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Biodiesel from Used Cooking Oil - Future Potential Gold.

Shubham Mukherjee*.

Computer Science Department, Campus-15, KIIT University, Patia, Bhubaneswar-751024, India.

Research Article

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***For Correspondence**

Computer Science department, Campus-15, KIIT University, Patia, Bhubaneswar-751024, India.

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ABSTRACT

Making your own fuel from vegetable oil or rather waste vegetable oil i.e. the oil which has been used for cooking and other purposes can be easy, cost effective, and environmentally beneficial. What makes this fuel even more attractive is that you can make it from the waste vegetable oil produced. In a country like the United States every year, which amounts to more than three billion gallons. With a bit of know-how and persistence, you can run any diesel engine on vegetable oil. Only diesel engines can run on vegetable oil-based fuels. This means that any engine that has spark plugs and is made for leaded or unleaded gasoline cannot use vegetable oil fuel. In this research paper, the focus has been made on how to make biodiesel which can be used by diesel engines from used cooking oil found in the kitchens.

INTRODUCTION

As already mentioned before, diesel engines found in trucks , cars , planes and so can all run on biodiesel produced from waste cooking oil generally found almost everywhere! With the amount of waste oil generated and thrown every day, one can generate enough biodiesel to run atleast 10 vehicles. Biofuels have been around as long as cars have. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil and even jatropa oil was said to be feasible. But discoveries of huge petroleum deposits kept gasoline and diesel cheap for decades, and biofuels were largely forgotten in the process. However, with the recent upward hike in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity. Gasoline and diesel are actually ancient biofuels. But they are known as fossil fuels because they are made from decomposed plants and animals that have been buried in the ground for millions of years. Countries around the world are using various kinds of biofuels. According to confirmed reports, for decades, Brazil has turned sugarcane into ethanol, and some cars there can run on pure ethanol rather than as additive to fossil fuels. And biodiesel—a diesel-like fuel commonly made from palm oil—is generally available in Europe. Much of the gasoline in the United States is blended with a biofuel—ethanol. This is the same stuff as in alcoholic drinks, except that it's made from corn that has been heavily processed. There are various ways of making biofuels, but they generally use chemical reactions, fermentation, and heat to break down the starches, sugars, and other molecules in plants. It is really a tedious process. The leftover products are then refined to produce a fuel that cars can use. On the face of it, biofuels look like a great solution. Cars are a major source of atmospheric carbon dioxide, the main greenhouse gas that causes global warming. But since plants absorb carbon dioxide as they grow, crops grown for biofuels should suck up about as much carbon dioxide as comes out of the tailpipes of cars that burn these fuels. And unlike underground oil reserves, biofuels are a renewable resource since we can always grow more crops to turn into fuel. Biodiesel is a renewable, clean-burning diesel replacement that is reducing U.S. dependence on foreign petroleum, creating jobs and improving the environment. It is seriously a great solution, not only for the developed countries but also and mainly for the developing countries like India and China as a whole. Within some years of commercial-scale production, the industry

