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Biodiesel Production from Different Non-edible oils containing High Free Fatty Acid

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Abstract: Demand of fuels is increasing gradually. It is likely to increase the import dependence for oil in India which is about 70 per cent. It is also well known that the petroleum resources are limited which are non-renewable in na-ture. Hence we must start to think about the alternatives as we are likely to run out of the petroleum resources in few decades or so. Production of energy from renewable sources should be given importance as they are bio-degradable and non-toxic.India being a tropi-cal country, a large variety of fruit yielding trees grows in forest and non-agricultural lands. The edible ones among these fruit and seeds are already being used for animal and human consumption. A significant part of these trees yield non-edible fruit and seeds whose oils are having high free fatty acid ranging from 3 to 16. The non-traditional seeds available in India are Karanja, Polanga, Simarouba, Mahua and Jatropha,Kusum etc. Here an attempt has been made to utilize non-edible oils from Karnja, Jatropha, Sima-rouba, Mahua&Polanga for biodiesel produc-tion. The current paper also presents the dif-ferent properties of biodiesel like specific gravity, viscosity, acid value, flash point etc. The study reveals that the properties of bio-diesels are as per standards and can be used as a substitution to diesel because its proper-ties are nearly equal to diesel.

Key words: Biodiesel, Transestrification, Viscosity, Degumming

Introduction

Current investigation on the world energy utilization highlights that a major portion of the total energy consumed is derived from the combustion of fossil fuels. Liquid petroleum based fuels contributes maximum because of their inherent physicochemical and combustion properties. Unfortunately, the reserves of fossil fuels, specially the liquid fuels are limited. If not used economically it may exhaust within few decades. Efforts are being made throughout the world to reduce the consumption of liquid petroleum fuels. Biodiesel is a renewable fuel which is produced from vegetable oil or animal fat through a chemical process and can be used as an additive to diesel fuel in compression ignition engines.

Biodiesel is typically produced through the reaction of vegetable oils or animal fat with methanol or ethanol in the presence of catalyst to yield glycerol as major by product[1] (biodiesel chemically called methyl or ethyl ester). However, the price of biodiesel is presently more as compared to petrol, diesel [4]. Higher cost of biodiesel is primarily due to the raw material cost [12].

India being a tropicalcountry, a large variety of fruit yielding trees grows in forest and non-agricultural lands. The edible ones among these fruit and seeds are already being used for animal and human consumption. A significant part of these trees yield non-edible fruit and seeds. MNRE has identified around 400 oil seed species in India. The non-traditional seed available in India are Karanja, Jatropha, Neem, Mahua, Simarouba, Polanga, Kusum etc. Potential availability of selected non- edible seeds is given in table. 1. Our state odisha is also a major producer of non- edible oil seeds. So attempts are being taken to investigate the suitability of Karnja, Jatropha, Simarouba, Mahua&Polanga for biodiesel production and to compare the properties of non-edible oil and biodiesel produced from it with diesel.

Table. 1. Annual Production of Non-edible Oil Seeds in India [8]

Sl. No	General Name	Botanical Name	Potential, Million Metric Tonnes/Year			Oil Con-tent,%
			Seed	oil	cake	
1	Karanja	*Pongamiapinnata*	0.20	0.055	0.145	27-39
2	Jatropha	*jatrophacurcas*	0.05	0.015	0.035	30-40
3	Kusum	*Scheleicheraoleosa*	0.08	0.025	0.055	34
4	Neem	*Azadirechtaindica*	0.50	0.100	0.400	20
5	Sal	*Shorearobusta*	1.50	0.180	1.320	12-13
6	Mahua	*Madhucaindica*	0.50	0.180	0.320	35

Plant Description

Karanja

Karanja (PongamiaPinnata) is a tree which needs no pesticides for growing plantations and average rainfall required is 500-500mm. Karanja trees can be normally planted along the highways, roads and canals to stop soil erosion and they also have potential to grow in wastelands. The ripe pods are flat and elliptical, about 5-7 cm long with one or two kidney shaped reddish kernels. The size of seed is 1.7-2.0 cm in length and 1.2 to 1.8cm in breadth weighs about 1-1.2g.The pods contains about 50% of its weight of seeds. The kernels are white and covered by reddish brittle skin, called testa.

