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PRODUCTION OF AN ALTERNATIVE FUEL FROM A LOW COST FEEDSTOCK- AN ECONOMICAL VIEW

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Abstract — *Due to the finite stock of fossil fuels and its negative impact on the environment, many countries across the world are leaning toward renewable energy sources. Biodiesel is one kind of biofuel which is renewable and biodegradable. It is proved to be the best replacement for diesel because of its unique properties like significant reduction in green house gas emissions, non-sulfur emissions, non-particulate matter pollutants and low toxicity. Biodiesel can be produced from vegetable oils and animal fat. In this work, biodiesel was prepared using waste cooking oil which will be discarded as a waste in the environment. The main reason for using waste cooking oil as a feedstock is to reduce the production cost of biodiesel and also to maintain food security. With this cheaper feedstock, biodiesel is prepared by the process of transesterification with the addition of base catalysts like NaOH and KOH in methanol. In addition, quantification of fatty acid methyl ester in biodiesel was studied using FTIR.*

Keywords*- biodiesel, waste cooking oil, catalysts, transesterification etc*

I. INTRODUCTION

Transportation system plays a vital role for communicating people all over the world, not only for communicating people but also for transporting goods all over the world. Fossil fuel being non-renewable energy resource take millions of years to form is now exhausted due to the over consumption of fuel. Some disadvantages associated with are increased price, environmental degradation like emission of harmful gases, increase in CO_2 concentration which is largely responsible for green house effect and global warming etc. In order to overcome the above mentioned defects, biofuels have been used nowadays instead of fossil fuels. Examples of biofuels are bioethanol and biodiesel.

Biodiesel is one kind of biofuel that is renewable, biodegradable and has similar properties of fossil diesel fuel [Neha et al., 2013]. Biodiesel refers to a vegetable oil or animal fat based diesel fuel consisting of long chain alkyl (methyl, ethyl or propyl) esters. Biodiesel is meant to be used in standard diesel engines. Biodiesel can be used alone or blended with petrodiesel in any proportions [1]. The National Biodiesel Board (USA) also has a technical definition of “biodiesel” as a mono-alkyl ester.

Biodiesel is produced by the process of transesterification. In transesterification reaction, the triglyceride component of oil reacts with alcohol in presence of NaOH or any other catalyst to give corresponding ester and glycerol [2]. However, greater conversions into biodiesel can be reached using methanol. Common catalysts for transesterification include sodium hydroxide, potassium hydroxide, and sodium methoxide. The catalysts used for the transesterfication of triglycerides may be basic or acid or enzymatic.

The term waste cooking oil (WCO) refers to vegetable oil that has been used in the cooking of food and which is no longer viable for its further use in food production. WCO arises from many different sources, including domestic, commercial and industrial [2]. Used oils can only supply a small percentage of diesel fuel demand, so this source will not solve the energy problem, but it may decrease the dependence on fossil oil while reducing an environmental issue(Dorado,2008) [3].

The main objective of this work is the production of biodiesel from waste cooking oil which is a low-cost feedstock by using cheaper catalyst like NaOH and KOH. Properties of biodiesel were studied. The biodiesel produced in the study is characterized by FT-IR studies.

“II. Experimental Methods”

A. Free fatty acid (FFA) analysis

The first step to carry out for the production of biodiesel is FFA analysis. This analysis is used to determine, whether the production of biodiesel is done by esterification or transesterification. The acid value is a common parameter in the specification of fats and oils. It is defined as the weight of KOH/NaOH in milligram needed to neutralize the organic acids present in 1g of fat or oil [4, 5] and it is a measure of the free fatty acid (FFA) present in the fat or oil.

Acid value

Where,

N is the normality of KOH/NaOH,
V is the volume remaining in the burette after titration,
W is the weight of the sample.

From this acid value formula, the FFA value of the sample can be found using the formula given below,
FFA = 0.503× ACID VALUE

B. Experimental Details of biodiesel production:

Experiments were designed to determine the yields of methyl esters using two different catalysts i.e., KOH and NaOH.

The transesterification of waste cooking oils is performed in a simple process. However, the process conditions must be carefully controlled in order to achieve an optimal yield at the optimal temperature and reaction time [2]. 50 ml of oil + 10 ml of methanol + catalyst (NaOH/KOH) mixture are placed in a magnetic stirrer for 1 hour at 350 rpm and then it is maintained at 60^{o}c. The mixture is transferred to the separating flask which is used to separate methyl ester and glycerol. The mixture is left undisturbed for 8 hours. The separated methyl ester is water washed for 3-4 times using distilled water. After washing the methyl ester is heated upto 104^{o} C for removal of excess of water.

