PRODUCTION OF ECO-FRIENDLY FUEL FROM MAHUA SEED

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Abstract

Rising petroleum prices, an increasing threat to the environment from exhaust emissions, global warming and the threat of supply instabilities has led to the choice of inedible Mahua oil (MO) as one of the main alternative fuels to diesel oil in India. . Mahua seed is a fruit from sappotaacae family. In the present work, MO was converted into biodiesel by transesterification using methanol and sodium hydroxide. The cost of Mahua oil biodiesel (MOB) is lesser than diesel. Hence mahua biodiesel,which is one of the cheapest gaseous fuels available in India, was fumigated along with the air to reduce the operating cost and to reduce emissions.

Index Term- ***Mahua oil(MO), Transesterification, Cetain number***

1. INTRODUCTION

'Mahua' is the name for a medium to large tree belonging to the sapotaceae family. The tree may attain a height of up to 20 meters. Mahua is a slow growing species, attains a mean height of 0.9 to 1.2 m at the end of its fourth year. As a plantation tree, Mahua is an important plant having vital socio-economic value. This species can be planted on roadside, canal banks, etc., on a commercial scale and in social forestry programmes, particularly in tribal areas. The seed and oil potential of the mahua tree in India is 0.5 and 0.18 MMT respectively.

The fresh oil from properly stored seed is yellow in colour (Bringi, 1987). Mahua seeds are shown in Figure 1.1

fig 1 mahua seeds

Biodiesels are derived from edible oils and non edible oils such as Jatropha, Pongamia, Mahua, Cottonseed, Soy bean, Neem, Sunflower, Rapeseed, Palm etc. Cotton Seed Oil (CSO) was the first commercial cooking oil in many countries but it has progressively lost its market to other vegetable oils that have larger production and less cost. In India biodiesel is costlier than diesel and hence fumigation of low emission and cheaper gaseous fuels is one of the ways of reducing the operating cost. (Manzoor Elahi M Soudagar-2017)

II.MATERIALS AND METHODS

1 PRODUCTION OF BIODIESEL

Biodiesel fuel can be made from new or used vegetable, non edible oils and animal fats which are nontoxic, biodegradable, renewable resources. Fats and oils are chemically reacted with an alcohol (methanol is the usual choice) to produce chemical compounds known as Fatty Acid Methyl Esters. Biodiesel is the name given to these esters when they are intended for use as fuel. Glycerol is produced as a co-product which is used in pharmaceuticals and cosmetics, among other markets.

There are three basic routes to ester production from oils and fats:

i. Base catalyzed transesterification of the oil with alcohol.

ii. Direct acid catalyzed esterification of the oil with methanol.
iii. Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

The majority of the alkyl esters produced today is done with the base catalyzed reactor because it is the most economic for several reasons:

i. Low temperature (150˚F) and pressure (20 psi) processing.
ii. High conversion (98%) with minimal side reactions and reaction time.
iii. Direct conversion to methyl ester with no intermediate steps.
iv. Exotic materials of construction are not necessary.

The experimental study was conducted by using a single cylinder water-cooled, naturally aspirated (NA) 4-stroke DI diesel engine.The flow rate of the fuel was measured by timing with a stop watch the consumption for known quantity of fuel (10cc) from a burette. The speed was measured directly from the tachometer attached with the dynamometer. The engine torque was measured by using rope brake dynamometer, which is coupled to the engine. The cooling water outlet and exhaust gas temperature were measured directly from the thermometer attached to the corresponding passages. An inclined water tube manometer connected to the air box (drum) was used to measure the air pressure. A high pressure mechanical fuel pump and a printle type fuel injector with a nozzle hole (nozzle diameter 0.25 mm) were used in the injection system.

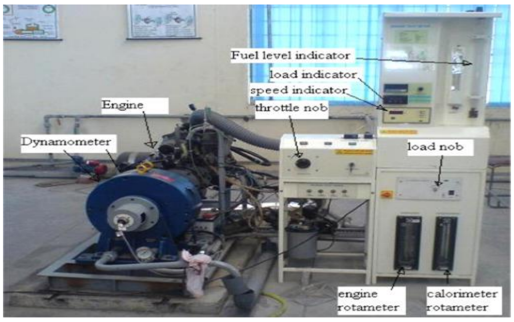

FIG 2 Diesel engine machine

The fuel injection time was set at 24° BTDC. Initially, the engine was run by the diesel fuel for about 30 minutes to warm up and bring to stable condition. In that situation, emission and exit line temperature was uniform and it was ensured to be constant for every observation to evaluate performance. A portable digital gas analyzer (IMR 1400) was used to measure the exhaust gas emission like CO and NOx.

