CONSERVATIVE PRODUCTION OF BIODIESEL FROM WASTE VEGETABLE OIL

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ABSTRACT

Biodiesel can be made only from oils and fats which are triglycerides and not from any other kinds of oil (such as engine oil). Chemically, triglyceride consists of three long chain fatty acid molecules joined by a glycerin molecule. Waste oil is more appealing than using new oil because refined fats and oils have a free fatty acid (FFA) content of less than 0.1%, in contrary with used and waste oil, where FFA contents are high. FFAs are formed by cooking, the oil longer and hotter the oil has been cooked, the more FFAs it will contain. The study reports on biodiesel production from waste vegetable oil procured from markets where a catalyst (lye) was used to break off the glycerin molecule and combine each of the three fatty acid chains with a molecule of methanol or ethanol, creating mono-alkyl esters, or Fatty Acid Methyl Esters (FAME)—biodiesel. In this process of Transesterification, the glycerin sunk to the bottom and was removed. FFAs interfere with the Transesterification process inhibiting biodiesel formation. With waste oil more lye had to be used to neutralize the FFAs.

KEY WORDS: Biodiesel, Waste vegetable oil, Triglyceride, FFAs, Transesterification

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INTRODUCTION

Petroleum was formed by geologic processes dating from the Cretaceous and Jurassic periods, 90 to 150 million years ago, when vast amounts of zooplankton, algae, and other organic material were deposited on ocean floors. However, the majority of petroleum now extracted in the range of 85% is used to produce fuels. Most of these are transportation fuels such as gasoline, diesel fuel, and jet fuel, while some, such as fuel oil, liquefied petroleum gas, and propane, are used for heating and power generation. Petroleum accounts for more than 90% of transportation fuel, but only for 2% of electricity generation. Increasing worldwide demand for petroleum will affect the transition in important ways. Global petroleum demand is currently at 84 million barrels per day, and it is predicted to increase by 1% to 2% per year, reaching 116 million barrels per day by 2030. Much of this increasing demand will occur in developing nations (Howard Frumkin et al., 2009).

Air quality data generated by the Central Pollution Control Board (CPCB) for 2007 under the National Air Quality Monitoring Programme (NAMP) presented deadly facts about air pollution levels in Indian cities. Centre for Science and Environment has analysed the official data to assess the state of air quality and trend in Indian cities. The most widely monitored pollutants in India are particulate matter (PM), nitrogen dioxide (NO2), sulphur dioxide (SO2), and on a limited scale carbon monoxide. Some of the worst forms of air pollutions are found in Indian cities. The Central Pollution Control Board (CPCB) considers air to be ‘clean’ if the levels are below 50 per cent of the prescribed standards for pollutants (Centre for science and environment, 2012).

Biodiesel is an alternative fuel source made from renewable resources such as vegetable oil or animal fat, which is simple to use, gives clean burning, biodegradable, non toxic, and essentially free of sulfur and aromatics. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel contains no petroleum, but it can be blended with petroleum diesel to create a biodiesel blend. It can be used in diesel engines with no major modifications. Biodiesel is registered as a fuel and fuel additive with the U.S. Environmental Protection Agency (EPA) and meets clean diesel standards established by California Air Resources Board (ARB). Neat (100 percent) biodiesel has been designated as an alternative fuel by the U.S. Department of Energy (DOE) and the U.S. Department of Transportation (DOT) (California energy commission, 2012).

Since the passage of the Energy Policy Act of 2005, biodiesel has been increasing in the U.S. In Europe, the renewable Transport Fuel Obligation obliges suppliers to include 5% renewable fuel in all transport fuel in the EU by 2010.

This study was undertaken to awaken the utility of waste Vegetable oil which is a trashed product from hotels, canteens etc. which after little chemical treatment can be used as an efficient bio-diesel. Chemically, triglycerides contained in vegetable oil or animal fat consists of three long chain fatty acid molecules joined by a glycerin molecule. Waste oil is more appealing than using new oil because refined fats and oils have a free fatty acid (FFA) content of less than 0.1%, in contrary with used and waste oil, where FFA contents are high. FFAs are formed by cooking, the oil longer and hotter the oil has been cooked, the more FFAs it will contain. Hence this study was conducted to use these waste oils where lye was used to break the Glycerin chain.

MATERIALS (Keith Addison, 2012)

- 1 liter of fresh vegetable (sunflower) oil and waste vegetable oil from a local canteen was procured.
- 4.5 g of potassium hydroxide (also known as lye)
- 200 ml of ethanol (ethyl alcohol)
- 10 ml isopropyl alcohol
- Glass or plastic container that is marked for 1 liter
METHODOLOGY

Basic titration

- For processing used oil it is 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. Phenolphthalein indicator was used. 1g of pure Potassium Hydroxide lye (KOH) was dissolved in 1 liter of distilled water (0.1% W/V KOH solution).
- In a small beaker, 1 ml of dewatered waste vegetable oil was dissolved in 10 ml isopropyl alcohol. The beaker was gently warmed on a hot water bath; stirred until all oil dissolved in the alcohol and the mixture turns clear. 2 drops of phenolphthalein indicator was added. Using graduated syringe, 0.1% KOH solution was added drop by drop to the Oil-alcohol-phenolphthalein indicator, stirring all the time, kept stirring. The lye solution was added until the solution stays pink for 15 seconds. The number milliliters of 0.1% lye solution used was noted and added to the 3.5 grams of lye (the basic amount of lye needed for fresh oil). So the total quantity of lye used to process the Waste vegetable oil per liter is 4.5 gms (Venkata Ramesh Mamilla et al., 2011; C.V. Sudhir et al., 2007).

