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Optimized Parameters for Production of Biodiesel from Fried Oil

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Abstract: Optimization of transesterification process variables affecting biodiesel production is worthy of continued study because renewable energy sources are the one which uses as alternative resources for the problems arising from the scarcity of conventional energy sources. These alternative sources are majorly used in transportation which is a major aspect in nowadays. A liquid or gaseous fuels for the transport sector that are mostly produced from biomass is called biofuels. They include energy security reasons, environmental concerns, social and an economic issue related to the rural sector.Biodiesel is one of the biofuel which is a renewable replacement to petroleum based diesel. Several processes for biodiesel fuel production have been developed, among which transesterification using alkali-catalysis gives high levels of conversion of triglycerides to their corresponding methyl esters in short reaction times. It is prepared from waste vegetable oils and animal fats by transesterification process. It is alkali catalyzed reaction which involves waste cooking oil, methanol, and Potassium hydroxide. The study focuses on the Yield of biodiesel is affected by ratio of methanol and waste cooking oil, KOH concentration and operating parameters.

Key words*:* Renewable energy, biofuel, transesterification, Vegetable oil.

I. INTRODUCTION

Increasing the environmental pollution by the usage of conventional fuels and their price together with depletion of fossil fuels motivated the scientists to research on identification of alternative sources like bio fuels. Biodiesel is a renewable, biodegradable, environmentally benign, energy efficient, substitution fuel which can fulfill energy security needs without sacrificing engine's operational performance. Thus, it provides a feasible solution to the twin crises of fossil fuel depletion and environmental degradation [1]. It is superior to conventional diesel in terms of its sulphur content, aromatic content and flash point [2]. These advantages could be a key solution to reduce the problem of urban pollution since transport sector is an important contributor of total gas emission.

It is essentially comes from plants and animals. The major source of biodiesel is soya bean oil, but other oils include rapeseed, canola, palm, cottonseed, sunflower, and peanut[3]. However, the raw material costs and limited availability of vegetable oil feed stocks are always critical issues for the biodiesel production. The use of edible vegetable oils and animal fats for biodiesel production has recently been of great concern because they compete with food material-the food versus fuel dispute. There are concerns that biodiesel feedstock may compete with food supply. Hence, the use of non-edible plant oil sources and waste products of edible oil industry as the feedstock for biodiesel production [4]. Moreover, according to many researches, net energy ratio of waste vegetable oil is higher than edible as well as petro diesel. Based on waste management standpoint, producing biodiesel from used frying oil is environmentally beneficial. Since it reduces the CO_2 content in the yield which is the main contributor of global warming and climate change through enhanced use of fossil fuels. Relative to the fossil fuels they displace, greenhouse gas emissions are reduced 41% by the production and combustion of biodiesel [3].

Method of biodiesel production- Transesterification

The common and industrial method to produce biodiesel is chemically described as the transesterification of oil with short chain alcohol. Transesterification is nothing but where an ester is transformed into another through interchange of the alkoxy moiety [5].

Generally, the main contents of vegetable oil and animal fats were triglycerides. The transesterification of triglycerides with alcohol is a three steps reversible reaction. This reaction proceeds essentially by mixing the reactants, however, it may accelerate with the presence of a catalyst.

There are so many methods of transesterification to produce biodiesel in this we have chosen base or alkali catalyzed transesterification[6].

Base or Alkali catalyzed transesterification

Base-catalyzed transesterification involves stripping the glycerin from the fatty acids with a catalyst such as sodium or potassium hydroxide and replacing it with an anhydrous alcohol, usually methanol.