Jatropha

Jatropha (Jatrophacurcas) is a drought-resistant perennial, growing well in marginal/poor soil.Jatropha thewonder plant produces seeds with an oil content of around 37%. The by-products are press cake a good organic fertilizer, oil contains also insecticide. It is found to be growing in many parts of the country and can survive with minimum inputs and easy to propagate. Jatropha grows almost anywhere, even on gravelly, sandy and saline soils [11]

Simarouba

Simarouba (SimaroubaceaeQuasia) is originated native to North America, now found in different regions of India. It was a medium sized tree generally attains a height about 20 m and trunk diameter approximately 50 – 80 cm an d life about 70 years. It was suited for temperature range 10 - 40 0 C, pH of the soil should be 5.5 – 8 [3]. Itsseeds contain about 40 % kernel and kernels content 55 -65% oil. The amount of oil would be 1000 – 2000 kg/ha/year for a plant spacing of 5m x 5m. [10].

Mahua

Mahua (MaducaIndica) is non-edible oil also known as Indian butter tree. The annual production of mahua is nearly 181 kT.Mahua seed contain 30-40 percent fatty oil called mahua oil. In India the mahua plant is found in most of the state e.g. Orissa, Chatishgada, Jharkhand, Bihar, Madhya Pradesh, Tamilnadu[11]. Based on the existing tree density of Mahua trees in India, the Ministry of New and Renewable Energy Sources of India has estimated the Mahua seed potential in India to be around 0.50 million tons per annum[8].

Polanga/ Undi

Polanga (CalophullumInophyllum) is a large tree of shorelines and coastal foersts. It usually grown 12-20 cm in height, but open grown trees can become wider than they are tall, often leaning with broad and spreading crowns. The scientific name calo-phullumcomes from Greek word meaning “beautifu l leaf” and the species name “ inophyllum” refers to the straight lines made by the veins in the leaves. The plant usually fruits twice a year.

Oil processing technology of oil seeds

Choosing efficient extraction methods can increase the yield by more than 5%. Two types of oil extraction process are followed: oil extraction in mechanical expeller, solvent extraction method. The solvent extraction method enhances the efficiency up to 99% [7]. A disadvantage with the solvent extraction is that the quantity of phospholipids in solvent extracted oil is twice as high as compared to pressed oil. This necessitates a further step of oil de gumming before trans- esterification. Oil extraction methods in mechanical expeller are also being developed. In this process, cell walls of the oil plant seeds are destroyed followed by the release of the oil present within the cells. The effi-ciency so far obtained is 86%. The extracted oil can be purified by Sedimentation prosesss. This is the easiest way to get clear oil, but it takes about a week until the sedi-ment is reduced to 20 - 25 of the raw oil volume. The purification process can be acceler-ated tremendously by boiling the oil with about 20 % of water [11].

Material and Methods 1.Materials

Samples were collected from nearby oil expelling factory. All chemicals used in the ex-periments, such as phosphoric acid methanol, potassium hydroxide were of analytical reagent (AR) grade. Instruments for measuring the properties are used in College of Agricultural Engineering and Technology, OUAT, Odisha renewable energy lab.

2.Determination of acid value

The acid value of lubricating oil is defined as the number of milligrams of potassium hydroxide required to neutralize the free acid present in 1 gram of oil. 1.4gm KOH was taken and 250 ml waterwas added to it. 0.5gm sample oil was added with 20ml ethyl alcohol or 10ml ethyl alcohol followed by stirring without heating. Four drops of phenolphthalein indicator added to the solution and it was titrated with KOH solution.

Acid value = Weight of Sample *5/burette reading
Free Fatty Acid (FFA) = Acid Value/2

3.Determination of Density

Density is defined as its mass per unit volume. Empty pycnometer is weighed with cap then weighed with sample.