is proud of its careful approach to growth and strong focus on sustainability and development. Production has increased from about 20-30 million gallons in the early 2000s to almost a little more than a billion gallons in 2012. This represents a small but growing component of the annual U.S. on-road diesel market of about 40 billion gallons. Consistent with projected feedstock availability, the industry has established a goal of producing about 10 percent of the diesel transportation market by 2022.Reaching that goal would significantly lessen U.S. dependence on imported oil, bolstering national security and reducing our trade deficit. At the same time, biodiesel's growth would boost the U.S. economy, not just by creating jobs but also by reducing our dependence on global oil markets and vulnerability to price spikes. There are currently about 200-220 biodiesel plants across the country – from Washington state to Iowa to North Carolina – with registered capacity to produce some 3 billion gallons of fuel. The industry is supporting almost a million jobs, generating billions of dollars in GDP, household income and tax revenues. The industry's economic impact is poised to grow significantly with continued production increases. The industry supports jobs in a variety of sectors, from manufacturing to transportation, agriculture and service. The EPA has recognized biodiesel's environmental benefits by classifying it as an Advanced Biofuel, making biodiesel the only commercial-scale U.S. fuel produced nationwide to meet the agency's advanced criteria. According to the EPA, biodiesel reduces greenhouse gas emissions by at least 60 percent and up to 86 percent when compared to petroleum diesel – making it one of the most practical and cost-effective ways to immediately address climate change. In addition, biodiesel sharply reduces major tailpipe pollutants from petroleum diesel, particularly from older diesel vehicles. This is important because the EPA has consistently cited diesel exhaust – primarily from older trucks, buses and other vehicles – as one of the nation's most dangerous pollutants. Biodiesel is produced using a broad variety of resources. This diversity has grown significantly in recent years, helping shape a nimble industry that is constantly searching for new technologies and feedstocks. In fact, industry demand for less expensive, reliable sources of fats and oils is stimulating promising research on next-generation feedstocks such as algae and camelina. For the future, many think a better way of making biofuels will be from grasses and saplings, which contain more cellulose. Cellulose is the tough material that makes up plants' cell walls, and most of the weight of a plant is cellulose. If cellulose can be turned into biofuel, it could be more efficient than current biofuels, and emit less carbon dioxide. Now basically, there are three ways in which vegetable oil can be used as fuels:

Biodiesel

Today one of the most efficient methods of running a diesel engine on vegetable oil fuel is to produce a fuel called biodiesel. Biodiesel is made by combining around 10-15 percent alcohol with generally 0.30-0.50 percent lye (The percentage of Lye depends upon the small batch test of waste oil) and 80 to 90 percent vegetable oil. A very orderly reaction can be made with 80-85 percent of used vegetable oil, 20 parts methanol, and 0.35 parts lye. These ingredients are mixed together for some time(take half an hour) and left to settle for eight hours. After the chemical reaction is complete and the new products settle out, we have biodiesel fuel and glycerine soap. The fuel is golden yellow to amber in colour and flows like water. The soap is brown in colour and has the consistency of gelatine. The soap settles to the bottom, allowing you to pump, siphon, or pour off the biodiesel.

Veggie/Kero Mix

The second method for using vegetable oil in a diesel engine is to simply "cut" the oil with kerosene. This method is best suited for emergencies, heavy duty engines, and warm temperatures. Although it is possible to mix other petroleum products with vegetable oil, kerosene is most suited for the diesel engine. Depending on ambient temperature, the blend of kerosene to vegetable oil will be anywhere from 10 percent kerosene and 90 percent vegetable oil to 40percent kerosene and 60 percent vegetable oil. A fairly reliable blend is 20 percent kerosene to 80 percent vegetable oil. The effectiveness and reliability of the veggie/kero method is increased by starting and cooling down the diesel engine on diesel fuel or biodiesel fuel. This can be accomplished by installing an extra fuel tank and switching to the veggie/kero mix when the engine is warmed up. This is in fact a tedious process.

Straight Vegetable Oil

The third method for running a diesel engine on vegetable oil is to use straight vegetable oil. As with the other methods, you can use either pure vegetable oil or used cooking oil. To ensure the efficiency and longevity of your diesel engine, the engine must be started and cooled down on diesel or biodiesel fuel. The use of an extra fuel tank is also required. Also a valve to switch between the tank of diesel or biodiesel fuel and the tank of vegetable oil is required. The key to running a diesel on straight vegetable oil is to heat the vegetable oil at every stage—in the fuel tank, fuel hose, and fuel filter. The vegetable oil must be

heated to at least 70°C (160°F). Most diesel engines have hoses that carry hot coolant. This coolant can be directed to heat the vegetable oil hoses, tank, and filter. You can make simple modifications to the coolant hoses. These modifications combined with some extra fuel and oil hoses, an extrafuel tank, and an electrically operated switch will allow you to run your diesel engine on straight vegetable oil.