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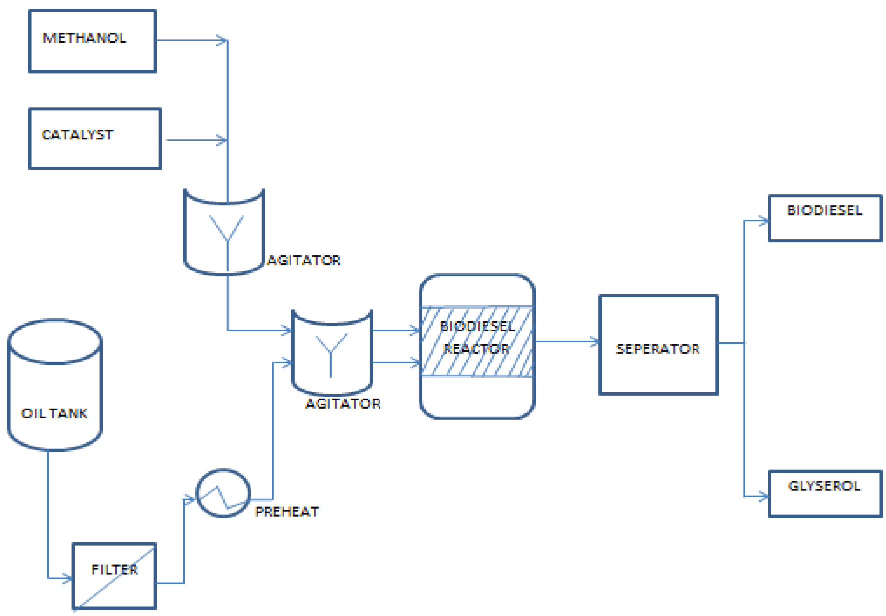

Fig 1: Base catalyzed transesterification process flow sheet

II. EXPERIMENTAL

Pretreatment processes

The negative effects of the undesirable compounds from frying or waster vegetable oils can be avoided by different types of pretreatment processes [7]. These processes can be done by maintaining the oil relatively by heating. To ensure an anhydrous medium the filtered oil can be subjected to drying by heating it to 50 ºC for at least 15 min. Here hot air oven as a heat source which supplies our required temperature to the oil. As we were maintained this temperature, all the moisture content and undesirable volatile components were evaporated. At last we got moisture-free pure oil.

General Procedure:

After completion of pretreatment process, To prepared the mixture of methanol and NaOH of suitable quantity, the catalyst (NaOH) was dispersed in methanol by vigorous shaking. Now this mixture is allowed to mix vigorously with pretreated oil by using magnetic stirrer for 20 minutes [8].

The magnetic stirrer we are using gave the homogeneous mixture as well as it maintains the constant reaction temperature. We should ensure that the reaction temperature should be constant, because during the stirring the reactants gets involved in the reaction and converts into product. After thorough mixing we kept it in rest condition for required period of time to permit complete reaction. After that three layers were formed, in that upper layer contains soap, middle layer contains our required product biodiesel whereas the lower layer consists of Glycerin which is by-product and this layer consists of excess methanol, unreacted catalyst. At final stage, we separated these three layers by using manual operations and we measured the quantity of yield of biodiesel[9].

Biodiesel Testing method:

We have dissolved 25 ml of biodiesel in 225 ml of methanol. The biodiesel was fully soluble in the methanol forming a clear bright phase. This complete solubility of required product in methanol confirms that our final product is biodiesel. The yield of biodiesel can be affected by several parameters.

III. RESULTS AND DISCUSSION

Parameters affecting base-catalyzed transesterification:

The main parameters affecting the base-catalyzed transesterification process are: alcohol formulation, alcohol/oil molar ratio, catalyst formulation, concentration, reaction temperature, reaction time [10].

(i) Alcohol formulation:

Short-chain alcohols such as methanol, ethanol and butanol are the most frequently employed. Although the use of different alcohols presents some differences with regard to the reaction kinetics, the final yield of esters remains more or less inalterable. Therefore, selection of the alcohol is based on cost and performance consideration. Methanol was dominating in most conditions, where ester production was modeled because methyl esters are the predominant commercial products. Methanol is considerably cheaper and more available, and the downstream recovery of unreacted alcohol is much easier.

Methanol is not miscible with triglycerides at room temperature and the reaction mixture is usually mechanically stirred to enhance mass transfer.

During the curse of reaction, emulsions are usually formed. In the case of methanolysis, these emulsions break down quickly and easily to form a lower glycerol rich layer and upper methyl ester rich layer. Methanol shows more solubility than other two alcohols (ethanol, butanol), because the increase in carbon content will leads to decrease in solubility. Because of this solubility biodiesel yield observed on methanol was higher than other alcohols.

