching for new fuel sources. To evaluate the use of peanuts as biofuel, I will be investigating the question: can we create a usable and viable form of biodiesel using peanut oil?

Nuts are an easy source of oil to use in creating biodiesel because they are very accessible. Peanuts, in specific although they are grown mostly in southeastern states, can be found almost anywhere because they can be shipped to most places around the world. This is important because it shows even further that peanuts are very accessible and can be acquired almost anywhere. Another reason why peanuts are a great source of oil to make biodiesel is that they have over 50% oil content which means more possible fuel can be made per nut. Because of this extremely high oil content, peanuts are capable of producing 123 gallons of oil per acre[5].

[5] http://www.make-biodiesel.org/Oil-Seed-Plants-for-Biodiesel/peanut-oil-biodiesel.html

To execute this experiment, I will be using peanut oil as well as other chemicals to produce a viable form of biodiesel. There are many parts to this experiment, some of which include, a titration to determine the free fatty acid content of the peanut oil, a mixing phase, and a settling phase. These phases will be followed by certain quality tests in order to determine whether the biodiesel that was made is actually usable.

To carry out the steps to this experiment we need specific materials. The materials that are required for the steps are listed below:

Materials (Titration)

- 1 gram of pure sodium hydroxide(NaOH)
- 1 liter of distilled or deionized water
- 1 small beaker
- 1 mL of dewatered peanut oil
- 10mL of isopropyl alcohol (isopropanol)
- 1 graduated syringe
- phenolphthalein (only a few drops needed)

Materials (Making the Biodiesel)

- 1 liter of peanut oil
- 200mL of methanol 99+% purity
- Lye catalyst, NaOH (amount determined based on the results of titration)
- Mixing device of any kind (like a blender or mini processor)
- Scales accurate to .1 grams, preferably less--.01 grams is best

- Measuring beakers for methanol and oil
- Half-liter translucent white HDPE container with bung and screw-on cap
- 2 funnels to fit the HDPE container, one for methanol, the other for the lye
- 2-liter PET bottle (water or soft-drink bottle) for settling
- Two 2-liter PET bottles for washing
- Duct tape
- Thermometer

Methodology (Titration)

For processing oil, it's essential to titrate the oil to determine the free fatty acid (FFA) content and calculate how much extra lye will be required to neutralize it. An electronic pH tester can be used but in this experiment we chose to use phenolphthalein solution. The methods used in the titration process are as follows

1) Dissolve 1 gram of pure sodium hydroxide lye (NaOH) in 1 liter of distilled or deionized water (0.1% weight/volume NaOH solution).
2) In a small beaker, dissolve 1 mL of dewatered nut oil in 10 mL of pure isopropyl alcohol (isopropanol).
3) Warm the beaker gently by standing it in some hot water and stir until all the oil dissolves in the alcohol and the mixture turns clear.
4) Add two drops of phenolphthalein to the solution.

5) Using a graduated syringe, add the 0.1% NaOH solution drop by drop in the oil-alcohol-phenolphthalein solution, stirring all the time. It might turn a bit cloudy. Keep stirring.
6) Keep carefully adding the lye solution until the solution stays pink (actually magenta) for 15 seconds.
7) Take the number of milliliters of 0.1% lye solution that was used and add 3.5 (the basic amount of lye needed for fresh oil). This is the number of grams of lye that will be needed per liter of oil to process the nut oil.

Methodology (Making the Biodiesel)

Lye

a) You need to be quick when measuring out the lye because it rapidly absorbs water from the atmosphere and water interferes with the biodiesel reaction.
a) Measure the lye into a handy-sized lightweight plastic bag on the scales (or even do the whole thing entirely inside a big clear plastic bag). Then, close the lid to the container firmly and close the plastic bag, winding it up so there's not much air in it with the lye and no more air can get in.
b) Have exactly the same kind of bag on the other side of the scale to balance the weight, or adjust the scale for the weight of the bag

Mixing the Methoxide

a) Measure out 200 mL of methanol and pour it into the half-liter HDPE container via the funnel. Methanol also absorbs water from the atmosphere so do it quickly and replace the lid of the methanol container tightly.
b) Carefully add the lye to the HDPE container via the second funnel
c) Replace the bung and screw on the cap tightly
d) Shake the container a few times--swirl it around rather than shaking it up and down. The mixture gets hot from the reaction
e) If you swirl it thoroughly for a minute or so five or six times over a period of time the lye will completely dissolve in the methanol, forming sodium methoxide. As soon as the liquid is clear with no undissolved particles begin the process
f) The more the container is swirled the faster the lye will dissolve. With NaOH it can take from overnight to a few hours to as little as half-an-hour with lots of swirling

The Process

a) For this step of the procedure use a blender, or any other mixing device to mix the components together
b) Preheat the oil to 55 degrees C(130 degrees F) and pour it into the blender
c) With the blender still switched off, carefully pour the prepared methoxide from the HDPE container into the oil

d) Secure the blender lid tightly and switch it on. Lower speeds should be enough. Mix for 20-30 minutes,or longer