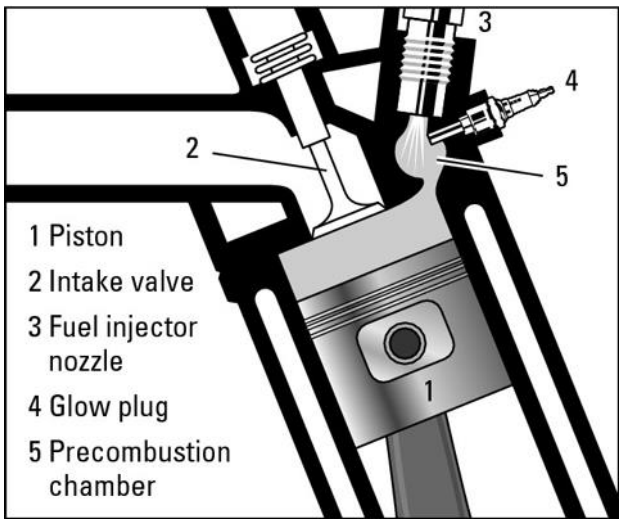
Table 1: Comparison Table Between The Vegetable Fuels

Property	Biodiesel	Veggie Mix	Vegetable Oil
Can be used as lubrication additive to diesel fuel	YES	NO	NO
Requires vehicle modification	NO	YES	YES
Reliably cuts emissions in all diesel engines	YES	NO	UNKNOWN
Considered an alternative fuel under the United States Energy Policy Act (EPACT)	YES	NO	YES
Simple way to run a vehicle in an emergency	NO	YES	NO
Stable fuel at room temperature	YES	NO	NO
Requires added chemicals to produce	YES	YES	NO
Requires startup tank of biodiesel or diesel fuel	NO	YES	YES
Good startup fuel	YES	NO	NO
Better lubrication than diesel fuel	YES	YES	YES
Gels in cold weather	YES	YES	YES
Covered by many engine warranties	YES	NO	NO
Can be made from used cooking oil	YES	YES	YES
Can be made from pure vegetable oil	YES	YES	YES
Safe to store and handle, biodegradable, won't spontaneously ignite, and non-toxic	YES	NO	YES
Works in all diesel engines	YES	YES	YES
Can be reliably mixed in any proportion with diesel fuel without vehicle modification	YES	NO	NO
Approved for use by EPACT in a 20% mix with 80% diesel fuel	YES	NO	NO
Engine life, power, torque, fuel mileage, and overall performance are relatively unaffected	YES	YES	YES
Can clog fuel injectors if used improperly	NO	YES	YES
Requires heating for operation at any temperature	NO	NO	YES
Tested and documented by U.S. universities	YES	NO	YES
Possible substitute for home heating oil in furnaces.	YES	NO	NO
Can be used in ***Petromax*** brand and similar lanterns and stoves	YES	NO	YES

Now firstly, we need to have the knowhow about the working of a simple diesel engine. Then only we can understand the concept of biodiesel in a better way.

WORKING OF A DIESEL ENGINE

Figure 1: Internal View of a Diesel Engine



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The diesel engine works on the principle of compression ignition. Inside the diesel engine, the fuel is injected into a chamber of pressurized air. This pressurized air ignites the fuel. The diesel engine is different from the electric spark engine which uses electric sparks to ignite gasoline. The diesel engine contains no spark plugs, no distributor, no ignition coils, no carburettor. Instead the diesel engine contains small electric heaters that help in igniting the fuel.

Generally diesel engines are more reliable than those engines that run on gasoline because of lack of electrical ignition components. Due to the thick nature of diesel fuel, some diesel engines emit partially burnt fuel in form of soot. Biodiesel can easily solve this problem.

Let us now go to the main focus of this paper ,i.e., how to make biodiesel from used cooking oil. This is actually a great project to start on if you are a college student where used cooking oil is in abundance. Students living in the campus eat their food in the mess or canteens where gallons of waste cooking oil are produced. So practically the cost for accessing the raw materials required for this process is actually very low as waste cooking oil can also be accessed from the nearby restaurants.

