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Biodiesel Production from Waste Cooking Oil

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Abstract: **Biodiesel is receiving increased attention as an alternative, non-toxic, biodegradable and renewable diesel fuel and contributes a minimum amount of net greenhouse gases, such as CO2, SO2 and NO emissions to the atmosphere. Exploring new energy resources, such as biofuel is of growing importance in recent years. The possibility of obtaining oil from plant resources has created a great importance in several countries. Vegetable oil after esterification being used as bio diesel, Considering the cost and demand of the edible oil is bearable, so it may be preferred for the preparation of bio diesel in India.**

The transesterification of waste cooking oils with methanol as well as the main uses of the fatty acid methyl esters are reviewed. The general aspects of this process and the applicability of different types of catalysts (acids, alkaline metal hydroxides, alkoxides and carbonates, enzymes and non-ionic bases, such as amines, amides, and guanidine and triamino (imino) phosphoranes) are described. Transesterification is carried in a reaction cavity, once the reaction is complete, glycerine and biodiesel are gravity separated.

Keywords: **Waste cooking oil, Transesterification, Bio Diesel, Fuel Characterization, Alternate Energy**

I. INTRODUCTION

The increasing awareness of the depletion of fossil fuel resources and the environmental benefits of biodiesel fuel has made it more attractive at present time. The concept of using vegetable oil as a fuel dates back to 1895 when Dr. Rudolf Diesel developed the first diesel engine to run on vegetable oil. Diesel demonstrated his engine at the World Exhibition in Paris in 1900 using peanut oil as fuel.

The cost of biodiesel, however, is the hard work to its commercialization in comparison to petroleum-based diesel fuel. Used cooking oil is one of the economical sources for biodiesel production. Waste cooking oil contains water and free fatty acids; supercritical transesterification offers great advantage to eliminate the pre-treatment capital and operating cost.

Especially for the conversion of waste cooking oil to biodiesel, the supercritical process is an interesting technical and economical alternative.

II. BIODIESEL

Biodiesel consists of the methyl esters of the fatty acid components of the triglycerides that make up most animal fats and vegetable oils which can be used in unmodified diesel-engine vehicles. While there are numerous interpretations being applied to the term biodiesel, the term biodiesel usually refers to an ester, or an oxygenate, made from the oil and methanol or we can say that Biodiesel is the trans esterified vegetable oil that makes it suitable for use as a diesel fuel. Transesterification, also called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis.

A. *Waste Cooking Oil*

Cooking oil used for frying are sunflower oil, palm oil, coconut oil etc. As they are easily available and especially so of the coconut oil which is abundantly available in South India. The waste cooking oil samples used for the purpose is of usually palm oil because it is commonly used oil in the restaurants and hostel kitchens.

B. *Characteristics of Waste Cooking Oil*

The quality of oil is expressed in terms of the physio-chemical properties such as acid value, saponification value, and iodine value. The saponification value of waste cooking oil (WCO) was reported as 186.3 (mg KOH/g). The acid value of waste cooking oil was found to be 17.41 mg KOH/ gm. It has been reported that transesterification would not occur if FFA content in the oil were above 3 wt%.

C. *Chemical Composition of waste cooking oil*

Huge quantities of waste cooking oil and animal fats are available throughout the world, especially in the developed countries. Palmitic acid and stearic acid were the major saturated fatty acids found in our waste cooking oil. The fatty acids composition of palm oil is palmitic, oleic and stearic acid and in addition to it much less proportion of myristec, lauric, lenolenic and capric acid.

D. *Yield comparison of other oils biodiesel candidates*

Soya oil	446
Sunflower oil	952
Castor oil	1413
Coconut oil	2689
Palm oil	5950

(Crop oil in liters per hectare)

E. *Indian & World Scenario*

Waste cooking oil is produced in different countries in various amount as statistics show that developed countries like Canada, U.S.,U.K produce million gallons of waste cooking oil per day as large amounts of waste cooking oils are illegally dumped into rivers and landfills causing environmental pollution. The use of waste cooking oil in production of Biodiesel offers significant advantages because of the reduction in environmental pollution.

The energy information Administration in the United States estimated that some 100 million gallons of waste cooking oil is produced per day in USA. The per capita waste cooking oil production in Canada is approx. 9 pounds per year. In the EU countries, the total waste cooking oil production is approximately 700,000-1,000,000 tons/year. The UK produces over 200,000 tons of waste cooking oil per year.

