Experimental Investigation on Production of Jatropha Methyl Ester

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Abstract. At present transportation and agricultural machinery are heavily dependent on petroleum fuels. In current scenario few nations only produce the petroleum fuel that leads to variability in the cost and demand in supply of fuels. Due to this problems it is necessary to find an alternate source for the mineral oil. Based on many research work biogas, ethanol, methanol and vegetable oils are best alternate fuel for mineral oil. The vegetable oils are consider as an alternate to mineral oils since they are environmentally friendly and biodegradable. Compare to mineral oils vegetable oils has high viscosity, low friction coefficient, low volatile, high flash and fire point. In this work it shows that Jatropha oil Methyl Ester (JME) based biofuel is an alternative to fossil fuels. JME can be used as an alternate to fossil fuel and also due to its viscosity index and lubricity properties it has the potential to use as lubricant. The Ester is formed by transesterification process and the viscosity, flash and fire point tests are conducted to analyse the properties of JME over mineral oil. Further, the maximum yield of JME is obtained by varying the proportions of KOH (catalyst), methanol (alcohol) and stirring speed by L27 Orthogonal Array based on Taguchi method.

Keywords: jatropha oil, transesterification, diesel, lubricant

1. Introduction

Current situation indicates that the conventional mineral oils used in these days will not be used for longer period due to price and uncertainty in supply of fuels. It leads to focus the research on finding alternate fuel for mineral oil by taking various vegetable oil. As an initiation for this, the sunflower vegetable oil is being tested for its performance in two stroke engines and to attain a better result out of it.

Transesterification process is one the best method for conversion of the methyl ester from vegetable oil. In this research work Jatropha curcas oil is used to prepare the methyl ester. Among the non-edible oil source of India Jatropha curcas is one of the prime source, catalyst presence make the reaction of
fatty acid to alcohol in transesterification process the chemical composition of jatropha are as follows: 6.2-6.5% of moisture, 18-20% of protein, 38-40% of fat, 17-20% of carbohydrates, 15.5-17% of fiber and 5-6% of ash. The presence of fatty acid develop the saponification reaction in vegetable oil while the process of transesterification.

Jatropha curcas seeds contains around 25-30 percentage of oil content. Jatropha oil contain 79% of unsaturated fatty acids and 21% of saturated fatty acids. In cosmetic industry soap and candles are manufactured from jatropha viscous oil, it’s an alternate for the commercial fuels available in the market. It explore the great alternate for fossil fuel.

Development of the nation is depends on the growth of energy sector, but consumption of present conventional fuel may exhaust shortly due to the high rate of consumption. So the worldwide courtesy is moving towards the usage of bio degradable fuel. Renewable energy resources are used to prepare the biofuels. In this research work it was also found that the transesterification process is affected by the following parameters reaction temperature, oil temperature and purity of reactants. Comparing sodium hydroxide (NaOH) catalyst the use of potassium hydroxide (KOH) catalyst increase the ester yield during transesterification process.

Glycerine will be separated from vegetable oil to prepare the mono-alkyl ester and the ester is user to produce bio fuels and lubricants. The ester floats on top and the glycerine descends to the bottom and glycerine can drain off in this work. Reactants purity, temperature of reaction of acid, mixture of liquids, type of catalyst are some of the parameter which improves the esterification process.

1.1. *Jatropha curcas*

There are plenty of variety is available in jatropha among all of these jatropha curcas is the best oil to extract the methyl ester. In rural areas jatropha oil plays the vital role for cooking and lighting needs. Energy extracted in jatropha oil is equal to the energy extracted in diesel. Jatropha oil directly used in diesel engine by added to diesel fuel or it can be converted as a bio diesel fuel by transesterification process. While using a jatropha oil directly in diesel engine it create the technical issue in the engine that major problem needs to be overcome. Same time preparing bio diesel from jatropha curcas is quite expensive compare to the preparation of diesel fuel.

