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Processing Of Neem And Jatropha Methyl Esters –Alternative Fuels From Vegetable Oil

S Ramasubramanian[1], S Manavalan[2], C Gnanavel[3], and G Balakrishnan[4]

[1,2,3] Asst. Professor, [4]Asso. Professor
[1]Department of Automobile Engineering, Vels University, Chennai, India
[2]Department of Mechanical Engineering, Bharath Institute of Science and Technology, Chennai
[3]Department of Automobile Engineering, Vels University, Chennai, India
[4]Centre of Excellence in Patterned Multiferroics & Nanotechnology, Bharath Institute of Science and Technology Chennai, India

E-mail: raams87@gmail.com

Abstract. Biodiesel is an alternative fuel for diesel engine. The methyl esters of vegetable oils, known as biodiesel are becoming increasingly popular because of their low environmental impact and potential as a green alternative fuel for diesel engine. This paper deals with the manufacturing process of Biodiesel from jatropha and neem oil. Biodiesel was prepared from neem oil and jatropha oil, the transestrified having kinematic viscosity of 3 & 2.6 centistokes, methanol ratio is 6:1 & 5.1respectively. The secondary solution is preheated at 65 C & 60 C and reaction temperature is maintained at 60C & 55 C and reaction time is 60 minutes approximately with NaOH catalyst and low viscosity oil is allowed to settle 24 hours. The average yield of neem and jatropha methyl esters was about 85%. These methyl esters shows excellent alternative under optimum condition for fossil fuels.

1. Introduction

There are three most extensive methods for biodiesel production they are Transesterification, Pyrolysis and Micro emulsion. Chemically, biodiesel is defined as the monoalkyl ester of long-chain fatty acids derived from renewable bio-lipids. Biodiesel is better than diesel fuel in terms of sulfur content, aromatic content and bio-degradability. Among this process physical characteristics and free fatty acid of vegetable oil are nearer to that of diesel. The transestrification process is very simple and two step process. Gaurav Paul et al [1] concluded that the usage of jatropha biodiesel decreases the torque and brake thermal efficiency in CI engines. Due to the higher oxygen content in Jatropha there is a increase in NO_x. The complete combustion of bio diesel reduces the PM and smoke emission. Kavati Venkateswarlu et al [2] suggested that increase in WGR percentage results in BTE increase at first and then start deceasing wile BSFC initially decrease in peak pressure NO_x and exhaust gas results with the increase in percentage of EGR. Nagaraj et al. [3] analysed the Honge oil methyl ester. When this oil is used directly it resulted in poor performance and reduced BTE with increased emission. But when silver nano – particle additive is added it results in improved performance and drastic reduction in emission

2. Experimental Setup

Figure 1 shows the transestrification setup, the components are three neck flask (capacity: 5 liters max), heater windings with controller, stirring apparatus, thermometer, measuring jar, conical flask, separating funnel, magnetic stirrer, hot air oven, weighing machine, pipette.

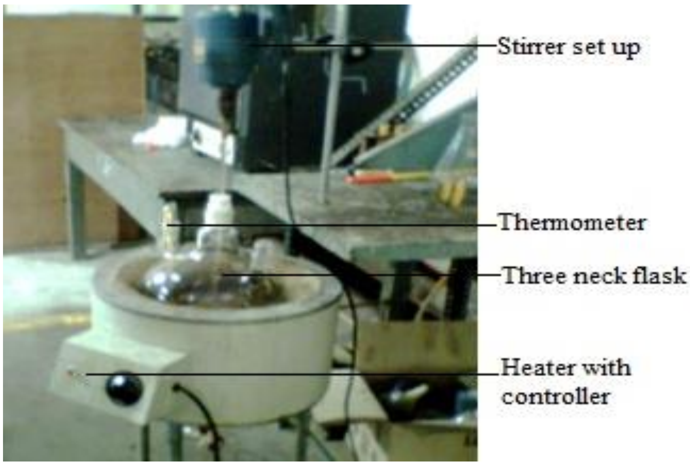

Figure 1. Photograph of Transesterification set up

3. Vegetable oil details

In particular tropical countries like India having higher chance to grow plants like Jatropha, which is an energy crop. India imports about 45-56% edible oil for its domestic requirement and therefore, it is not possible to divert the edible oil resources for biodiesel production in the country. In order to avoid food vs fuel problem, the usage of non-edible oil is gaining interest. So the non-edible oil resources like Jatropha, Pongamia, neem etc., seem to be the only possibility for biodiesel production in the country.