Transfer

a) As soon as the process is completed, pour the mixture from the blender into the 2-liter PET bottle for settling and screw on the lid tightly
b) As the mixture cools it will contract and more air might have to be let into the bottle later

` Settling

a) Allow to settle for 12-24 hours(longer is better)
b) Darker-colored glycerine by-product will collect in a distinct layer at the bottom of the bottle, with a clear line of separation from the paler liquid above, which is the biodiesel. The biodiesel varies somewhat in color according to the oil used and so does the by-product layer at the bottom, but it’s usually a pale yellow.
c) The biodiesel might be quite clear or it might still be cloudy, which is not a problem. It will clear eventually but there’s no need to wait
d) After settling, carefully decant the top layer of biodiesel into a clean jar or PET bottle, taking care not to get any of the glycerine layer mixed up with the biodiesel. If any of the glycerine does get mixed in with the biodiesel, re-settle it and try again

Quality Tests - There are many different types of quality tests including wash tests, methanol tests, or reprocessing tests. However in my experiment I will be undergoing a wash test for the biodiesel that I produce.

Wash Test

a) Put 150 mL of unwashed biodiesel (settled for 12 hours or more, with the glycerine layer removed) in a half-liter glass jar or PET bottle
b) Add 150 mL of water (at room temperature), screw the lid on tight and shake it up and down violently for 10 seconds. Then let it settle
c) The biodiesel should separate from the water in half an hour or less, with amber (and cloudy) biodiesel on top and milky water below, and no more than a paper-thin white interface layer between the oil and water. This is quality fuel, a completed product with minimal contaminants.
d) But, if it turns into something that looks like mayonnaise and won't separate, or if it only separates very slowly, with a thick, creamy white layer sandwiched between the water and the biodiesel, it's not quality fuel and the process needs improvement
    i) Either too much catalyst was used and made excess soap (solution: more accurate measurements, better titration)
    ii) An incomplete reaction with poor conversion has left you with half processed monoglycerides and diglycerides, fuel contaminants that also act as emulsifiers. Emulsifiers are used to make stable mixtures of oil and water, such as, indeed mayonnaise (solution:

more accurate measurements, better titration; longer processing time, better temperature control, also using more methanol)

From our titration, we were able to calculate the amount of lye necessary for the making of the biodiesel. We found that the amount of the NaOH/water solution that was necessary to keep the alcohol/oil/phenolphthalein mixture stay pink for 15 seconds was 1.74 mL. This number was added to 3.5(the basic amount of lye needed for fresh oil) to see how much lye would be needed when actually making the biodiesel.

Next I underwent the process of making the biodiesel. This was a long and tedious process, but was accomplished over a period of many days. Finally, after the biodiesel had separated from the glycerine, it was time to undergo a wash test. Following the procedure listed above, I mixed 150 mL of the biodiesel that had separated from the glycerine with 150mL of water. At first, when washing the biodiesel, it wasn't separating and it seemed like it may not separate at all. But once it reached a bit over the time specified in the procedure, the percentage of biodiesel to water was almost 50:50. So then after having washed some of the biodiesel, we needed to was the rest in order to have clean, quality fuel. After doing so we separated the rest of the biodiesel from the water. Now we have clean biodiesel ready to be used.

The next step after creating the biodiesel is to calculate how this can be projected on a larger scale. The piece of information needed for these calculations is that there are 4,000 pounds of peanuts produced per acre. This equates to 1,814,369 grams. And in kilograms that would be 1,814.4kg. The next piece of information to note is that 1 kilogram of peanuts produces about .5 kg of oil, which is equivalent to 549mL.

If we then divide the amount of biodiesel produced in my experiment(325mL) by the amount of oil initially used(500mL) we can see that the amount of biodiesel produced will be 65% the amount of oil used. A ratio can then be set up to determine how many milliliters of oil is produced by one acre of land: $\frac{1kg}{549mL} = \frac{1{,}814.4kg}{x}$ x=996,105.6mL of oil per acre. This value can then be multiplied by .65 to determine the amount of biodiesel, in milliliters is produced per acre which, when calculated, is 647,468.6mL of biodiesel per acre. Lastly, this value can be converted into liters per acre by dividing the last value by 1000: 647,468.6/1000 = 647.5 liters of biodiesel per acre.

Through these calculations it can clearly be seen that peanuts have the ability to produce massive amounts of biodiesel in only one acre of land. This further proves that peanuts can be seen as a viable option of fuel when trying to limit the amount of fossil fuels produced by our planet. Under no circumstance am I suggesting that we switch completely to only one other source of fuel, like that of biofuel. Rather, I suggest that biofuel, along with other fuel sources like wind, solar, and hydro energies be used together in order to fuel our communities instead of the fossil fuels that are currently destroying our environment.

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