HOW TO MAKE BIODIESEL FROM USED COOKING OIL

This fuel can be made in a blender or in a larger mixer. The materials you'll need are used vegetable oil, methanol, and lye. If you are using new vegetable oil, always use 3.5 grams of lye per litre of oil. Since each batch of used cooking oil is different, the amount of lye in each batch of biodiesel will be different. To ensure that you are using the correct amount of lye, make a small test batch of biodiesel in a blender before attempting a reaction in a large mixing tank. This will at least ensure that mixing proportions are correct. For the test batch, use 100 millilitres of vegetable oil and 20 millilitres of methanol. Mathematical calculations are required to ensure the exact amount of lye needed. If you are using used vegetable oil, use 0.45 grams of lye for the first test batch. If this batch makes biodiesel and glycerin, use the same proportions for the large batch reaction. If the test batch does not form two distinct layers, increase the amount of lye to 0.55 grams and make another test batch. If this batch is unsuccessful, make another batch and increase the amount of lye to 0.65 grams. If that batch is unsuccessful, make another batch with 0.75 grams of lye. Make sure you can make biodiesel on a small scale before attempting a large reaction. Once you have made a successful small test batch of biodiesel, multiply the number of grams of lye you used by ten to see how much lye you will need for each liter of oil in the large reaction. For example, if you used 0.55 grams of lye in the test batch, you will need to use 5.5 grams of lye per litre of used cooking oil for a large reaction. Here is the basic procedure for making biodiesel fuel:

- Purchase or collect used vegetable oil.
- If the oil is used cooking oil, use a restaurant fryer filter to remove burned food bits, etc.
- Purchase some methanol alcohol from a local racetrack or chemical supply store. Ethanol alcohol can also be used, but the process is different.
- Purchase some granulated lye (Red Devil is one brand) or caustic soda sold as a drain cleaner from the hardware or grocery store. It must be pure sodium hydroxide (NaOH).
- Measure the amount of vegetable oil you want to use in liters. We will call this number V. Pour the vegetable oil into the mixing container.
- When the temperature is below 70°F (21°C), or when the vegetable oil is solid or lumpy, it will be necessary to heat the reactants before, during, and possibly after the mixing. The ideal temperature toattain is 120°F (49°C). A fish tank heater will heat 10 to 30 gallons (40–120 l) of reactants. For largerbatches of biodiesel, a water heater element can be mounted in a steel biodiesel mixing tank. Makesure that you follow the manufacturer's directions and safety precautions when adding any electricaldevice to the system. Be careful when heating vegetable oil in a plastic container. Polyethylenecannot withstand temperatures above 140°F (60°C).
- Multiply V x 0.2. The result will be the amount of methanol you will need in litres. We will call thisnumber M.
- To determine how much lye you will need to use for new vegetable oil, multiply V times 3.5 grams. For used vegetable oil, use the number of grams of lye you got in the small test batch. For example, if you used 0.55 grams of lye in the test batch, you will multiply V times 5.5 grams of lye. Call this number L.
- Carefully pour L grams of lye into M liters of methanol. Stir until the lye is dissolved in themethanol. Be careful, this creates a toxic substance called sodium methoxide.
- Pour the sodium methoxide into the vegetable oil right away. Stir vigorously for one hour.
- Let the mixture settle for eight hours.

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- Pump the biodiesel from the top, or siphon it off with a hand siphon. Or if you are lucky enough tohave a container with a spigot, open the spigot and drain the bottom layer of glycerin. The glycerin willbe much thicker and darker than the top layer of biodiesel.
- Allow the glycerin to sit in the sun for a week. After that, the trace methanol will be evaporated. You have made a nice glycerin soap. You can scent it with the fragrance of your choice, add other soap agents as desired, or just use it as it is. This soap is especially good for cleaning grease off your hands and cleaning greasy equipment!
- Make sure your biodiesel goes through a 5 micron filter before entering your diesel engine.