2 CALCULATION OF CATALYST AND ALCOHOL

Amount of catalyst and alcohol to be added depends on the FFA value. Methanol: For 1 liter of vegetable oil 200 ml of methanol is added.¬NaOH is added To calculate FFA% from a titration valuethe formula is:

$$FFA\% = \frac{28.2 * 0.1N NaOH * Burettereading}{W}$$

Where,
Burette Reading: Volume in ml of titration solution
N is the normality of the titration solution (0.1 gram/liter).
W is the weight of the sample of oil in grams (10 grams).
28.2 is the molecular weight .

FFA =.(28.2*.1*.1)/10
= .0282*100
= 2.82%

3 EXPERIMENTALSETUP

3.1 BASE CATALYZED METHOD

One liter sample oil (vegetable oil) is taken in a three necked flask which is heated till temperature reaches close to boiling point of methanol (65-700C) on magnetic stirrer as shown in fig. The amount of NaOH needed as catalyst for every liter of crude vegetable oil was determined based on FFA carried out by titration . NaOH and methanol(200 ml) mixture known as methoxide was added slowly and heated for one and half hour. After the reaction, the oil was transferred to a separating funnel for glycerol separation. The lower glycerol layer was removed and remaining upper layer i.e. biodiesel/ mono methyl ester contains some traces of NaOH, methanol and glycerol.

3.2WASHING OF PRODUCT

After transesterification the upper ester layer may contain traces of NaOH, methanol and glycerol. Since the remaining unreacted methanol in the biodiesel has safety risks and can corrode engine components, the residual catalyst (NaOH) can damage engine components, and glycerol in the biodiesel can reduce fuel lubricity and cause injector coking and other deposits. These being water soluble is removed by washing (4-6 times) the biodiesel with water maintained at 40-50ºC. Washing is carried out by spraying hot water over the biodiesel; precautions were taken to avoid soap formation.

3.3 HEATING OF PRODUCT

After the completion of washing process the biodiesel may contain some traces of water. Biodiesel is heated to 110 °C to remove the trapped traces of water.

3.4 TRANS ESTERIFICATION

- The Trans esterification reaction was performed in a round bottom vessel of 500 mL in volume.
- First, the reactor vessel was filled with 210 mL of MO.
- Then, a measured amount of the methanolic sodium hydroxide, which was prepared by dissolving 2 g of sodium hydroxide in 85 mL of methanol, was added to the reactor.
- For refluxing purpose, a vertical water cooled condenser was used.
- A hot plate cum magnetic stirrer was used for heating and stirring the reactants.
- The reactor was immersed in a constant temperature water bath which maintained at 60 C
- The Trans esterification reaction was carried out for two hours.
- After Trans esterification, the condenser was removed and the products were heated, to be remove excess methanol.
- After heating, the products were shifted to a 500 mL separator funnel, for phase separation.
- The top layer containing methyl esters of Mahua oil (biodiesel) were washed with warm water, to wash out impurities such as soap and other residues.
- Finally the biodiesel was dried using 5 gm. of anhydrous sodium sulphates.

Fig 3 Methanolic reaction

Fig 4 Production of bio diesel

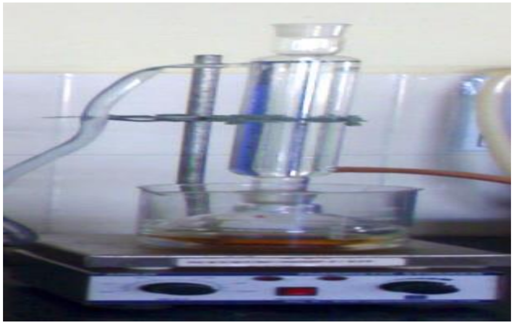

Fig 5 Transesterification set up

Fig 6 Biodiesel

3.5 TESTING OF MAHUA OIL BIO DIESEL

After checking the characteristics features of mahua bio diesel , the oil is filled into the tank of engine for testing . Then starts the engine , it is running successfully .