2. Production Process

2.1. *Transesterification*

Transesterification is the process of chemical reaction of oil with alcohol in the presence of catalyst. Hydrochloric acid is used as an alcohol and sodium hydroxide or potassium hydroxide is mainly used as a catalyst for the transesterification process. Ester and glycerin are the product produced by the transesterification process. Glycerine is co product produced during the transesterification process.

2.2. *Separation*

Purification process is done to separate the biodiesel from the glycerine after completing the transesterification process.

2.3 *Investigational Procedure*

2.3.1 *Neutralization*

In nature nearly 14 to 20 percentage of free fatty acid will presence in the vegetable oil, the fatty acid must remove from the vegetable oil before taking into the conversion process of vegetable oil to biodiesel. Fatty acid presence nearly 14% in jatropha curcas it unsuitable for biofuel production in industry. For neutralization of jatropha oil, the dehydrated oil is disturbed with 4 % of hydrochloric

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acid solution about thirty minutes then 0.82g of potassium hydroxide (KOH) was added per 100 ml of jatropha oil to counterbalance the fatty acid.

\[ RCOOH + NaOH \rightarrow RCOONa + H_2O \]

2.3.2 Ester Production

In this present work biodiesel is produced from jatropha curcas by transesterification process. Batch reactor is used to carry out the transesterification-ion reaction process. During the transesterification process, to eliminate the moisture content in the jatropha oil, 250 ml of oil is heated and stirred vigorously at 700C in round bottom flask. High purity methanol is used in the transesterification process having a density of 0.79 g/cm³. Based on weight percent ratio for 250ml oil 2.5 grams of KOH is liquefied in methanol, in separate vessel and stirred vigorously then it was added to round bottom flask while stirring the mixture continuously. The mixture was maintained in an atmospheric pressure at 700C for 60 minutes. At the end of the transesterification process the ester and glycerine mixture is allowed to settle under gravity for 24 hours in separating funnel. The product made during the process are jatropha methyl ester and glycerine. The upper layer consists of methyl ester and the bottom layer consists of glycerine, excess alcohol, unreacted oil and catalyst. The vaporisation of water and alcohol gives 82-86 % pure glycerine, which can be sold as crude glycerine. After removing glycerine from separating funnel unreacted alcohol will be removed from jatropha methyl ester by washing the jatropha methyl ester with hot distilled water. Then the ester was allowed to settle under gravity for 24 hours. The separated biodiesel is taken for characterization.
3. Factorial Design
Factorial design was framed to indicate the most influencing factors in jatropha crucas transesterification process. Three level and three factors were selected and L27 orthogonal array is used to produce the required number of samples. Reaction temperature was kept constant and reaction speed, catalyst and methanol are consider as varying parameter.

4. Ester Characterization
Transesterification process reduce the viscosity value from 57 to 4.7 centistokes, which is equivalent to viscosity of biodiesel as per ASTM standard. Transportation, handling and storage of biodiesel depends on the flash and fire points. Jatropha methyl ester flash and fire point was found to be 195°C and 210°C. Work output per unit volume is high in biofuel compared to diesel due to higher mass of fuel per unit volume in vegetable oil. After transesterification process flash point of jatropha oil will be reduced, it shows that it safe to handle and improvement in volatile characteristics. Usage of vegetable oil in diesel engine is a major issue due to its high viscosity. Fuel will be considered as low temperature performance of fuel based on its pour and cloud point criterion. For example pour point of diesel is –4°C and the cloud point for Diesel is 4°C which is very low compare to methyl ester so it can performs adequately even in cold climatic conditions. If the methyl ester has higher pour point it cannot be used in diesel engine during winter season. If pour point of biofuel is greater than the ambient temperature it will lose the flow characteristics and the presence of wax will affect the fuel supply and filter. Due to this injector will not inject the fuel during working cycle of engine. Fuels which are has above 65°C as flash point are considered as safe fuels.

