IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁙ Impact Factor 7.105 ⁙ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9703

Experimental Investigation on the Fuel Properties of Mahua oil Biodiesel and Its Blends

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Abstract: In this research, the properties of biodiesel (from mahua oil), diesel and their blends were investigated. The blends were prepared on a volume basis. The density, kinematic viscosity, flash point and fire point of the samples were measured. The results showed that the density, kinematic viscosity, flash point and fire point of diesel fuels (B0) are lower than the biodiesel (B100). Therefore, the density, viscosity, flash point and fire point of the blend increases with the increase of biodiesel concentration.

Keywords: Biodiesel, Mahua oil, Density, Viscosity, Flash point, Fire point, Properties

I. INTRODUCTION

Now a days, a considerable attention has been paid to different kinds of fossil energy resources such as coal, oil and natural gas. Diesel fuel has significant and greater importance in the industrial, transportation and power generating sectors of the economy of developed and developing countries. The demand for diesel is rapidly increasing worldwide. The continuous increasing demand for energy and the decreasing petroleum resources has led to the search for alternative fuel which is renewable and sustainable. Bio-diesel is an alternative to petroleum-based fuels derived from vegetable oils, animal fats, and used waste cooking oil. Biodiesel possesses technical and environmental advantages, low toxicity, derivation from renewable sources, higher superior flash point, very low or no sulphur content, biodegradability and lower exhaust emissions. Biodiesel's characteristics strongly depend on various plant feed stocks, growing climate conditions, soil type, plant health and plant maturity upon harvest. These parameters affect the physical and chemical properties. Current worldwide production of vegetable oil and animal fat is not enough to replace liquid fossil fuel use. These reasons gave rise to the increasing importance of blends of other fuels like diesel fuel, bio-ethanol etc with biodiesel.

II. LITERATURE REVIEW

T. Yogeeswara et al [1] studied the physical and chemical characterization of waste frying palm oil biodiesel and its blends with diesel. Major fuel properties such as kinematic viscosity, density, lower calorific value, flash point and fire point were evaluated as per ASTM standards for B100 (or biodiesel) and its blends with diesel like B20, B40, B60, B80and compared to B0 (pure diesel). The study revealed that the density (0.875 g/cc), kinematic viscosity at 40 °C (7.7 mm^2/s), cetane number (62), and flashpoint (127 °C) of biodiesel were observed to be higher but the calorific value (37.78 MJ/kg) was lower than that of diesel fuel.

The properties of olive oil biodiesel, diesel fuel and n-butyl alcohol blends were measured by Mert Gülüm et al [2]. In this research, olive oil biodiesel was produced, the ternary blends including commercially available diesel fuel, produced olive oil biodiesel and n-butyl alcohol were prepared, and densities and kinematic viscosities of the blends were measured at 15ºC and 40ºC according to ISO 4787 and DIN 53015 standards, respectively. Experimental results show that viscosities non-linearly and densities linearly as expected decrease with increasing n-butyl alcohol content in blend.

The basic fuel properties of biodiesel and blends were analysed by Ertan Alptekin et al [3]. In this research, commercially available two different diesel fuels were blended with the biodiesels produced from six different vegetable oils (sunflower, canola, soybean, cottonseed, corn oils and waste palm oil). The blends (B2, B5, B10, B20, B50 and B75) were prepared on a volume basis.

Sandeep Singh et al [4] determined properties of biodiesel-diesel fuel blends. Two biodiesels produced from waste cotton seed oil and waste mustard oil. The properties of biodiesel are to be checked at different blends (B10, B15, B20). The density, FFA content, flash point and fire point, ash content, carbon residue content and calorific value of B10

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blends of cotton seed and mustard methyl ester were observed to be less as compared to blends B15 and B 20 of both esters. The results indicate that characteristics of B10 blend of cotton seed methyl ester and mustard methyl ester was more optimized as compared to B15 and B20 blends.

Sharzali Che Mat et al [5] determined viscosities, calorific values and densities of binary bio fuel blends. A total of fourblends with the mixing ratios of 20%, 40%, 50% and 60% of melaleucacajuputi oil were prepared. It was found that viscosity and density of the blends decreased with the increase of melaleucacajuputi oil fraction. Meanwhile, the calorific value of the blends increased linearly as the melaleucacajuputi oil fraction increased.