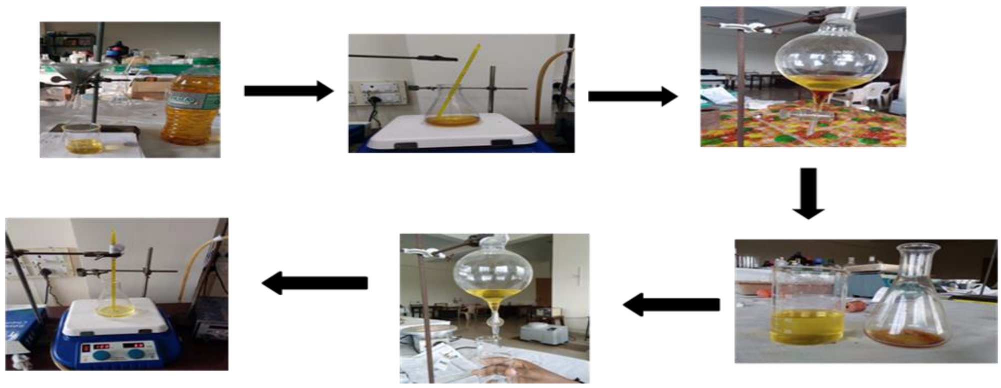

Figure 1.1 Preparation of biodiesel

"III. Results and Discussion"

If the value of FFA is below 3, transesterification process alone is enough for the production of biodiesel. If the FFA value is greater than 3, both esterification and transesterfication process are involved in the production of biodiesel. In the present study, FFA of the oil is 0.2 mg/KOH which is below 3, therefore the process of transesterfication alone is carried out.

The rate of reaction is strongly influenced by reaction temperature and therefore it is carried out close to the boiling point of methanol at atmospheric pressure. Stoichiometrically, the reaction need 3 moles of alcohol per mole of oil to give 3 moles of fatty acids and one mole of glycerol. A molar ratio of 6:1 is used in industrial process to obtain methyl ester higher than 98%. The mixing plays a significant role during the reaction. After phase separation, mixing becomes insignificant.

Concentration in the range of NaOH as a catalyst from 0.15 to 0.225g/ml has been worked to achieve maximum conversion of oil into ester. It is shown in Fig.1.2. Similarly, concentration with the same ratio of KOH as a catalyst was also studied (Fig.1.3). Comparison on the basis of yield is made between the two catalysts. It is observed that, KOH exhibits better catalytic activity than NaOH.

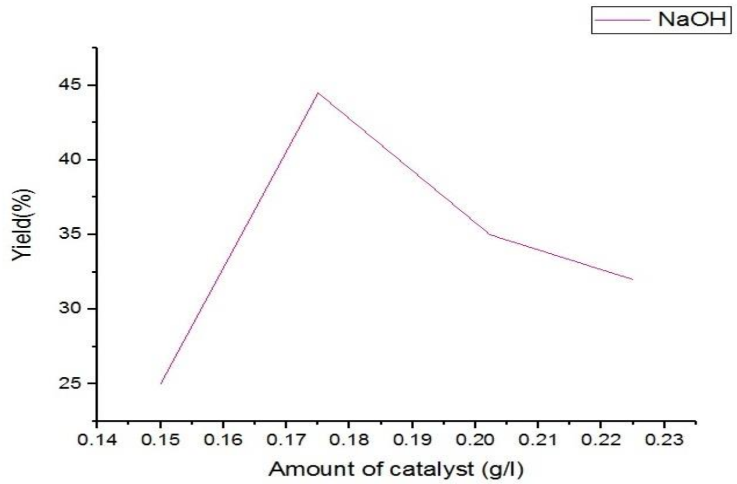

Figure 1.2 Effect on amount of catalyst (g/l) with respect to their Yield (%)

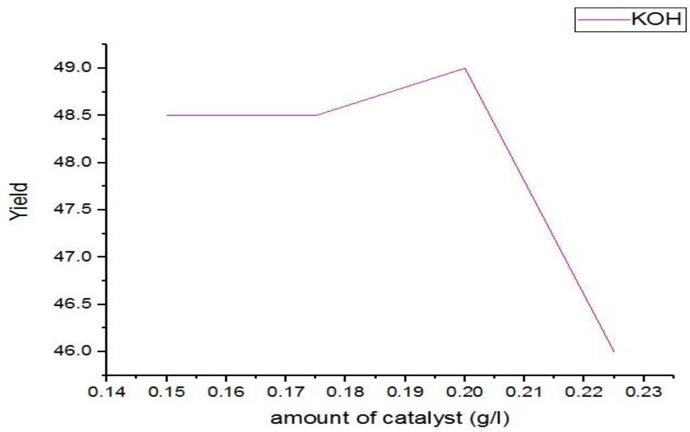

Fig 1.3 Effect on amount of catalyst (g/l) with respect to their Yield (%)

KOH produces a better yield than NaOH in all the transesterification process. Considering the properties measured such as specific gravity, kinematic viscosity, saponification value, iodine value etc. all fell within the standard range of ASTM D6751. Contamination of biodiesel significantly affects its density; therefore density can also be an indicator of contamination. The density of an ester depends on the molar mass, free fatty acid content, the water content and temperature. The specific gravity of biodiesel at 25 C is 0.82.

The viscosity of the liquid fuel is their property to resist the relative movement tendency of their composing layers due to intermolecular attraction forces. Due to the presence of electronegative oxygen, biodiesel is more polar than the diesel fuel. The viscosity of the produced methyl ester in the study was 3.89 cSt. The following table explains the fuel properties of biodiesel.