The production of biodiesel (Keith Addison, 2012)

- Fresh Sunflower oil & Waste Vegetable oil were taken to which the amount of catalyst to be added was calculated as 4.5 for both.
- 200 ml ethanol was poured into glass blender pitcher.
- Blender was turned on to its lowest setting and slowly 4.5 g of potassium hydroxide (lye) was added. This reaction produced potassium methoxide.
- Ethanol and potassium hydroxide was mixed until the potassium hydroxide has completely dissolved (about 2 mins), 1 liter of waste vegetable oil was added to this mixture. Similar procedure was followed for new vegetable oil.
- This mixture (on low speed) was blended continuously for 20 mins to 30 mins.
- After completing the procedure the oils were kept for observation. The bottle of oil was kept for 2 days, uncovered inside a rack.

Purification step

Purification of the resultant bio-diesel was done in accordance with the method explained by Y. Zhang et al., 2003 & Arjun B. Chhetri et al., 2008.

Figure 1: The apparatus used for Biodiesel production
The confirmatory test:

**Wash test**

- 150 ml of unwashed biodiesel (settled for 12 h or more, with the glycerin layer removed) was taken in a half liter glass jar or PET bottle.
- 150 ml of water (at room temperature), was added. Screwed the lid on tight and shaken it up and down violently for 10 seconds and was let to settle (figure 2) (Keith Addison, 2012).

**Methanol test**

25 ml of biodiesel was dissolved in 225 ml of methanol in a measuring glass. The biodiesel got dissolved completely in methanol. “The biodiesel should be fully soluble in the methanol, forming a clear bright phase (figure 6) (Jan Warnqvist, 2005).

Figure 2: Wash test for biodiesel

Figure 3: Picturing shows Methanol test carried out for biodiesel, along with biodiesel
RESULTS

Production results

Biodiesel was obtained after processing the waste vegetable oil and new sunflower oil.
- After 2 days of observation, it was observed that the biodiesel was on top of the glycerin, which settled at the bottom. The amount of biodiesel obtained from waste vegetable oil was 540 ml from 1 liter and 850 ml of biodiesel from 1 liter sunflower oil (figure 4).

The purification step

- This step was done by washing biodiesel with water. This was done to remove the impurities and the incomplete reaction products like soap.
- 10 ml of normal tap water was added to 100 ml of biodiesel, shaken vigorously, allowed for some time and the water was removed. This was done until we got clear water indicating that most of the impurities were removed.

Wash Test

The biodiesel should separate from the water in half an hour or less, with amber (and cloudy) biodiesel on top and milky water below. After a violent 10-second shaking; biodiesel and water separated cleanly within minutes. This is quality fuel, a complete product with minimal contaminants. It was observed that the clear water was at the bottom and biodiesel was on the top. This indicates the positive result for biodiesel for wash test. This tells that the biodiesel got purified, that is the oil which underwent incomplete reaction was removed by wash test. The biodiesel which is purified stands on the top leaving clear water at the bottom (figure 5).

Results of Methanol test:

Biodiesel dissolves easily in methanol, whereas vegetable or animal oils and fats (triglycerides) do not dissolve in methanol. Any uncovered oil left in the biodiesel will settle out at the bottom of the tank. 25 ml of biodiesel was added in 225 ml of methanol. A clear solution indicates a positive result for biodiesel (figure 6).
DISCUSSION

Biodiesel is an alternative fuel similar to conventional or fossil diesel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. The process used to convert these oils to biodiesel is called Transesterification (Ulf Schuchardt et al. 1997).

Biodiesel has many environmentally beneficial properties. The main benefit of biodiesel is that it can be described as ‘carbon neutral’. This means that the fuel produces no net output of carbon in the form of carbon dioxide. The (figure 7) below shows the chemical process for methyl ester biodiesel. The reaction between the fat or oil and the alcohol is a reversible reaction and so the alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion.

Mixing of alcohol and catalyst

The catalyst used was typically potassium hydroxide. It was dissolved in alcohol which acts and enhances the reaction with the oil to form esters (figure 7) which is nothing but the crude biodiesel which is in compliance with the study done by Venkata Ramesh Mamilla et al., 2011. Excess of catalyst was used to convert the oil completely into esters. The reaction happens with vigorous agitation, done using a mixer. The recommended reaction time was 20 minute to 1 hour. The so formed biodiesel is kept ideal for 24 to 48 hours under observation.
**Separation**

Our results on separation step are similar to the study conducted by Y. Zhang et al., 2003) which shows the clear separation of the biodiesel on the top, from the glycerine at the bottom which is much denser than the biodiesel. Once its separated from glycerine, biodiesel is is sometimes purified by washing with warm water to remove residual catalyst or soaps, dried and sent to storage, which marks the end of the process. The process results in the clear amber-yellow liquid.

**CONCLUSION**

In the present situation where the natural resources in the form of fossil fuel are getting exhausted, it has become very important to think the alternate source of energy. So biodiesel is one of the alternate solutions which are ecofriendly. It is also advantageous over the pollution caused by petroleum products because Biodiesel is a biodegradable, non toxic and virtually free from sulfur and aromatics. A number of studies have found that biodiesel biodegrades much more rapidly than conventional diesel. In this respect, its action is similar to petroleum diesel fuel. However, biodiesel does not have the toxicity and the solvent action that diesel fuel has, so its effects on animals are expected to be less severe. A lot of research and development is needed in this aspect to make the biodiesel easily available to everyone.

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