Fig 7 Testing of mahua oil bio diesel

III RESULT AND DISCUSSIONS

Mahua oil was observed as 88.26% of diesel on weight basis and 96.30% on volume basis. The calorific value of mahua oil was found nearer to diesel fuel in comparison with other liquid fuel options like ethanol and methanol. The higher cetane number may be due to the difference in chemical composition and molecular structure of mahua oil .

Characteristis	MO biodiesel	Biodiesel (research gate.net)
Viscosity at 40℃ (mm2/sec)	4.85	2.68
Density at 15 C(kg/m3)	883	846
Flash point C	129	56
Calorific value(kj/kg)	36914	42960
Cetain number	64	49
Iodine value (g I2/1000g)	70	38

Table 4 characteristics of MO biodiesel and biodiesel

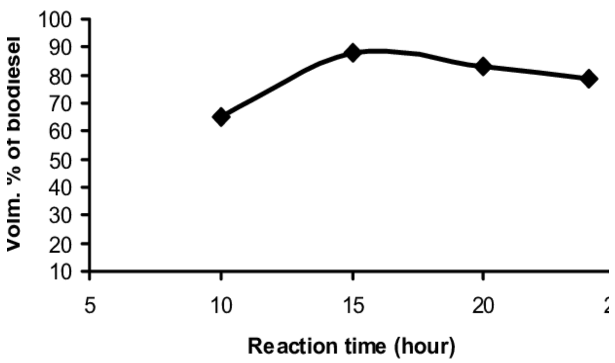

FIG 4.1 Effect of reaction time &volume

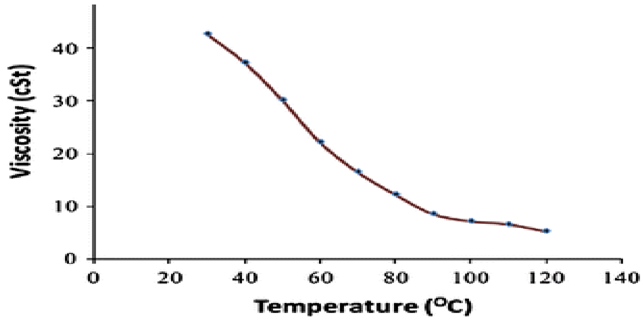

FIG 4.2 Effect of reaction temperature with viscosity

IV COST ANALYSIS

The cost for production of one litre of mahua oil biodiesel and bio -diesel blend are estimated and evaluated in terms of rupee on the basis of production process prevailing in India. The cost of bio diesel purchased from local commercial is Rs.75 per litre . (source : global CCS institute) . The cost of mahua biodiesel production is is RS 60 per litre . It is observed that the cost of mahua bio diesel is lower than bio diesel .

Processing cost	Unit	Mahua
Seed collection cost	Rs. per kg	12
4 kg seeds yields 1kg oil	Rs. per kg	48
Oil expeller running cost	Rs. per kg	5
By-product(oil cake)	Rs. per kg	-8
Packing and storage	Rs. per kg	3
Total cost of biodiesel	Rs. Per litre	60

Table 5 Total cost of biodiesel

V CONCLUSION

The bio-fuel was extracted from the mahua seeds in pressure reactor through transesterification process. It is observed the physical properties like kinematic viscosity, flash point, cloud point and density of the fuel. The expeller method was found to be suitable for extracting Mahua oil at 350 ml per kg of Mahua seed . using titration technique ; the free fatty acid content of mahua oil was found to be 18% which was reduced to less than 2% by acid esterification in which 5% of concentrated Sulphuric acid and methanol were added. The base catalyzed transesterification with sodium hydroxide and methanol at molar ratio of 1:6 was found to be very effective which yielded 89 % of biodiesel. The biodiesel production was optimized with reaction temperature, reaction time and molar ratio in which the reaction temperature of 65°C yield more than 85% of mahua oil biodiesel than 35°C and 50°C of reaction temperature. It was experimentally found that mahua emits the least amount of CO and NOx which were 44.44% and 38.3% respectively compared to the neat diesel. The Mahua oil biodiesel was characterized using Gas chromatography Mass spectrometry.

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