In this study, jatropha and neem oil was chosen for biodiesel production and key properties which decide the transesterification also tabulated. Hence two step transesterification works well. According NOVOD there are more than ten non edible oils for production of biodiesel. Out of which, Jatropha and neemlesser extend Pongamiapinnata have received much attention. Vegetable oil main constituents are Oleic and Linolenic acid, which are highly unsaturated. The fatty acid and moisture contents were tested in standard laboratory.

Table 1. Key Properties of Vegetable oil

Properties	Jatropha oil	Neem oil
Free Fatty Acid content (in %)	9.53	9.58
Moisture Content (%)	0.52	0.56

4. Acid catalysis

To reduce the viscosity of raw vegetable oil and to improve flow properties transestrification process is performed. Since jatropha oil having higher fatty acid content cannot be evolved for base catalysis, because alkali catalyst react with FFA to form soap, resulting in serious emulsification and separation problem. Due to inappropriate storage condition and improper handling the quality of jatropha oil gradually decreased. The vegetable oil is exposing to sunlight and open air for long period free fatty acid level would be increased above 1%. It is well known that improper handling of jatropha oil would

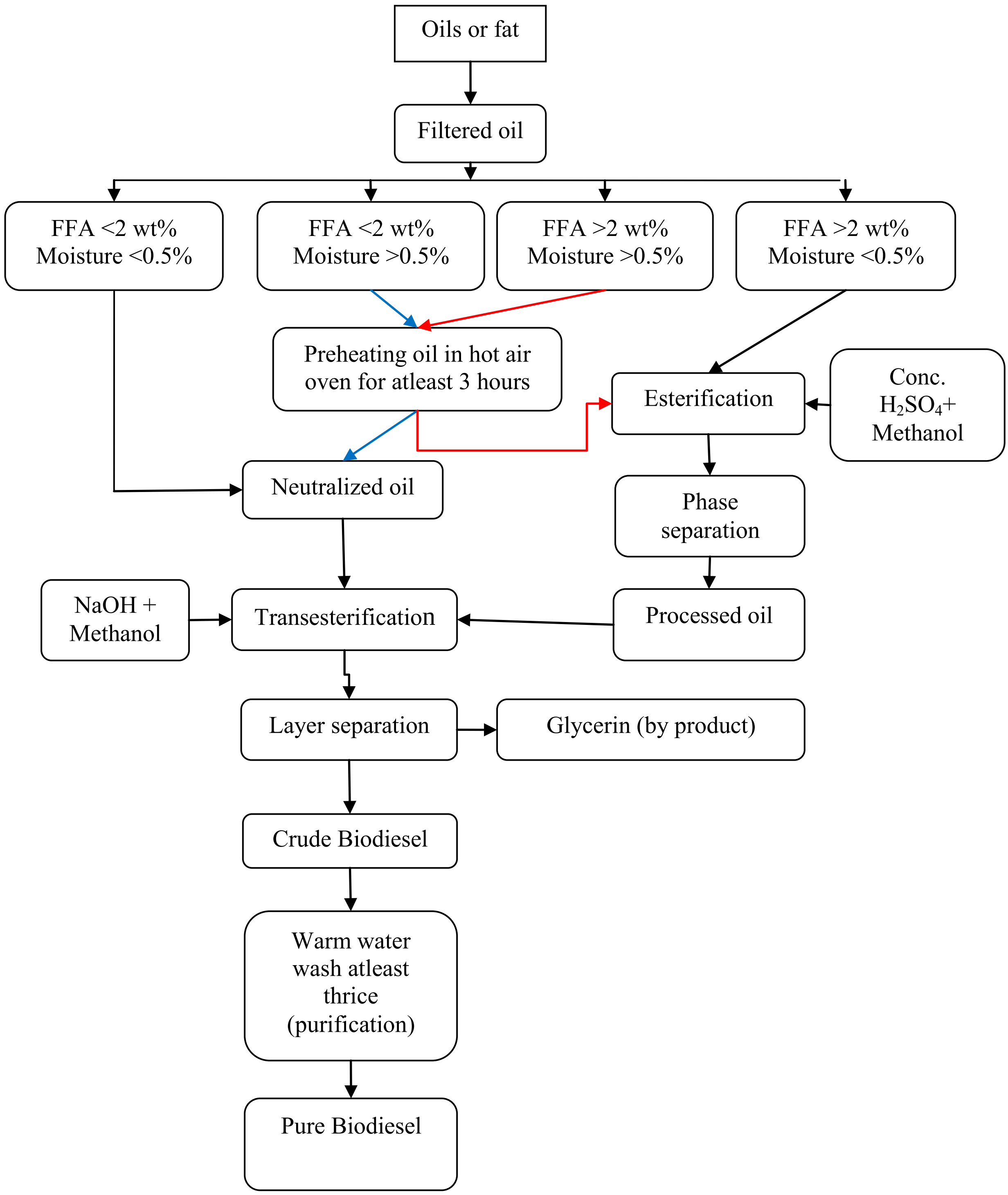

Figure 2 Optimization Flowchart

cause increased water and free fatty acid content. Free fatty acid percentage will vary depending on the feed stock quality. Removing or reducing FFA content in the oil is the pre-treatment and first step acid esterification, which is a pretreatment step, which will be reduce the FFA in the presence of optimised methanol and catalyst concentration.