4.Determination of viscosity

Viscosity is a measure of the internal resistance to motion of a fluid and is mainly due to the forces of cohesion between the fluid molecules. Viscosity was measured in kine-matic viscometer.

5.Biodiesel processing

Conversion of oil into biodiesel from oil containing high free fatty acid (FFA) (>1%) is difficult that will form soap with alkaline catalyst.The soap can prevent separation of the biodiesel from the glycerin fraction. Crude oil contains about more than 25 % FFA, which is farbeyond the 1% level. Few researchers have worked with feedstock having higher FA levels using alternative processes. Pretreatment step to reduce the free fatty acids of this feedstock to less than 1% before transesterification reac-tion was completed to produce biodiesel. The reduction of FFA <1% is best if esterifi-cation followed by Transesterification.

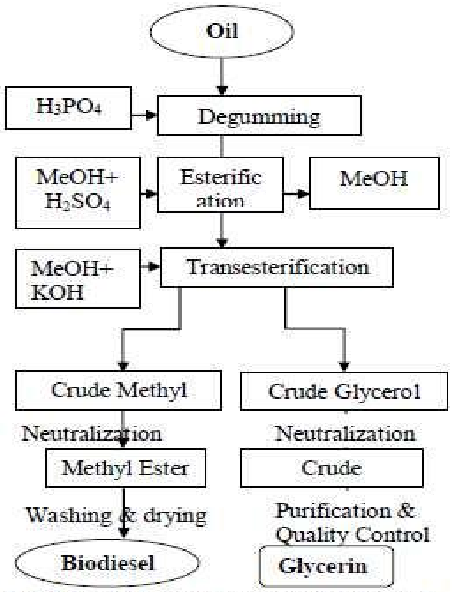

Fig. 1.Flow chart of biodiesel production from different oils

(i) Esterification

Same quantity of degummed oil was taken in the biodiesel processor along with 22% v/v methanol and 1% v/v sulphuric acid. The mixture is then stirred for a period of one hour at a temperature of 650 C. The esterification process is repeated for further purification of the high FFA oils.

(ii) Transesterification

The experimental setup for carrying out the transesterification reaction of esterified oil is shown in fig. 2. The quantity of esterified oil under study was mixed with a mixture of anhydrous methanol (22% v/v) and a base catalyst KOH (0.5% v/v). The mixtures were maintained at a temperature little below 65 °C (bei ng the boiling point of methanol) and were continuously stirred for around two hours. After the stirring process, the mixture was allowed to settle down for 24 hours. The layer of glycerol, settled at the bottom, was carefully taken out by decantation and the upper layer, the methyl ester of oils was tapped separately. The washing of the transesterified oil was done for the removal of additional ester, followed by the heating/evaporation for the removal of water particles and alcohol to obtain pure biodiesel.

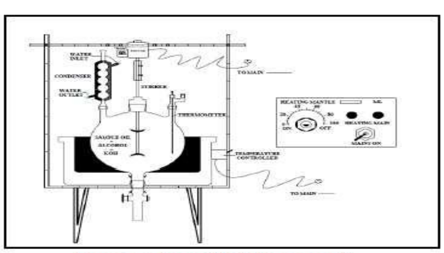

Fig. 2. Schematic Diagram of Transesterification Unit for Biodiesel Production

6. Calorific Value

Calorific value is the net heat content of fuel and it affects brake thermal efficiency and specific fuel consumption of the diesel engine. It was measured by bomb calorime-ter.

7.Flash Point

Flash point of a fuel is defined as the lowest temperature at which fuel is heated under standard conditions gives off sufficient vapor to ignite on application of a small flame. Higher flash point helps in better storage and handling of a fuel.

