PROPERTY TESTING OF BIODIESEL DERIVED FROM COCONUT TESTA OIL AND ITS PROPERTY COMPARISON WITH STANDARD VALUES

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Abstract

The fuel obtained from biological sources are termed as biofuel. Biofuel satisfies the physical and chemical standards of the diesel. Hence it can be used as an alternative for diesel in compression ignition engines. As compared to normal diesel, biodiesels are non-exhaustible, causing less pollution and widely available. Biodiesel is being prepared from various feed stocks such as coconut oil, sunflower oil, karanja oil, jetropha oil etc. The use of edible oils for the production of biodiesel may lead to food crisis and there is a need to find out non edible feed stocks for bio diesel production. The primary motive of this experiment is find out the fuel related properties and engine related properties of Coconut Testa biodiesel. Compare the results with standard values and make sure that it can use as an alternate fuel for compression ignition engine.

Keywords: Acid value Biodiesel, Density, Fire point, Flash point, Iodine value, Saponification value, Transesterification, Testa oil, Viscosity

1. Introduction

The fuels currently use in internal combustion engines are nonrenewable in nature. The resources of the fossil fuels will get exhausted. As a result of combustion of fossil fuels, produce harmful emissions which is dangerous to environment and living beings. It is the need of hour to find out alternate sources of energy which has advantages over the conventional fossil fuels. Many experiments are conducted on internal combustion engines using fuel from biological feed stocks.

The oils use for biodiesel production includes edible and non-edible oils. Edible oils include coconut oil, sunflower oil, peanut oil etc. But use of edible oils for biodiesel production can cause food crisis and increase in the price of edible oils. Thus non edible oils are a better option as compared to edible oils for biodiesel production.

The feed stocks can be saturated type and unsaturated type. The biodiesel produced from unsaturated feed stocks cannot be stored for a long time. It will get degraded and fuel quality reduces accordingly and also it produce more emission as compared to fresh biodiesel.

Coconut is a tropical fruit widely available in South India and South East Asian countries. Various experiments have been conducted till date using biodiesel produced from coconut oil. Coconut biodiesel has higher number of saturated content. So long term storage stability biodiesel is higher compared to biodiesel derived from feed stock which has higher amount of unsaturated content. The use of coconut oil as feed stock has a number of disadvantages. Coconut oil is widely used for cooking and other domestic purposes. The use of coconut oil for biodiesel production can cause its scarcity for domestic use.

Coconut testa is a waste removed from coconut during coconut oil production. The industries producing products like coconut milk, virgin oil etc. use only the kernel by peeling out the testa. This work aims the property testing at producing biodiesel from coconut testa. Due to the wide availability, non-edible nature and high degree of unsaturation of the oil, biodiesel produced from testa has enormous potential in meeting the future fuel demands.

2. Literature survey

Prakruthi Appayya et al [1] studied the composition of coconut testa. The samples had fat as the major component ranging from 34 to 64%. Oils had 90 to 98.2% triglycerols, 1 to 8% diaglycerols and 0.4 to 2 % triglycerols.Oils from testa were richer in monosaturates and polysaturates than other coconut oil samples. These studies indicated that the oil from testa contained more natural anti-oxidants such as tocopherols, tocotrienols and phenolics compared to coconut kernel oil.

Liaquat et al [2] studied the effect of coconut biodiesel blended fuels on engine performance and emission characteristics. As results of investigations, there has been a decrease in torque and brake power, while increase in specific fuel consumption has been observed for biodiesel blended fuels over the entire speed range compared to net diesel fuel. In case of engine exhaust gas emissions, lower HC, CO and, higher CO2 and NOx emissions have been found for biodiesel blended fuels compared to diesel fuel.

Mohankumar Chinnamma et al [3] studied Production of coconut methyl ester (CME) and glycerol from coconut oil and the functional feasibility of CME as biofuel in diesel engine. The test run showed the technical specifications torque (Nm) and power (bhp) similar to the efficiency of diesel fuel. The experiment showed a significant increase in the mileage.

Oguntola J Alamu et al [4] studied the production and testing of coconut oil biodiesel fuel and its blend Test quantities of coconut oil biodiesel were produced through transesterification reaction. The coconut oil biodiesel produced was subsequently blended with petroleum diesel and characterized as alternative diesel fuel through some ASTM standard fuel tests.

Godwin Kafui Ayetor et al [5] studied the Effect of biodiesel production parameters on viscosity and yield of methyl esters. The highest yield was obtained with 1% NaOH concentration for all. The effect of methanol in the range of 4:1–8:1 (molar ratio) was investigated, keeping other process parameters fixed. Optimum ratios of palm kernel oil and coconut oil biodiesels yielded 98% each at methanol: oil molar ratio of 8:1.

Bhuiya et al [6] studied the potential of non-edible oils as an alternative to- edible oil-derived biodiesel. To establish and continue to optimise the procedures for the use of second generation biodiesel, various aspects such as cost effectiveness, necessity of second generation biodiesel, biodiesel conversion technology, improving efficiency of the production process as well as performance and emission characteristics must be scrutinized and studied. The transesterification method is the most suitable method among the several possible methods for biodiesel production.