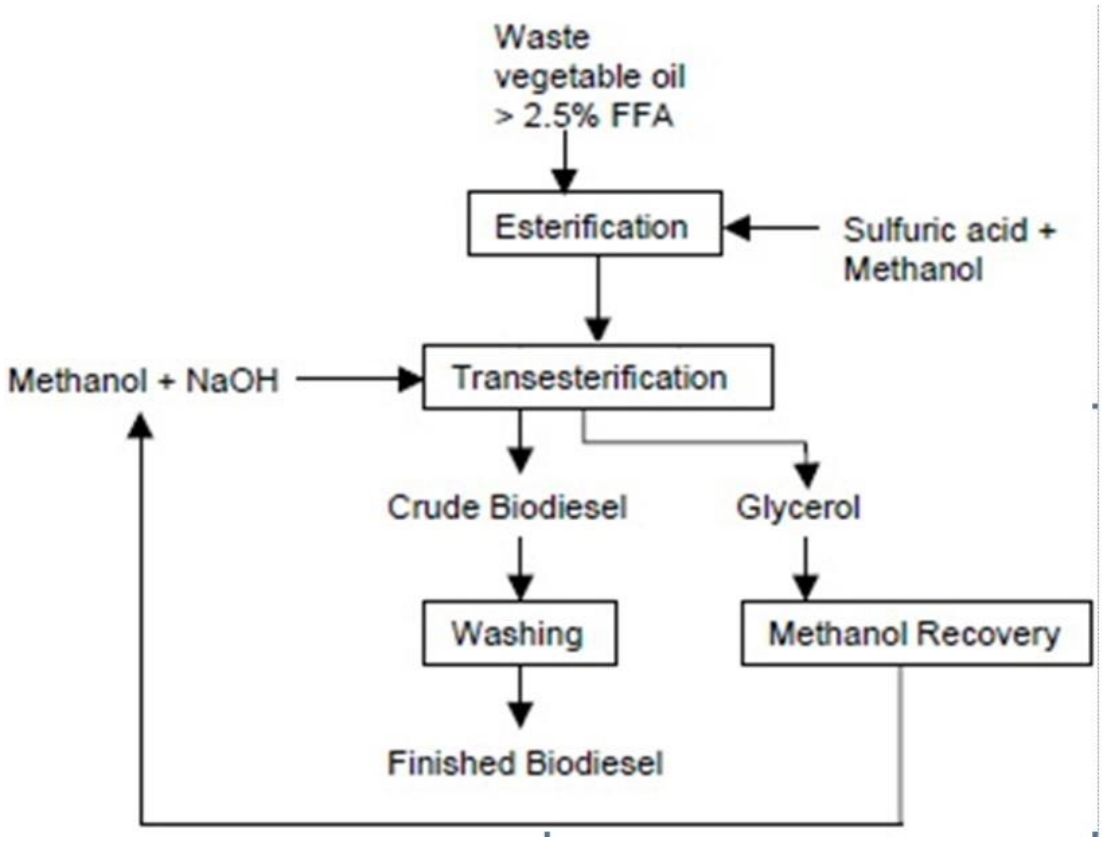

Figure 2: Flow Chart of Making of Biodiesel

The above diagram also explains an extra process which is esterfication which is necessary if you want a purer biodiesel at the end of the process. When the two products are formed, methanol can be recovered from the glycerine and can be used earlier in the process thus, reducing the cost of production of biodiesel even more. Here a simple problem stands up. Production of biodiesel manually takes up a lot of time. So large batches of production in a short span of time is actually very difficult. But to a large extent, a biodiesel processor can reduce this problem. The simplest way to make a biodiesel processor is to use a 55 gallon (208 l) steel drum and some sort of mixer. The mixer can be a circulating pump, such as a sump pump, or it can be an electric mixer for chemicals, specially made for drum stirring. A pump or stirrer will cost about US$200 if you buy it new, but you can build your own instead. With a bit of ingenuity, you can build a biodiesel processor that is inexpensive and effective. Tim Garrits of Kelseyville, California built such a processor from mostly recycled parts for under US$50. A simple biodiesel processor can be built from the following parts:

- A 55 gallon (208 l) metal drum.
- A 1/2 hp electric motor.
- Two pulleys that give about 250 to 400 rpm at themixer blade.
- A belt that goes around both pulleys.
- A rolled 2 inch (5 cm) rod for the mixer shaft.
- A propeller made from two shelf brackets, welded to either side of the rolled 2 inch rod. The shelf brackets look like two opposed “L”s and form a propeller about 14 inches (36 cm) in diameter. Basically any propeller-shaped metal would do, if it is made from about 12 or 14 gauge steel.
- A 3/4 inch (19 mm) brass ball valve for draining the glycerin.