Table 1.1 Fuel properties of biodiesel

Parameters	**Value**
Specific gravity @25 °C	0.82
Kinematic Viscosity	3.89 cSt
Saponification value	191
Iodine value	86
Moisture	0.12

C. Characterization of biodiesel using FT-IR

FT-IR stands for Fourier transform infrared, the preferred method of infrared spectroscopy. When IR radiation is passed through a sample, some radiation is absorbed by the sample and some passes through (is transmitted). The resulting signal at the detector is a spectrum representing a molecular fingerprint of the sample.

The FTIR spectra for the sample of waste cooking oil methyl ester obtained with the conditions of catalyst (NaOH) 0.175 g/ml, reaction time of 1 hr and 6: 1 molar ratio of methanol to oil at 60 °C is presented in Fig 1.4. The FTIR spectra for the sample of waste cooking oil methyl ester obtained with the conditions of catalyst (KOH) 0.2 g/ml, reaction time of 1 hr and 6: 1 molar ratio of methanol to oil at 60 °C is presented in Fig 1.5.

In the region from 1800 – 1700 cm^{-1}, it can be observed peaks that can be attributed to the stretching of C=O, typical of esters and thus are common in both the samples. The peak at 1500 cm^{-1} corresponds to the asymmetric stretching of –CH_3 present in the biodiesel spectrum (Rabelo et al., 2015). The stretching of O-CH_3 represented by the absorbance at 1172 cm^{-1} and 1168 cm^{-1} is typical peak of biodiesel for both NaOH and KoH.

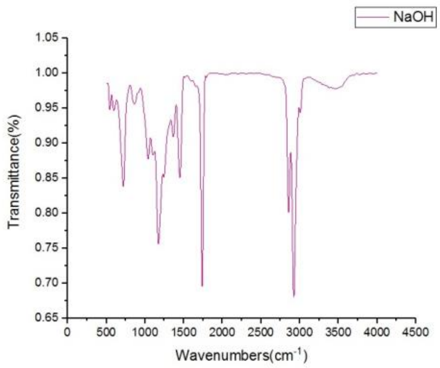

Figure 1.4 FT-IR of NaOH

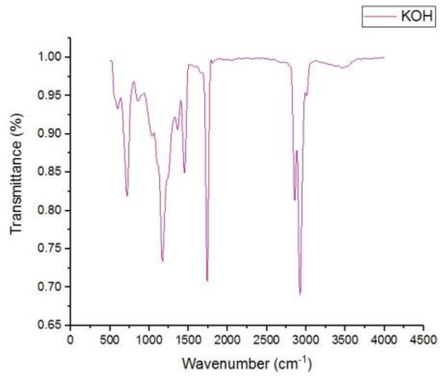

Figure 1.5 FT-IR of KoH

D. Economics of biodiesel

India has rich and abundant resources of edible and non edible oil seeds, the production of which can be stepped up manifolds if the government provides incentives to farmers for production of biodiesel (Shereena and Thangaraj, 2009). The economic feasibility of biodiesel depends on the price of crude petroleum and the cost of transporting diesel over long distance to remote areas. It is a fact that the cost of diesel will increase in future owing to the increase in its demand and limited supply. Further, strict regulation on the aromatic and sulphur content of diesel fuels will make diesel costlier, as the removal of aromatics from distillate fractions needs costly processing equipment and continuous high operational cost as large amount of hydrogen are required for ring saturation. Similarly, reducing the sulphur content is a big challenge for the industries. The production of biodiesel is much more expensive than mineral diesel due to the relative cost of vegetable oil. Methyl ester produced thus cannot compete economically with diesel fuels unless they are granted protection from tax levies. It is considered that waste cooking oil can be diverted for biodiesel production and thus may reduce the cost of fuel.

Table 1.2 Economic study of biodiesel

SI.NO	VARIABLES	QUANTITY USED	RATE
1	Waste cooking oil	1 litre	No cost since the raw material is a disposable oil
2	Methanol	200ml	27. 04
3.	Catalysts (NaOH and KOH)	3.5 g	02.18
4.	Electricity		07.00
5.	Total		36.22

Economics of biodiesel production from waste cooking oil were studied (Table 1.2). The raw material used here are the waste cooking oil which are discarded from the University Canteen (Science Block) every week. When discarded, the oil causes environmental pollution. Since the oil is unfit for cooking, there is no need to calculate the cost of raw material. The quantity and cost of alcohol, catalyst and the electricity utilized are calculated and was estimated as Rs. 36.22/litre. The cost of conventional diesel in the market today is Rs.68 which is double the cost of production. Hence, biodiesel production was found to be affordable and comparable to the existing diesel prices.

"IV. Conclusion"

An experimental study to investigate the effects of alkaline catalysts on biodiesel yield and its quality was carried out. Since the catalytic activity is very high in KOH than NaOH, results of the study recommend that KOH can be a preferred catalyst for biodiesel production. Overall study in the properties and characterization by FTIR indicates that waste cooking oil can be used as a potential source for the preparation of biodiesel.

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