Osman Gokdogan et al [6] researched density and kinematic viscosity of castor oil and its blends. The biodiesel was produced from castor oil using sodium hydroxide and methanol by the two-step transesterification method. Nine different fuel blends (2, 5, 10, 20, 30, 40, 50, 60 and 75% by volume blending with diesel) were prepared. The density values of castor oil biodiesel and its blends were measured at the temperature range from 0 to 93°C in steps of 5°C and the kinematic viscosity values of castor oil biodiesel and its blends were measured at the temperature range from 30 to 100°C in the steps of 5°C. The results showed that the density and kinematic viscosity of fuel samples decrease as temperature increases; and also these properties decrease as a result of the increase in the amount of diesel in the blends.

III. MATERIALS AND METHOD

Raw Material

Mahua seeds were purchased from K.P.Traders, K.P.complex, Katharipulam, Vedaraniam. Photograph of mahua seeds is given in figure- 1. The seeds should be de-shelled by pressing and then dried to get the kernel. Expeller process was used to extract mahua oil at the quantity of 380 ml per kg of kernels.

Figure-1: Photograph of mahua seeds.

Biodiesel production

Biodiesel was prepared by transesterification method. The mahua oil was heated to a temperature of 60 ^{O}C and methanol and catalyst sodium hydroxide were added to it. Then the final mixture was stirred for 4 hours. After transesterification the total mixture was separated into two layers. The lower layer was glycerol and upper layer was methyl ester (biodiesel). The upper layer (methyl ester) was separated then the methyl ester layer was washed with warm water. After the washing, the methyl ester was subjected to a heating at 100^{O}C to remove excess alcohol and water.

Preparation of samples

Biodiesel is prepared from mahua oil. The blends of biodiesel and diesel were prepared in glass container at atmospheric conditions. The homogeneity of the fuels was achieved by rotating agitator at medium speed for 10 minutes. The percentage of samples is given in table-1.

Table -1: Percentages of biodiesel and diesel fuel used in preparing samples

Biodiesel Blend	Percentage of Biodiesel (%)	Percentage of Diesel (%)
B0	0	100
B25	25	75

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B50	50	50
B75	75	25
B100	100	0

Apparatus and Measurements
Properties of the biodiesel and its blends were determined on different apparatus. Table-2 shows the list of the apparatus on which properties were tested and determined.

Table-2: Apparatus used for determination the properties

Properties	Apparatus
Density	Weighing balance
Kinematic viscosity	Redwood viscometer
Flash and fire point	Open cup apparatus

Density, kinematic viscosity, flash point and fire point were measured using standard methods. The density was measured using weighing equipment. The viscosity was measured using redwood viscometer. The flash point and fire point were measured using open cup apparatus.

IV. RESULTS AND DISCUSSIONS

The fuel properties of diesel, biodiesel and its blends with diesel fuel are given in table-3.

Table-3: Properties of different blends of biodiesel and diesel

Properties	B0	B25	B50	B75	B100
Density (gm/cm^3)	0.825	0.838	0.851	0.864	0.878
Kinematic viscosity (mm^2/s)	2.4	2.8	3.2	3.7	4.1
Flash point (^OC)	52	82	111	140	174
Fire point (^OC)	56	87	117	148	183

Density
Figure-2 depicts the relationship between density and different blends of biodiesel. As observable in the figure, the density increases linearly with increase in biodiesel composition. It is observed that the density of biodiesel is the higher at $0.878 gm/cm^3$ and density of diesel is the lowest at $0.825 gm/cm^3$. The density of the biodiesel blends increased from B25 to B100. Shuman Guo et al [7] studied the physical and chemical properties of biodiesel (from waste cooking oil) and diesel fuel blends (B10, B20, B30, B40, B50, B60, B70, B80 and B90). They reported that the density of the blends gradually increased with an increasing volume fraction of biodiesel. Thus, the density of biodiesel is only 1.055 times that of diesel, and the density of the blend was between the two values. Kiran Raj Bukkarapu et al [8] investigated the effects of blending on the properties of diesel and palm biodiesel. The results revealed that the density of all the samples of biodiesel was higher than that of mineral diesel.