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5. Base Catalysis

For direct alkali transesterification requires lower FFA, hence higher FFA content oil is pre-treated and it is evolved to base catalysis using optimized amount of methanol and base catalyst. After the completion of the reaction, it forms two layers. The upper will be methyl ester and higher molecular weight glycerin settles at the bottom.

6. Process optimization

The objective of transesterification is to reduce the viscosity of higher molecular fatty acid by converting in to lower molecular weight ester. The parameter to be optimize for transesterification are Methanol to oil ratio, Catalyst to oil ratio, Temperature, Stirring speed and Reaction time. For small scale production and process optimization magnetic stirrer with heater set up was used. Two step processes (Acid-Base catalysis) was chosen for transesterification. In the first step pretreatment (acid catalysis) methanol quantity was varied from 0.2 to 0.6 w/w ratio of oil and Concentrated Sulphuric acid was used as acid catalyst and it is varied from 0.5 to 1.5 %.
In the next step (base catalysis), methanol quantity was varied from 0.1 to 0.3 w/w ratio of oil and base catalyst as sodium hydroxide in varying proportion from 0.5 to 1.5 %. For both catalysis, in order to stirr the mixture, the stirring speed was optimized to 300 rpm and temperature at which acid catalysis takes place also varied from 45 to 60°C. Reaction time also varied from 30, 60, 90, 120 minutes. Based on this result the optimized quantity was tabulated and it was utilized for mass production.

Table 2. Optimised quantity for transesterification

Parameters	Neem Oil		Jatropha Oil	
	Acid catalysis	Base catalysis	Acid Catalysis	Base Catalysis
Methanol to oil ratio (w/w)	0.7	0.4	0.6	0.24
Catalyst to oil Ratio	1% Con H_2SO_4	0.8% NaOH	1% Con H_2SO_4	0.8% NaOH
Temperature (^oC)	60	65	55	62
Stirring speed (rpm)	300	300	300	300
Time (hours)	1.5	2	1.5	2

7. Transesterification Process

The raw Jatropha oil and neem oil was filtered to remove all insoluble impurities followed by heating at 100°C in hot air oven for 20 min to remove all moisture. In the first step, the higher fatty acid oil was processed using 0.6w/w ratio of methanol to oil in presence of concentrated Sulphuric acid as a catalyst (1 wt% of oil). The reaction takes place for one hour at optimum temperature of 55°C and stirred at 300rpm in a three neck flask with heater as shown in Figure. After the reaction the mixture was allowed to settle in a separating funnel for 5 hours. The methanol water mixture was separated and processed oil was removed.

In the second step, the processed oil (which posses Fatty acid lower than 0.5%) was transesterfied using 0.24 w/w ratio of methanol to oil and 0.8 % of NaOH as an alkaline catalyst to produce biodiesel at temperature of 60°C [3]. The reaction takes place for 2 hours, at optimum speed of 300 rpm. Allow the mixture to settle for 6 hours to overnight in a separating funnel for gravity separation, and then it form two layers. The higher molecular weight glycerin separates at the bottom, which looks dark brown colour and upper yellow layer is methyl ester, it was separated. The methyl ester was washed gently using water for at least 3 times at a temperature of 40°C, in order make ester to neutral (PH=7) and also remove catalyst, glycerin and un reacted fatty acids. Final yield of biodiesel was 85%.

Table 3. Comparision of properties of biodiesels with diesel

Properties	Diesel	Neem Methyl Ester	Jatropha Methyl Ester
Density (kg/m^3)	822	868	860
Calorific value (kJ/kg)	42,500	38,500	40
Viscosity (mm^2/s)	3.2	4.5	5.2
Cetane number	45-55	50	48
Autoignition temperature (˚C)	280	302	286
Flash point (˚C)	70	120	145

8. Result and Discussion

Physical and chemical properties of jatropha and neem biodiesel were found, Biodiesel properties are similar to conventional diesel. The approximate yield of biodiesel was obtained 80%. It was confirming to the European and American standards.

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