Istvan Barabas and Ioan-Adrian Todoruţ [7] studied on Biodiesel Quality, Standards and Properties. The paper presented the main standards on commercial biodiesel quality adopted in different regions of the world and the importance and significance of the main properties that are regulated (cetane number, density, viscosity, low-temperature performances, flash point, water content, etc.) and unregulated (elemetal composition, fatty acid methyl and ethyl esters composition, heating value, lubricity etc.) .

Chuepeng [8] studied the use of biodiesel in diesel engines The use of biodiesel blends in diesel engines has affected engine performance as well as combustion characteristics, i.e. ignition delay, injection timing, peak pressure, heat release rate, and so on. The combustion of biodiesel in diesel engines improved and regulated emissions except nitrogen oxides emissions were reduced.

Michael C Madden et al [9] studied the toxicology of biodiesel combustion products. The paper examined human responses to combustion products through an extensive literature exists on nonhuman animal effects.

Bianchi et al [10] studied the use of non-edible oils as raw materials for sustainable biodiesel production .The study gave special consideration to the role played by the development of a sustainable and responsible biofuels production, with no impact on food chain. It was concluded that the use of the oilseed deriving from alternative crops or waste oils as a feedstock for biodiesel production represents a very convenient way in order to lower the production costs of this biofuel.

3. Methodology

3.1 Feed stock

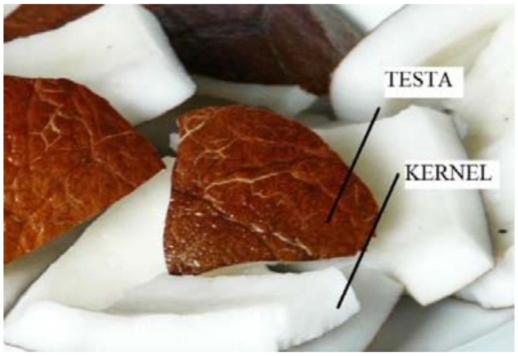

Fig:1 Coconut Kernel and Testa

Fig:2 Coconut Testa

The feed stock used in the production of biodiesel was coconut testa oil. Testa is the outer brown covering of the coconut kernel. In industries that produce coconut milk and virgin coconut oil, the outer brown covering is peeled off and discarded as a waste. The testa oil is produced by pressing the Testa. The properties and composition of the testa oil are similar to that of the coconut oil [1]. As compared to coconut oil, testa oil is advantageous for biodiesel production as it is non-edible and it is being produced out of a waste material.

3.2 Transesterification

Oils can be used directly as fuels in engines. Due to high viscosity of oil the atomization of oil become poor and this produces higher emission. Also long term use of oils lead to the damage of fuel injector. To overcome these barriers, the viscosity of the oil need to be decreased. The method used to decrease the viscosity of the testa oil is transesterification. It is the reaction between triglycerides in the oil and alcohol resulting the formation of esters and glycerol. 1 liter of coconut testa oil was taken in a conical flask. 8 g of KOH was dissolved in 250 ml methanol. The coconut testa oil was heated to 60 ^{0}C with constant stirring. The KOH solution was poured into the testa oil. The solution was stirred continuously for 45 minutes. The resulting mixture was poured into a separating flask and kept for 24 hours. After 24 hours the glycerol settled at the bottom of the flask was separated. The top portion was water washed.

Biodiesel get separated after 4 hours of water washing.

3.3. Properties Testing

1. Viscosity

The viscosity of biodiesel was measured using Brookfield Viscometer which satisfies ASTM standard. Viscosity is defined as the property by which a layer of fluid offers resistance to the motion of the adjacent layer. Viscosity (Engine performance related property) of a fuel determines the easiness by which it can be atomized in injectors. The obtained value is 4.05 centi poise (cP). This value is within ASTM standard value for viscosity (1.9-6.0 cP).

2. Density

Density is defined as the mass per unit volume. It is expressed in kg/ $m^{3.}$ This property (Engine performance related property) of the fuel influences the nozzle opening and injection timing of the fuel into the engine. The value for density was measured by a hydrometer. The obtained value of density for Testa biodiesel was 832.3 kg/m^3, which is within the ASTM standard (575-900 kg/m^3)

3. Flash point

The temperature at which the vapour of a liquid flash when subjected to a naked flame is known as the flash point of the liquid. 50 ml of Testa biodiesel was heated in a flash point measuring apparatus. The temperature was noted continuously with a thermometer. The vapour was exposed to naked flame and the temperature at which a momentarily flash obtained was noted. This temperature is the flash point of the biodiesel. The flash point of the Testa biodiesel was obtained as 124 ^{0}C. This satisfies ASTM standard .ASTM standard value is (minimum 100 ^{0}C)

4. Fire point

Fire point is the temperature of a fuel vapour, if once lit with the flame, will burn steadily at least for 5 seconds. Flash point is a good indication of the relative flammability of a fuel. 50 ml of Testa biodiesel was heated in a fire point measuring apparatus. The temperature was noted by a thermometer. The vapour was exposed to naked flame and the temperature at which the fuel vapour burns continuously for at least 5 seconds was noted. The fire point of the Testa biodiesel was obtained as 132 ^{0}C.Due to the higher fire point of Testa biodiesel, it can be transported and stored safely.