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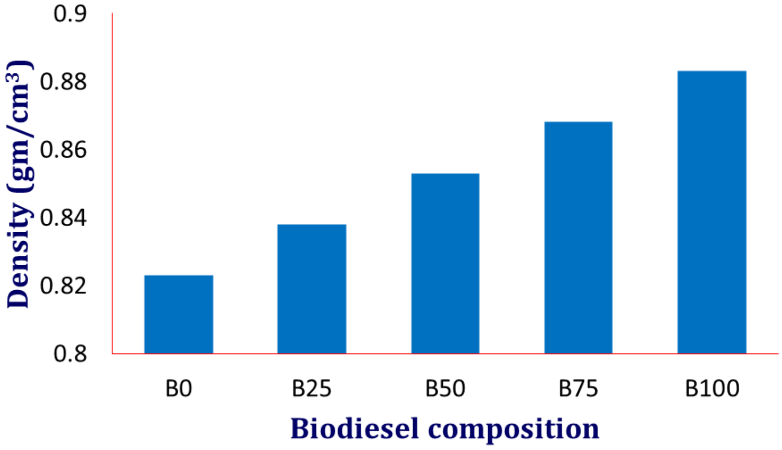

Figure-2: Density of different blends of biodiesel and diesel

Kinematic Viscosity

It was calculated with the help of redwood viscometer. In this, the time taken for gravity flow by a fixed volume of samples was measured. Viscosity is a measure of the internal friction or resistance of an oil to flow. The variation of kinematic viscosity and biodiesel blends is depicted in figure-3. The kinematic viscosity of B100 is higher than those of the fuel types (B25, B50 and B75) and B0. It can be noticed that pure biodiesel (B100) produced the maximum kinematic viscosity while pure diesel produced the least. The blends showed the intermediate results. The influence on viscosity of blending biodiesel and diesel fuels was studied by Minh Tuan Pham et al [9]. Three types of biodiesel were examined: Coconut oil-based biodiesel, Jatropha oil-based biodiesel, and Waste oil-based biodiesel. Twenty-four samples of the three types of biodiesel–diesel fuel blends were created by blending 5% (B5), 10% (B10), 20% (B20), 40% (B40), 50% (B50), 60% (B60), 75% (B75), and 100% (B100) of biodiesel with conventional diesel fuel to produce the corresponding blends for experimental purposes. The experimental results showed that the kinematic viscosity of biodiesel–diesel fuel blend increased as the volume fractions of the biodiesel increased. The physical and chemical properties of biodiesel and blends were investigated by Siraj Sayyed et al [10]. The blends of pongamiapinnata biodiesel and diesel were prepared in the ratios of their volumes at a laboratory. They conclude that the kinematic viscosity of biodiesel blends increases as the percentage of biodiesel increases in the blends due to the higher values of biodiesel than that of diesel.

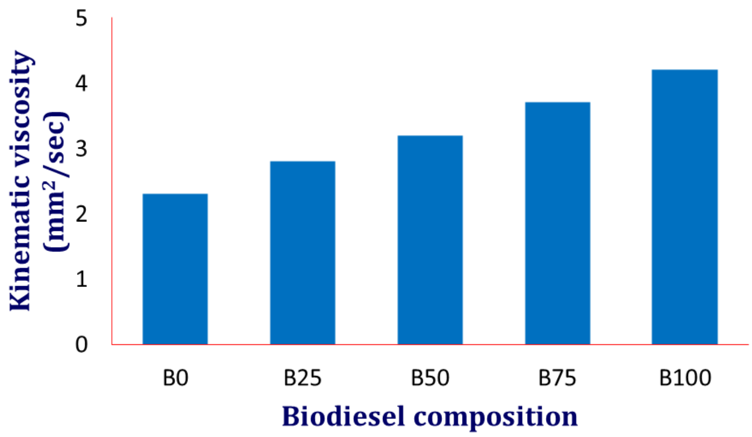

Figure-3: Kinematic viscosity of different blends of biodiesel and diesel

Flash Point

It is the minimum temperature at which the fuel vapors start to ignite in air. The flash point of the samples was calculated by the open cup apparatus. It indicates the flammability of the fuel. The flash point was measured for two samples and the overall results given in Table-3. The variation of flashpoint for different blends is as shown in figure-4. The maximum flash point is 174 ^{O}C measured for B100 biodiesel sample, and the minimum is 52 ^{O}C measured for

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diesel. Siraj Sayyed and his group [10] studied the effects of volume fraction of biodiesel and diesel on the properties of blends. Experimentations were conducted on 11 samples on the basis of volume % for pongamiapinnata biodiesel and diesel blends in the step of 10 varying from 0% (diesel) to 100% (Pongamiapinnata biodiesel). The study revealed that the values of flashpoint of biodiesel blends increases as the percentage of biodiesel increases in the blends due to the higher values of biodiesel than that of diesel. Idubor Fabian et al [11] investigated thermophysical properties of biodiesel from sunflower waste cooking oil and its blends. Blends at proportions of 10% (B10), 20% (B20) and 40% (B40) on volume basis were prepared. The results revealed that the flash point of the blends gradually increased with an increasing volume fraction of biodiesel.

