

Harnessing Biomass Energy for the Production of Biodiesel

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Abstract—The transesterification reaction is actually The demand for petroleum is increasing with each passing day. This may be attributed to the limited resources of petroleum crude. In that case it becomes utmost necessity to search for alternative fuels which are renewable and in that biodiesel emerges as a real solution. Biodiesel is a cleaner burning fuel than diesel and a suitable replacement. It is made from non-toxic, biodegradable, renewable resources. Biodiesel can be produced in many ways. The method used in the laboratory was transesterification which is actually replacement of alcohol group from an ester by another alcohol. The reaction was carried out by varying different parameters to find the best conversion of oil to biodiesel. Alkali catalysed transesterification is considered to be the best amongst all methods available for the production of biodiesel from fresh oil. It was found out that the rate of transesterification reaction in a batch reactor increases with temperature. Higher temperatures do not reduce the time to reach maximal conversion. The conversion of triglyceride, diglyceride and monoglyceride appears to be second order upto 10 minutes of reaction time. Our aim is to establish the kinetics of the reaction during transesterification and to do the modeling and predict rate equation for the reaction.

Index Terms—Biodiesel, parameters, reaction, transesterification.

I. INTRODUCTION

The most common way to produce biodiesel is by transesterification, which refers to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield fatty acid alkyl esters (i.e., biodiesel) and glycerol. Triglycerides, as the main component of vegetable oil, consist of three long chain fatty acids esterified to a glycerol backbone. When triglycerides react with an alcohol (e.g., methanol), the three fatty acid chains are released from the glycerol skeleton and combine with the alcohol to yield fatty acid alkyl esters (e.g., fatty acid methyl esters or biodiesel). Glycerol is produced as a by-product. Methanol is the most commonly used alcohol because of its low cost and is the alcohol of choice in the processes developed in this study. In general, a large excess of methanol is used to shift the equilibrium far to the right.

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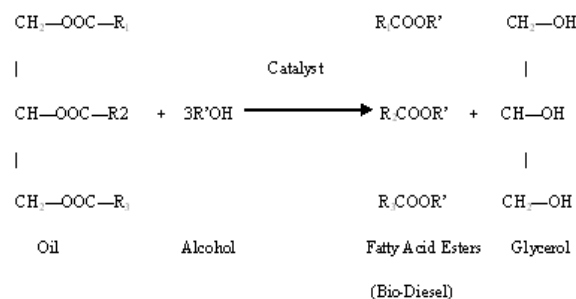


Fig. 1. Transesterification reaction

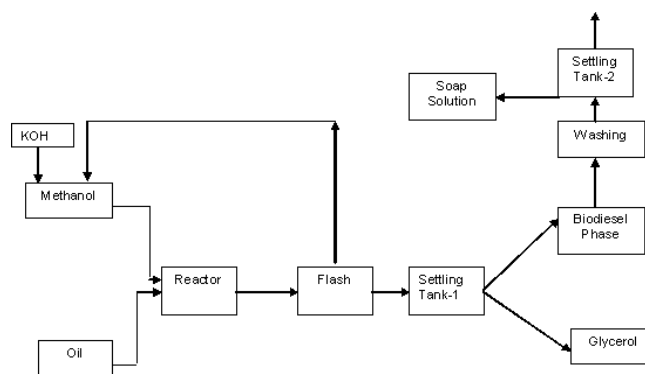
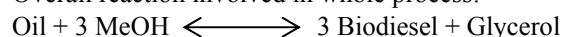


Fig. 2. Flow sheet for biodiesel production

II. METHODOLOGY

Transesterification Experiment

Overall reaction involved in whole process:



A. Experimental Procedure

A known quantity of Jatropha oil is taken inside the reactor and heated at about 70 °C. This temperature is maintained throughout the reaction by the thermostat inside the heat jacket. Preheating is used to remove unwanted moisture present in the oil. The trans-esterification is carried out in basic medium and to achieve it, KOH is used as a catalyst. Catalyst is dissolved in alcohol. Once the oil temperature reaches 70 °C, alcohol solution (containing dissolved catalyst) is added to the reactor and an equilibrium temperature is maintained. During the reaction, alcohol gets vaporized. To prevent any reactant loss condenser is used to condense the alcohol vapor and reflux it back into the reactor.

Once the reaction is over the products are taken out through the outlet in the lower side of the reactor and put in the separating funnel. Two phases (having different density) are formed as a result of trans-esterification. Separation is done using a separating funnel. Upper layer consists of bio-diesel, alcohol, and some soap (formed as a result of side reaction saponification - free fatty acids get converted to

soap). Lower layer consists of glycerin, excess alcohol, catalyst, impurities, and traces of unreacted oil. Purification of upper layer (to obtain bio-diesel) is done in two steps.

- 1) Removal of alcohol – by keeping mixture at elevated temperature ~80 °C.
- 2) Removal of saponified products – by washing with warm water. Water is immiscible with bio-diesel, hence can be easily separated from bio-diesel.

B. Experimental Set-Up

Reaction or trans-esterification is carried out in a reactor. Reactor consists of spherical flask, which is put inside the heat jacket. Oil is used as a medium of heat transfer from heat jacket to the reactor. Thermostat is a part of heat jacket, which maintains the temperature of oil and in turn the temperature of the reactants at a desired value. The reaction is carried out at around 65-70 °C. Spherical flask consists of three openings. The center one is used for putting stirrer in the reactor. The motor propels the stirrer. Thermometer is put inside the second opening to continuously monitor the temperature of the reaction. Condenser is put in the third opening to reflux the alcohol vapors back to the reactor to prevent any reactant loss.