(ii) Catalyst formulation:

The correct amount of catalyst should be used because both excess as well as insufficient amount of catalyst may cause soap formation. Correct amount of catalyst can be determined by volumetric titration on oil. Among the most commonly used alkaline catalysts in the biodiesel industry are potassium hydroxide (KOH) and sodium hydroxide (NaOH) flakes which are inexpensive and easy to handle in transportation and storage.

Here we are using NaOH pellets as the catalyst, which is a chemical solid catalyst, the advantages of this catalyst are Short reaction time, usually between 1hour to 4hours, Requires low catalyst concentration(about 1%), Catalyst is cheaper, No inhibition of reaction takes place.

(iii) Alcohol/oil molar ratio:

One of the most important variables affecting the yield of ester is the molar ratio of alcohol to triglyceride. The stoichiometric ratio for transesterification requires three moles of alcohol and one mole of triglyceride to yield three moles of fatty acid alkyl esters and one mole of glycerol. However, an excessive amount of alcohol makes the recovery of the glycerol difficult, so that the ideal alcohol/oil ratio has to be established empirically. To get the exact value of methanol required, we have conducted this experiment by taking different values of methanol.

We have done four experiments, each experiment consists of 250 ml of fried oil and the amount of alcohol varied as 42 ml, 65 ml, 75 ml, 85 ml. As this four experiments have the different ratios of amount of methanol and alcohol, the resulting biodiesel values also varies, resulting the below figure.

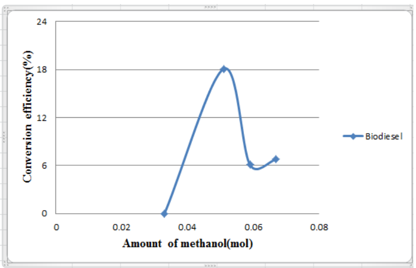

Fig 2: Effect of amount of methanol on transesterification

From fig.2, we can conclude that the maximum production of the biodiesel can be obtained by taking 65 ml of methanol. The higher alcohol molar ratio interferes with the separation of glycerol because there is an increase of solubility. For lower and higher values of alcohol, production of biodiesel decreases.

(iv) Catalyst Concentration:

The amount of catalyst plays vital role in this process because the solid catalyst (NaOH) that we are using here accelerates the rate of reaction. Based on the amount we are using, catalyst will give positive results or negative results. The addition of an excessive amount of catalyst, however, gives rise to the formation of an emulsion, which increases the viscosity and leads to the formation of gels. These hinder the glycerol separation and, hence, reduce the apparent ester yield. Further increases in catalyst concentration will not increase the conversion and will lead to extra costs because it will be necessary to remove it from the reaction medium at the end. Less amount of catalyst will slow the reaction.

We have conducted 7 experiments, each experiment consists of 250 ml of fried oil and the amount of alcohol varied as 2g, 2.5g, 3.5g, 4g, 5g,7g.

From fig.3 we can conclude that the maximum production of the biodiesel can be obtained by taking 3.5 grams of NaOH and 65 ml of methanol. For lower

Fig 2: Effect of amount of methanol on transesterification and higher values of alcohol, production of biodiesel decreases.

(v)Reaction temperature:

Temperature is one of the main parameter which controls the yield of the biodiesel. Higher temperatures decrease the time required to reach maximum conversion. Transesterification can be conducted at various temperatures ranging from room temperature to the boiling point of the alcohol (Here we are using methanol, having boiling point at 68^{0} C) employed. When the reaction temperature closes or exceeds the boiling point of methanol (68 °C), the methanol will vaporize and form a large number of bubbles which may inhibit the reaction. We have done 3 experiments, each experiment consists of 250 ml of fried oil and the reaction temperature varies as 50 ^{0}C, 60 ^{0}C and 70 ^{0}C.

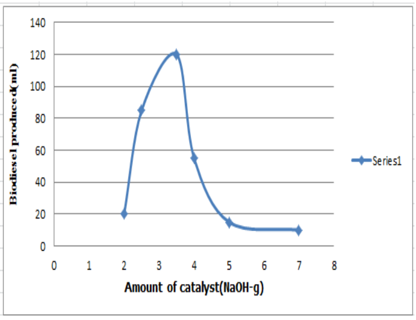

Fig 3: Effect of amount of catalyst (NaOH) on transesterification

From fig.4 we can say that at 60 °C higher biodiesel yield than the temperatures of 50 and 70°C for used frying oil. When the reaction temperature closes or exceeds the boiling point of methanol (68 °C), the methanol will vaporize and form a large number of bubbles which may inhibit the reaction. Hence we can say that

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optimum temperature is 60 °C.