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- A hinge and piece of wood acting as a belt tensioner.
- A 2,000 watt electric water heater element.
- A water heater thermostat.
- Wood, screws, bolts, and other assorted mounting hardware.

Figure 3: Biodiesel Processor

SAFETY NOTE

You are dealing with dangerous chemicals when you make biodiesel. Both methanol and lye are strong bases. They can deaden nerve endings and cause permanent damage. For this reason, chemical resistant gloves, aprons, and eye wear should be worn when dealing with methanol and lye. Shoes, long sleeve shirts, and long pants are a must. Keep both methanol and lye in clearly marked containers. We recommend putting a skull and crossbones on them and writing something to the tune of “Danger! Toxic!" in addition to the contents. Sodium methoxide, the chemical combination of lye and methanol, is even more toxic than the separate components. Keep this stuff away from any exposed skin. Do not let children play in or around biodiesel equipment. Remember, although you are creating two chemically benign substances when you make biodiesel, you are using dangerous chemicals in the process. Always keep safety in mind when preparing a biodiesel reaction. Have a faucet or hose nearby. Keep some vinegar handy to neutralize any methanol or lye that may spill. If you take the time to prepare and follow safety guidelines, your biodiesel reaction will go smoothly and you should have no problems.

WHY ACTUALLY BIODIESEL?

Biodiesel will definitely be a very important factor in the next 5 years. The reason is that the fossil fuels are depleting very quickly and also the use of fossil fuels causes carcinogenic and harmful gases to release in the atmosphere and all of these gases are not biodegradable. Whereas, on the other hand biodiesel is completely biodegradable. No harmful and fatal gases are released after its combustion. It is a known fact that everyday gallons of waste cooking oil is thrown. These harmful wastes add to the pollution over land and water. On the other hand, these harmful waste can used effectively to produce the harmless biodiesel. Because of the depleting fossil fuels, prices regarding petroleum are shooting up like anything. Because of

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such, the governments of the countries where there is shortage of petroleum has to spend more on the import of petroleum products thus, disrupting economic progress. Nowadays, fossil fuels corporations and companies are terming Compressed Natural Gas (CNG) as "future fuel". However , CNG is a non-renewable source of energy and confirmed reports say that its production will start dwindling as early as 2040. Now we are all familiar with the concept of GLOBAL WARMING. Earth is currently going through a period of global warming. Average worldwide temperatures are increasing rapidly. Factors which are contributing to the scene of global warming are many but figures show that burning of fossil fuels do give rise to rapid increment in the percentage of carbon dioxide in the atmosphere. But fortunately there is a solution- Renewable sources of energy. There is infinite amount of renewable sources of energy and vegetable oil is one of them. There is no need to think big from starting.If we contribute by making small changes then it will surely be noticeable in the long run. For e.g.- If your university has a transportation system, then we can make an effort to convince them to switch their fuels to biodiesel which will not only lessen the pollution in your area but also revolutionise the transportation system of your university.

Figure 4: Portrayal of Biodiesel as a Renewable Source of Energy

CONCLUSION

Disclaimers aside, biodiesel is used all over the world. Island people are making biodiesel from coconut oil, some countries are experimenting with biodiesel from hemp seed oil, and many others are using canola oil. Millions of miles of road tests have been done with this fuel. Tests have shown less wear on the internal components of engines using biodiesel. Biodiesel is a reliable, exciting fuel that you can make. If you are worried about your diesel engine, you can install an extra fuel filter system from similar aftermarket parts manufacturer. After traveling over 25,000 miles (40,000 km) on biodiesel made from used cooking oil, we continue to choose and recommend biodiesel over toxic, carcinogenic petroleum diesel fuel.

Figure 5: Fuels In Different Stages

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