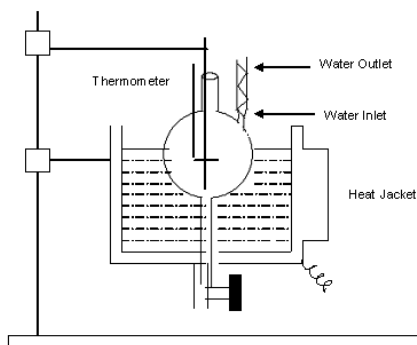


Fig. 3. Biodiesel production reactor

III. RESULT ANALYSIS

Following parameters have been studied:

- Variation of the amount of catalyst in reaction
- Effect of the ratio of the methyl alcohol to Jatropa oil.
- Effect of temperature on reaction
- Effect of stirring on reaction

Representative values of experimental observation:

Jatropa oil: 181 gm; Methanol: 78 gm; KOH: 1.0 gm;
 Time taken: 3.0 hrs; Temperature of Reaction: about 65 °C ;
 Time for separation: 24 hrs

Effect of the Potassium hydroxide (KOH) concentration on transesterification

The variation of KOH was done with the range from 0.25 gm to 1.5 gm.

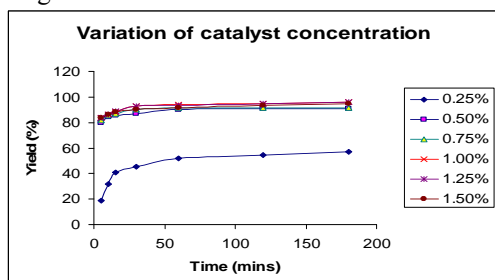


Fig. 4. Variation of catalyst concentration

Effect of the amount of methanol on transesterification

The range of variation of alcohol was from 39 gm per 181 gm of oil to 156 gm.

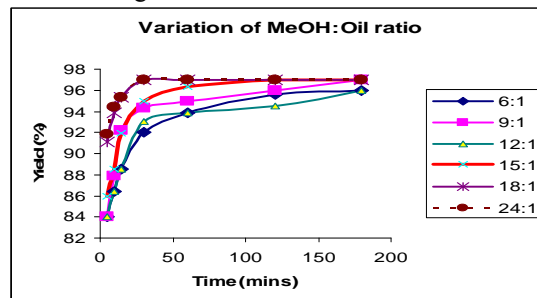


Fig. 5. Variation of MeOH : Oil ratio

Effect of Temperature on Trans-esterification

Temperature variation is considered from 37 deg°C to 65 deg°C. All other parameters were kept constant

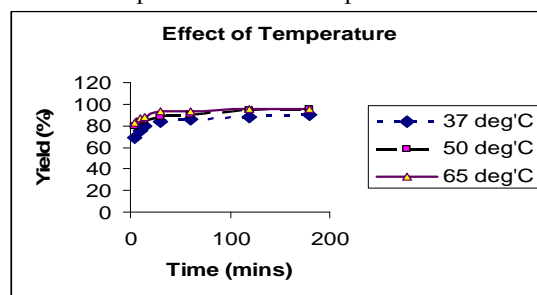


Fig. 6. Effect of Temperature

Effect of Stirring on Trans-esterification

Stirring variation is done from 180 rpm to 600 rpm. All other parameters are kept constant.

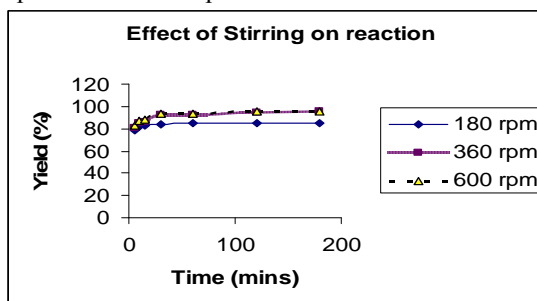


Fig.7. Effect of Stirring on reaction

A. Developing Rate Equation

We have 18 Experimental Readings. From these we have 18 'a' values and 18 'b' values.

The arithmetic average of 'a' and 'b' is found out.

$$a = 1.316 \text{ min}^{-1}; b = 1.06 \text{ min}^{-1}$$

Initial rate, a is correlated by:

$$q = at / (1 + bt)$$

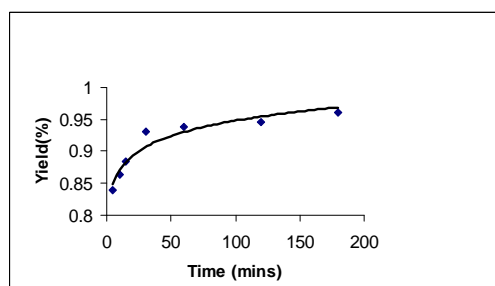


Fig. 8. Validation of results

where

q = Yield fraction, dimensionless

a = constant, min^{-1}

b = constant, min^{-1}

Rate Equation:

At time $t=0$, $dq/dt = a$

where a = initial rate

$$a = \frac{c}{f} (\text{moles of MeOH}) \cdot (\text{gm of catalyst})^e \cdot (\text{rpm of stirring})^d$$

where; $c = 0.023$, $d = 1.255$, $e = 0.38$, $f = 0.115$

IV. CONCLUSIONS

Results in this study can be summarized as follows:

- The best time of reaction is 1 hr
- Optimum catalyst is 1.0 gm per 181 gm of oil.
- Optimum amount of methanol is 39 gm per 181 gm of oil.
- The Rate expression shows the dependence of initial rate on reaction conditions.
- The parameter having most important effect on the production of Biodiesel is the amount (moles) of methanol.

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