Result and Discussion

1. Acid value

Fig. 3 indicates that acid value significantly decreases after esterification and small de-crease is observed after transesterification, followed by esterifcation

The acid value of oils is found to be varying from 10 to 42 before pre-treatment, and after pre-treatment they were found to be varying from 1.5 to 3.2.But the acid values for bio-diesels were found to be lying between 0.30 and 0.70, which are within the limits pre-scribed by both American and Indian biodiesel standards. Hence, the procedure followed for biodiesel production is quite successful in handling different feed stocks of high AV Highest percentage of conversion is seen in Simarouba oil and lowest in Mahua oil.

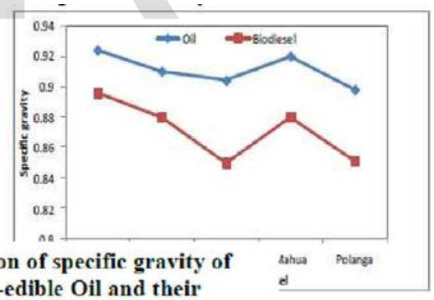

Fig. 4 Comparison of specific gravity of different non-edible Oil and their biodiesel

From Fig. 4, it is clear that there is a significant decrease of specific gravity when non-edible oils are converted into biodiesel.

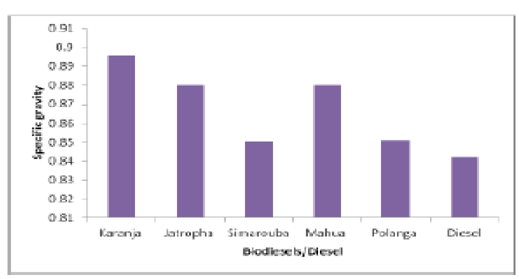

Fig. 5 Comparison of specific gravity of different Biodiesels and Diesel

Fig. 5 indicates that out of five non edible oil biodiesels

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Karanja biodiesel has highest spe-cific gravity and Simarouba biodiesel has lowest specific gravity value. The specific grav-ity of all five non-edible oil biodiesels is around 0.85 which is not much higher than diesel. This revels that biodiesels are not much denser than diesel.

3. Viscosity

From Fig. 6, it is clear that there is a significant decrease in kinematic viscosity when non-edible oils are converted into biodiesel.

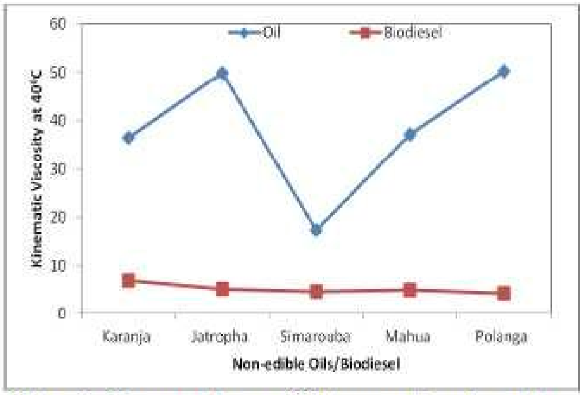

Fig. 6 Comparison of kinematic viscosity of different non-edible Oil and their biodiesel

After transesterification biodiesel of all five non-edible oils show almost same value, how-ever there is a great variation in oil viscosity.

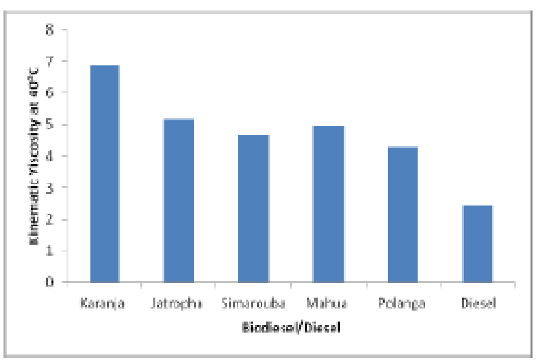

Fig. 7 Comparison of kinematic viscosity of different Biodieseld and Diesel

The viscosity of five non edible oil biodiesels and diesel is shown in fig. 7. Range of vis-cosity of biodiesel is 4.3 to 6.87 which is acceptable according to ASTM D445. Karanja bio-diesel has highest density and simarouba biodiesel has low-est density.