F. *Fuel Properties*

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Fuel properties analysis was carried out according to ASTM Biodiesel Standards. Fuel characteristics of biodiesel and high speed diesel (HSD) which were tested include dynamic viscosity at 40°C 5.311 eta., kinematic viscosity at 40°C 4.720 any, density at 40°C 0.860 Rho, color comparison, flash point 183°C, cloud point 4°C, pour point -5°C, specific gravity at 60°F 0.890 kg/1, sulphur contents 0.003 %, cetane index 50.40.

G. *Advantages of Biodiesel*

- Biodiesel is about 10% oxygen by weight and contains no sulphur.
- Biodiesels are biodegradable, nontoxic, renewable source of energy.
- Biodiesel can be used alone or mixed with petroleum fuel.
- Biodiesel has a high flash point making it one of the safest of all alternative fuel.
- Biodiesel runs in any conventional, unmodified diesel engine.

III. METHODOLOGY

A. *Biodiesel Production*

Biodiesel is made by a chemical process called transesterification, where organically derived oils (vegetable oils, animal fats and recycled restaurant greases) are combined with alcohol (usually methanol) and chemically altered to form fatty esters such as methyl ester. The biomass-derived esters can be blended with conventional diesel fuel or used as a neat fuel (100% biodiesel). The process results in two products -- methyl esters (biodiesel) and glycerin (a valuable by-product usually sold for use in the production of soap).

A. *Reference solution*

- 1 gram of NaOH dissolved in 1 liter of distilled water.
- Using a funnel, we pour ~20 ml of pre-made reference solution into burette.

B. *Making of the analyte solution*

- Measured 10 ml methyl alcohol into each of three 50 ml beakers.
- Add 2-3 drops of phenolphthalein solution into the alcohol in each beaker.
- Stirr to mix.
- Using a graduated pipette, measure 1 ml of feedstock oil into alcohol solution in each beaker
- Stirr to mix.

C. *Titrations*

- Placed the beaker under the burette containing reference solution.
- Recorded the initial quantity of reference solution.
- Slowly added reference solution ~.5 ml at a time to the oil/alcohol solution.
- Stirr the beaker.
- Continue to add reference solution to the oil/alcohol solution until it turns pink and stays pink for ~30 seconds.
- Stop.
- Determined and recorded the quantity of reference solution used: T = Remaining quantity – Initial quantity.
- Complete three titrations of filtered and settled waste vegetable oil recording each value.
- Average the three values to get T.
- Calculate the appropriate amount of lye in grams needed to neutralize a 1 liter batch of feedstock oil: (T+ 3.5)
- Production of Bio Diesel on a large scale is done in a reactor.

B. *Transesterification Process*

In the transesterification of vegetable oils, a triglyceride reacts with an alcohol in the presence of a strong acid or base, producing a mixture of fatty acids, alkyl esters and Glycerol. However, an excess of the alcohol is used to increase the yields of the alkyl esters and to allow its phase separation from the glycerol formed.

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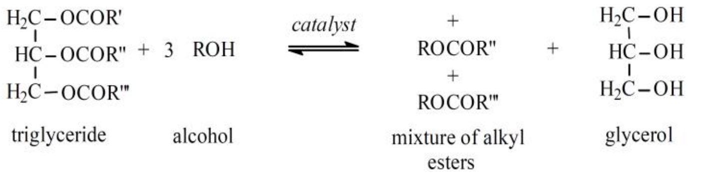
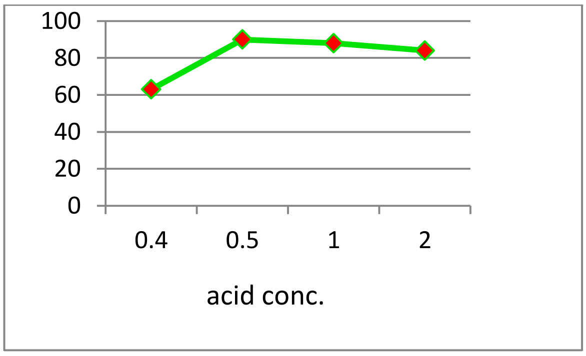
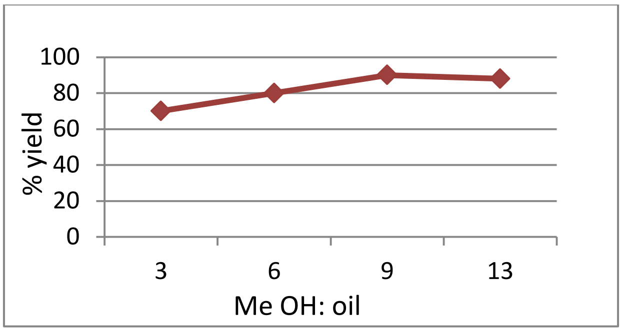