5. Acid value

The acid number is the measure of the amount of carboxylic acid groups in a chemical compound. Acid number determines the degree of degradation of biodiesel when the fuel is used. Acid value of the biodiesel is defined as the number of milligrams of KOH required to neutralize free acid present in one gram of biodiesel. 10 mg of biodiesel was mixed with 100ml neutral alcohol in a conical flask and heated in a water bath for 2 to 5 minutes to dissolve completely. 0.1N KOH solution was taken in a burette. The solution in the conical flask was titrated against 0.1N KOH solution in the burette using phenolphthalein indicator. Titration was continued till the first appearance of a persistent pink colour was obtained. The acid value of the biodiesel was obtained as 0.336 milligram KOH/g, which is within the ASTM standards. ASTM standard value is 0.5 milligram KOH/g.

6. Iodine value

The iodine number is an index of the number of double bonds in the biodiesel. The number of double bonds determines the extent on unsaturation content in the biodiesel. The extent of saturation determines the oxidation stability. Higher the Iodine value, the biodiesel has more unsaturated contents. During long term storage of biodiesel, Iodine value decrease due to degradation of the biodiesel.

0.2 to 0.3 g of Testa biodiesel was taken in a conical flask. 10 ml of carbon tetrachloride was added to the conical flask. 20 ml of Wij's reagent was added to the flask. The stopper of the flask was dipped in Potassium Iodide solution. The mixture was placed in dark for 30 minutes. After taking out from the dark, 20 ml of 15% Potassium Iodide solution and 50 ml of water was added to it. The solution was titrated with 0.1 N Sodium Thiosulphate solution till pale yellow colour appeared. Starch was added as an indicator to the solution. It was again titrated with 0.1 N Sodium Thiosulphate solution. End point was noted when the black colour of the solution just disappeared. The iodine value of the biodiesel was obtained as 23.57 mgI/g.

7. Saponification value

The process of formation of soap is called saponification. Saponification value is defined as the milligrams of KOH required to saponify 1g of fat or oil.

$$\textit{Saponification value} = \frac{56.1 \text{ x } (B - S) \text{ x } N}{W}$$

B = Titre value for blank, ml
S = Titre value for sample, ml
N = Normality of HCl
(B – S) = Vol. of HCl corresponding to KOH reacted.
W = Weight of sample of oil in g.

0.5 g of testa biodiesel was taken in a conical flask. 25 ml of alcoholic potash was added to it. Alcoholic potash was added to the flask. This served as blank. . Condensers were attached and the flasks were heated in a water bath gently but steadily for about an hour. After one hour of heating, the solutions are allowed to cool and the inside of the condensers were washed down by minimum amount of distilled water. Phenolphthalein indicator was added to both the flask and titrated using 0.1 N HCl. The saponification value of the biodiesel was obtained as 117.81 mgKOH/g, which is within the ASTM standards.

ASTM value is maximum 120 mg KOH/g.

Results and discussion

Biodiesel was prepared out of coconut testa oil and the properties were studied.

1. The value of dynamic viscosity of the Testa biodiesel is 4.05 centipoise. This value meets the ASTM standard.
2. 832.3 kg/m^3 is the value of density of Testa biodiesel obtained during density test which also satisfies ASTM standard.
3. Testa biodiesel has a Flash point of 124 ^{0}C and a fire point of 132 ^{0}C. Both this values satisfies ASTM standard.
4. Acid value of Testa biodiesel is 0.336 mgKOH/g and Iodine value is 23.57 mgI/g.
5. Testa biodiesel has a saponification value of 117.81mgKOH/g.

Biodiesel produced form Testa oil has similar properties as any other biodiesel. The values for engine performance related properties like density and viscosity are within standard value. This shows that it can use in CI engines as an alternate fuel. Fuel stability related properties, Acid value and Iodine value of Testa biodiesel is also within the range. Thus it has good storage stability. Higher flash point and fire point implies that it can be transported and handled safely.

Table: 1 Properties of Testa biodiesel

Sl. No	Property	ASTM standard	Evaluated value
1	Viscosity	1.9 – 6 cP	4.05 cP
2	Density	575 – 900 kg/m^3	832.3 kg/m^3
3	Flash Point	100 ^{0}C, min	124 ^{0}C
4	Fire Point		132 ^{0}C
5	Acid Value	0.5 mg KOH/g, max	0.336 mg KOH/g
6	Iodine Value		23.57 mgI/g
7	Saponification Value	120 mg KOH/g, max	117.81 mg KOH/g

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