4. Calorific Value

From Fig. 8 indicates that calorific value of biodiesel decreas-es from its parent oil. Maxi-mum decrease is seen in Jatropha and least variation is seen in Simarouba.

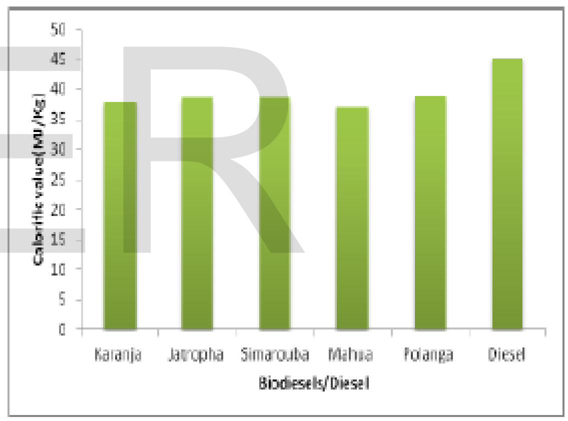

Fig. 9 Comparison of calorific value of different biodiesels and diesel

Comparison between all five non-edible oil biodiesels calorif-ic values and calorific value of diesel are shown in fig. 9. Cal-orific value of Biodiesels ranges from 37 to 38.67 MJ/Kg. Out of five Biodiesels, Jatropha oil Biodiesel has highest calorific value and Simarouba has lowest calorific value. All five bio-diesels have calorific values around 40 MJ/Kg which is close to the calorific value of diesel (around 45). This revels that biodiesels can be alternatives to diesel.

5. Flash Point

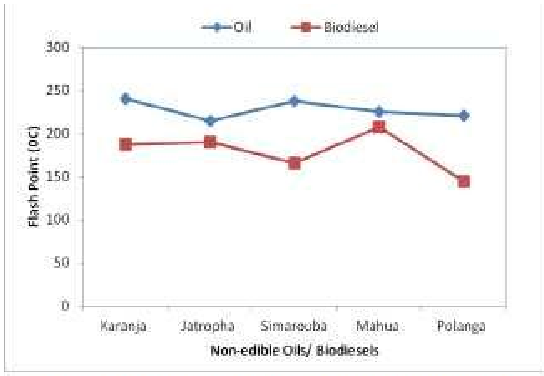

Fig. 10 Comparison of flash point of different non-edible Oil and their biodiesel

Fig. 10 indicates that flash point decreases when oil is converted to biodiesel

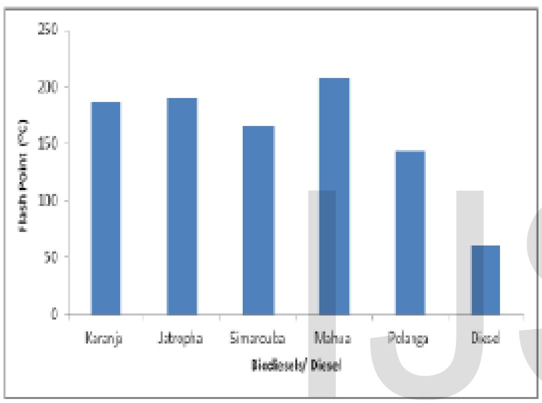

Fig. 11 Comparison of flash point of different biodiesels and diesel

Fig. 11 shows that flash point of biodiesels are higher than diesel. It ranges from 144°C to 208°C which meets the ASTM standard D93. Higher fla sh point is a major advantage of biodiesel because it helps in better storage and handling of biodiesel, as compared to petro-leum diesel. Flash point of Mahua biodiesel is highest and Simarouba biodiesel is lowest.

Conclusion

All the important properties of transesterified products (biodiesel) like specific gravity, kinematic viscosity, calorificvalue, carbon residue and flash pointare compared with ASTM standards and found to be within the specified parameters. Hence the biodiesel from non-edible oils like Karanja, Jatropha, Simarouba,Mahuaand Polanga can be used as an alternative to diesel fuel.

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