5. Results and Discussion
During the transesterification process mixing of methoxide with KOH is much faster compare to mixing with NaOH. NaOH is cheaper and easy to get but it takes long time compare to KOH. KOH dissolves in the methanol more easily than NaOH and it will be ready to use in ten minutes. To avoid the interferes of water with the lye catalyst it is vital to remove the presence of water content in the oil. While storing the oil it may react with ecological elements and atmospheric oxygen may lead to reduce the quality of oil by increasing the free fatty acid. It is essential to neutralize the oil to avoid the formation of free fatty acid content in the oil. Based on factorial design the required number of samples were prepared and the following results are obtained.
### Table 1. Experimental result.

| Combination No | Methanol (ml) | KOH (Grams) | Speed (rpm) | In Wt. (Grams) | In Wt. (%) | In (ml) | In ml (%) |
|----------------|---------------|-------------|-------------|----------------|------------|---------|-----------|
| 1              | 90            | 0.871       | 1000        | 203.08         | 93.26      | 231     | 92.4      |
| 2              | 100           | 1.306       | 1000        | 166.47         | 76.45      | 187     | 74.8      |
| 3              | 90            | 1.088       | 1100        | 137.7          | 63.24      | 158     | 63.2      |
| 4              | 90            | 1.306       | 1200        | 118.37         | 54.36      | 137     | 54.8      |
| 5              | 100           | 0.871       | 1100        | 215.66         | 99.04      | 246     | 98.4      |
| 6              | 100           | 1.088       | 1200        | 210.54         | 96.69      | 239     | 95.6      |
| 7              | 110           | 0.871       | 1200        | 207.63         | 95.35      | 235     | 94.0      |
| 8              | 110           | 1.088       | 1000        | 197.89         | 90.88      | 214     | 85.6      |
| 9              | 110           | 1.306       | 1100        | 209.93         | 96.41      | 237     | 94.8      |
| 10             | 90            | 1.088       | 1000        | 153.10         | 70.31      | 174     | 69.6      |
| 11             | 90            | 1.088       | 1100        | 165.55         | 76.03      | 186     | 74.4      |
| 12             | 90            | 1.088       | 1200        | 162.08         | 74.43      | 181     | 72.4      |
| 13             | 100           | 0.871       | 1000        | 134.77         | 61.89      | 153     | 61.2      |
| 14             | 100           | 0.871       | 1200        | 166.77         | 76.58      | 188     | 75.2      |
| 15             | 100           | 1.088       | 1000        | 186.80         | 85.79      | 213     | 85.2      |
| 16             | 100           | 1.088       | 1100        | 179.17         | 82.28      | 202     | 80.8      |
| 17             | 100           | 1.306       | 1100        | 175.04         | 80.39      | 189     | 75.6      |
| 18             | 100           | 1.306       | 1200        | 172.22         | 79.09      | 177     | 70.8      |
| 19             | 90            | 1.306       | 1000        | 164.78         | 75.67      | 182     | 72.8      |
| 20             | 90            | 1.306       | 1100        | 172.20         | 79.08      | 195     | 78        |
| 21             | 90            | 1.306       | 1200        | 178.34         | 81.90      | 204     | 81.6      |
| 22             | 110           | 0.871       | 1000        | 180.26         | 82.78      | 210     | 84        |
| 23             | 110           | 0.871       | 1100        | 184.02         | 84.51      | 215     | 86        |
| 24             | 110           | 1.088       | 1100        | 181.33         | 83.27      | 211     | 84.4      |
| 25             | 110           | 1.088       | 1200        | 194.94         | 89.52      | 228     | 91.2      |
| 26             | 110           | 1.306       | 1000        | 187.6          | 86.15      | 213     | 85.2      |
| 27             | 110           | 1.306       | 1200        | 161.01         | 73.94      | 184     | 73.6      |
6. Conclusion
In the present research, conforms that jatropha oil may use to produce the biofuel and it can be used as an alternate to mineral fuel. The investigational outcome conforms that alkaline catalyzed transesterification is a hopeful area of research for the large scale production of biofuel. Influence of constant reaction temperature and different level of reaction speed, reactant ratio and catalyst concentration on the biodiesel yield were analyzed. The result indicates that 100ml of Methanol to oil, 0.871g KOH catalyst, and reaction temperature of 70⁰C and reaction time of 60 minutes are the best combination to produce the methyl ester from the jatropha oil.

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