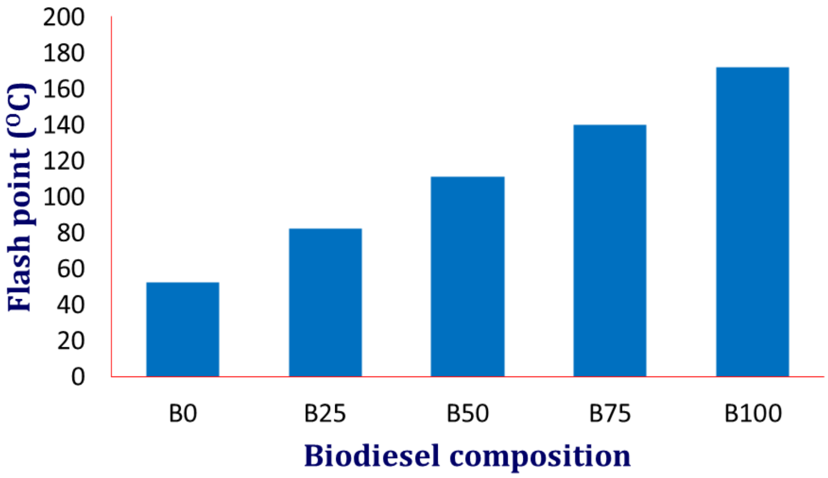

Figure-4: Flash point of different blends of biodiesel and diesel

Fire Point:
The fire point of fuel is very important as it conveys the burning capacity of fuel. Fire point is normally higher than flash point and is an important safety parameter. The fire point of diesel, biodiesel and their blends are plotted in figure-5. Diesel (B0) has the lowest fire point, biodiesel (B100) has the highest fire point while the fire point of the blends increased proportionately with the amount of biodiesel in the mix. Kiran Raj Bukkarapu et al [8] researched the properties of diesel and palm biodiesel. Blend of the produced palm biodiesel and diesel in different volume percentages were prepared and designated as PD0 (Neat Diesel), PD10, PD20…up to PD100 (Neat Palm Biodiesel). Experimental results show that the fire point of the sample increases with the biodiesel percentage. R. Tamizh Selvan et al [12] examined the influence of biodiesel and diesel blending on the properties. Mustard oil biodiesel blends as B5, B15, B25, B35, B45 and B100 were used as a fuel and compared with diesel (B0). They conclude that the fire point increases linearly with increase in biodiesel composition. The highest fire point is found to be associated with pure biodiesel (B100), and the lowest with pure diesel (B0).

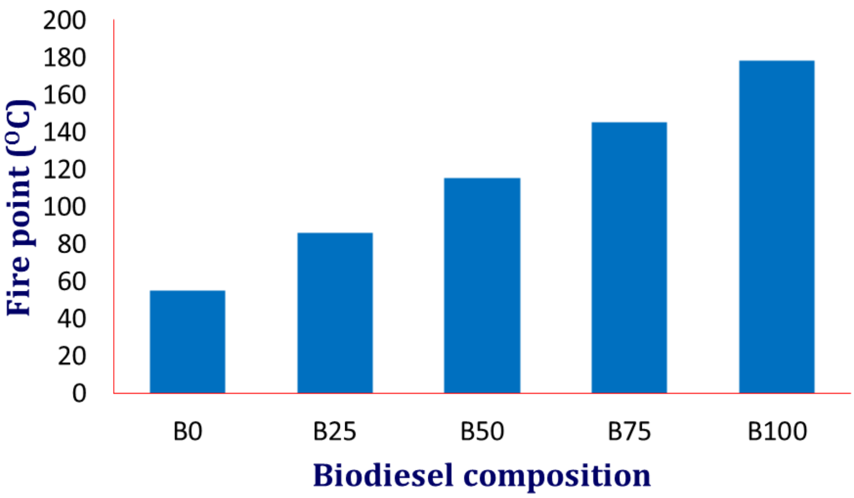

Figure-5: Fire point of different blends of biodiesel and diesel

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V. CONCLUSION

This investigation has established relationships between the percentage of mahua oil biodiesel blended with diesel and the properties like density, kinematic viscosity, fire point and flash point. The values of density, kinematic viscosity, flash point and fire point of biodiesel blends increases as the percentage of biodiesel increases in the blends due to the higher values of biodiesel than that of diesel.

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