(vi) Reaction time:

The completion of the basic- catalyzed transesterification process depends on reaction time. It is suggested that excess reaction time does not increase the conversion but favors the backward reaction (hydrolysis of esters) which results in a reduction of product yield. The experiment was conducted from 40-120 min of reaction time with 50-70°C of reaction temperature for 1 wt %

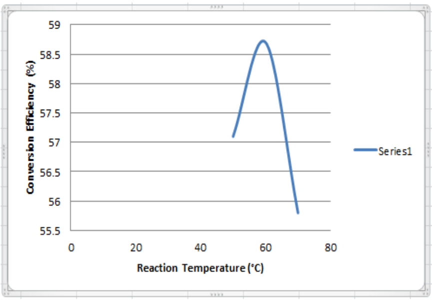

Fig.4: Effect of reaction temperature on biodiesel production.

of catalyst used in 6:1 molar ratio of used frying oil and fresh oil. 120 min of reaction time gave a good result than other reaction times used here.

We have done 3 experiments, each experiment consists of 250 ml of fried oil and the reaction time varies as 40 min, 80 min and 120 min.

Fig.5 shows that, the effect longer mixing gives higher yield than using shorter time. So, 120 min of reaction time gave a good result than other reaction times used here. In other words, the biodiesel yields increases with increasing the reaction time for lower and higher values of alcohol, production of biodiesel decreases. It was reported that excess reaction time does not increase the conversion but favors the backward reaction (hydrolysis of esters)

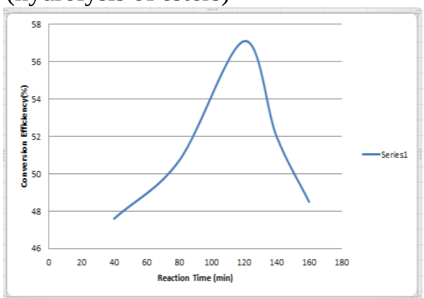

Fig 5: Effect of reaction time on biodiesel production.

Which results in a reduction of product yield. As well as for very less reaction time the reaction does not complete. Hence, 120 minutes is optimum reaction time.

Biodiesel applications:

- Environment pollution:

Biodiesel reduce the environmental pollution. The gases produced from the burning of biodiesel are non-toxic. It can reduce CO2 emissions by 78% and lower the carcinogenic properties of diesel fuel by 94%. The use of biodiesel also reduces emission of carbon monoxide and other pollutants such as Sulphur IV Oxide and unburned Hydrocarbon by 20 to 40%.

- Engine Operation:

Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely. Lowered content and gradually reducing of allowable sulphur to only 15ppm, has been to reduce the lubricity of petroleum diesel. To avoid this problem petroleum diesel blends with biodiesel. Biodiesel improves the fuel lubricity, raises the cetane number of fuel and also contributes to an engine's ease of movement.

- 20% Biodiesel is blends (20% biodiesel + 80% of petroleum diesel) are used run vehicles.
- Biodiesel is used as heating fuel in domestic and commercial boilers, as a solvent for varnishes and in producing power energy i.e electrical energy,thermal energy etc.

IV. CONCLUSION

Used frying oil may be an easily available resource for the transesterification of biodiesel. Transesterification is a low cost process which brings about a change in the molecular structure of the vegetable oil molecules, thus bringing down the levels of viscosity, density and unsaturation of vegetable oil. The methanol/oil molar ratio was one of the variables that had more influence on the process. Within the range of 42 ml to 85 ml, the optimum results are obtained at the 65 ml of alcohol. Catalyst concentration of 2g, 2.5g, 3.5g, 4g, 5g and 7g were employed and optimum concentration is 3.5g. The temperature ranges of 50, 60, and 70°C used for biodiesel production and the optimum temperature is 60^{O}C. We allowed this reaction to proceed for the time periods of 40 min,80 min,120 min, 140 min and 160 minutes and we got best results at 120 minutes. So these are the optimum conditions for optimum result.

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