IV. RESULTS AND DISCUSSION

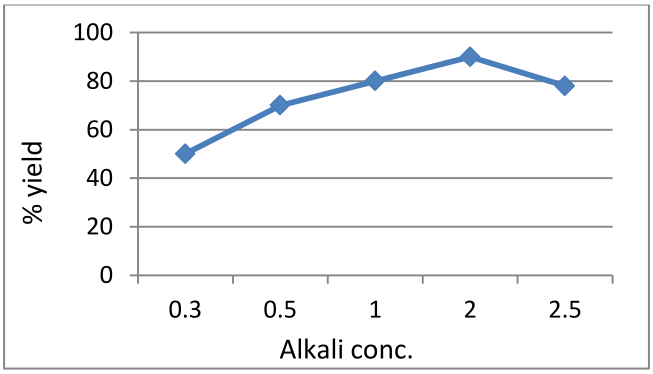
A. *Sulfuric Acid Process (Two-Step Transesterification)*



Acid esterification reaction was studied for four different molar ratios. The sulfuric acid catalyst amount was varied in the range of 0.3% to 2%. These percentages are based on volume of the oil used for the acid esterification reaction. The catalyst amount also affects the yield of process is shown in Figure 1. The acid-catalyst process attained maximum yield for waste cooking oil at 0.5% catalyst concentration. It was observed that the yield started to decline when the catalyst concentration was increased to above 0.5%.



Methanol to oil molar ratio was varied for waste cooking oil within the range of 3:1 to 9:1. The maximum biodiesel yield for waste cooking oil was found at the methanol to oil molar ratio of 6:1 in acid esterification. In alkali transesterification, the maximum yield for waste cooking oil was obtained at the methanol to oil molar ratio of 9:1. The yield remains the moreover same with further increase in the methanol to oil molar ratio. The excess methanol in the ester layer can be removed by distillation. Canakci and Van Gerpan [25] advocate the use of large excess quantities of methanol (15:1-35:1) while using the sulphuric acid as catalyst. **Figure 2** shows the methanol to oil molar ratio effect in alkali transesterification (Step 2). At higher levels, an excess methanol amount may reduce the concentration of the catalyst in the reactant mixture and retard the transesterification reaction.



An alkali catalyst was studied in the range of 0.3% to 2.5% using KOH as an alkali catalyst. The influence of the alkali catalyst amount on the yield is shown in Figure 3. The maximum yield was achieved for waste cooking oil at 2% of catalyst loading. During the experiments, it was also observed that transesterification could not take place properly with an insufficient amount of an alkali catalyst loading. The production yield slightly de-creased above 2% of catalyst loading. At higher concentrations, the intensification of mass transfer became more important than increasing the amount of catalyst. The reaction temperature effect on the yield was studied in the temperature range of 40°C to 100°C at atmospheric pressure.

B. Separation of Biodiesel from Byproducts

The separation of Biodiesel From its byproducts is done by magnetic stirrer. After mixing we leave it for some time then we see two different layers of Biodiesel ester and glycerin. At last Settlement and separation of glycerol is done by washing of Methyl ester with water.

C. Properties of methyl ester from waste cooking oil

Properties of methyl ester from waste cooking oil	Waste Cooking Oil	Waste cookin g methyl ester	Biodi esel standa rd	Regul ar Diese l
Specific Gravity	0.92	0.87 - 0.88	0.86 - 0.90	0.85
Viscosity (mm2/s) at 40°C	28.8	2.25 - 3.10	1.9 - 6.0	2.6
Calorific Value (MJ/kg)	44.44	45.08 - 45.24	Repor t	42
Cetane Number	32.48	55.45 - 56.10	47 min.	46

V. CONCLUSION

Waste cooking oil can be an important source for Biodiesel production in Canada as there is large quantity of waste cooking oil available. Use of waste cooking oil helps improvement of the Biodiesel economics. Biodiesel is environmentally friendly. Keeping in view its all properties it is a good substitute for diesel fuel. The Biodiesel is found to burn more efficiently than diesel. The emission of carbon monoxide, hydrocarbon, oxides of nitrogen and smoke are decreased in comparison with diesel.

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