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# Investigation of Fuel Properties of Sunflower Biodiesel and Its Blends with Diesel

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**ABSTRACT:** Sunflower is one of the leading oil seed crop, cultivated for the production of oil in the world. Biodiesel is gaining more and more importance as an attractive fuel due to the depleting fossil fuel resources. In this research, the sunflower biodiesel was extracted through transesterification process with methanol and NaOH as catalyst. Three different fuel blends (25, 50 and 75% by volume blending with diesel) were prepared. Density, kinematic viscosity, flash point and fire point, these are the four main fuel properties that were investigated. The results showed that the density, viscosity, flash point and fire point of diesel fuels (B0) are lower than the sunflower biodiesel (B100). Therefore, the density, viscosity, flash point and fire point of the blend increases with the increase of biodiesel concentration.

**KEYWORDS*:*** biodiesel, sunflower oil, density, viscosity, flash point, fire point, fuel properties.

## I. INTRODUCTION

The major percentages of energy used in the world today are being generated from fossil fuel sources. Coal, oil, and natural gas are examples of fossil fuels. Diesel fuel is one of the major sources of energy in transportation, agricultural, domestic and industrial sectors due to its availability, reliability, adaptability, higher combustion efficiency as well as the handling facilities. However, their reserves are wiping out every day. Biodiesel is considered as an attractive alternative to replace diesel fuels. Biodiesel is biodegradable, non-toxic, non-explosive, non-flammable, renewable, higher cetane number and an environmentally friendly (produces fewer emissions) fuel. Biodiesel is alkyl esters of fatty acids and can be obtained by employing the transesterification process of vegetable oils, animal fats and waste cooking oil. Transesterification process is a process which involves alcohol reacting with oil in the presence of catalyst which leads to formation of biodiesel. A catalyst is usually used to improve the reaction rate and yield. Among the alcohols that can be used in the transesterification reaction are methanol, ethanol, propanol, butanol, and amyl alcohol. Methanol and ethanol are used most frequently. Ethanol is a preferred alcohol in the transesterification process compared to methanol because it is derived from agricultural products and is renewable and biologically less objectionable in the environment; however, methanol is favorable alcohol because of its low cost and its physical and chemical advantages. NaOH is considered in transesterification due to its high purity and low cost. Vegetable oil can be obtained from both edible (palm oil, rapeseed oil, sunflower oil, coconut oil, sesame oil, peanut oil etc) and non-edible (calophyllum inophyllum, castor, jatropha, neem, cotton, rubber and mahua etc) oil sources. But odisha, chattisisgarh, Maharashtra, Madhya Pradesh and Tamilnadu people's still used mahua oil in their cooking. Table-1 shows the names of some important oil bearing species for biodiesel production. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend or can be used in its pure form.

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**Table 1: Oil bearing species for biodiesel production.**

| Category | Source of oil |
|---|---|
| Edible oil | Coconut, Sesame seed, Peanut, Palm, Sunflower, Rapeseed, Rice bran, Soybean, Corn, Safflower oil, Mustard, Olive, Pistachia Palestine, Opium Poppy, Amaranth, Apricot, Argan, Artichoke, Avocado, Babassu, Bay laurel, Beech nut, Ben, Borneo tallow nut, Carob pod (algaroba), Cohune, Coriander seed, False flax, Grape seed, Hemp, Kapok seed, Lallemantia, Lemon seed, Macauba fruit (Acrocomia sclerocarpa), Meadowfoam seed, Okra seed (hibiscus seed), Perilla seed, Pequi,(Caryocar brasiliensis seed), Pine nut, Poppy seed, Prune kernel, Quinoa, Ramtil (Guizotia abyssinica seed or Nigerpea), Tallow, Tea(camellia), Thistle (Silybum marianum seed), and Wheat germ |
| Non-edible oil | Mahua, Jatropha, Neem, Pongamia, Karanja, Cottonseed, Linseed, Deccan hemp, Jojoba, Kusum, Orange, Rubber seed, Sea Mango, Milk bush, Nagchampa, Rubber seed tree, Tobacco seed oil, Algae, Halophytes and Xylocarpus moluccensis. |

## II. LITERATURE REVIEW

Momar Talla Dieng et al [1] biodiesel produced from rapeseed oil by transesterification process. The effects of some parameters including amount of methanol, catalyst concentration, reaction time and reaction temperature were studied and the optimum conditions were obtained. The optimum transesterification conditions found were alcohol:oil ratio of 18:1, 1% of potassium hydroxide as catalyst, 60 min of reaction time, 60 °C of reaction temperature and stirring speed of 650 rpm.

Hadiza Garba Abubakar et al [2] investigated transesterification process with the objective of producing highest yield of biodiesel from coconut oil by optimizing various process variables like oil to methanol ratio, catalyst concentration, reaction temperature and reaction time. The result shows optimum conditions of biodiesel yield of 84.48% were found at 6:1 alcohol/oil ratio, 0.55 % catalyst concentration (KOH), reaction temperature of $65^0$C and reaction time of 40 min respectively.

Kaniz Ferdous and his group [3] manufactured biodiesel from sesame oil by transesterification process. The reaction parameters such as methanol/oil molar ratio, catalyst concentration and reaction time were optimized for the production of sesame oil biodiesel. They reported that the optimum condition for the base catalyst transesterification reaction was 0.87 wt% NaOH to oil as catalyst, methanol/oil molar ratio of 6:1 and the maximum conversion was 98.3% from oil to biodiesel at 90 minutes.

Md. Shazib Uddin et al [4] produced biodiesel from peanut oil by a transesterification process. Blends at proportions of 10% (B10) and 20% (B20) on volume basis were prepared to measure the fuel properties of them. The results showed that the density, viscosity, flash point and fire point increases with increase in biodiesel composition.

S. Savariraj et al [5] investigated fuel properties of biodiesel from fish oil and its blends with diesel. Three different fuel blends (25, 50 and 75% by volume blending with diesel) were prepared. The fuel properties of fish oil biodiesel and its blends were measured. The experimental results showed that the kinematic viscosity, specific gravity and flash point of biodiesel blend increases as the percentage of fish oil biodiesel increases in the blends.

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## III. MATERIALS AND METHODS

**Raw Material**

Sunflower oil was purchased from the local market.

**Biodiesel production**

Biodiesel was produced from sunflower oil by means of the transesterification process. A specified amount one litre of sunflower oil was added into the reaction flask. Raw sunflower oil temperature was raised to 105$^0$C and kept at this temperature for around 20 minutes while constantly stirring to decrease water content in the oil. The oil was later passed through a strainer while to remove solid particles and debris from the oil. An appropriate amount of methanol was measured and poured in a beaker with 1% of NaOH pellet added to it. The content of the beaker was manually stirred until the NaOH is completely dissolved in the methanol which would give a mixture called sodium methoxide. The sodium methoxide was poured into the reactor containing the heated oil and the entire content in the reactor stirred at the rate of 400 rpm and temperature maintained at 60 °C. The heating and stirring was stopped after two hours and the resulting product poured into a separating funnel mounted on a clamp stand and allowed to settle under gravity in separating funnel for 24 hours to separate biodiesel and glycerol. The lower layer was glycerol and upper layer was biodiesel. The upper layer was separated then the biodiesel was washed with warm water. After the washing, the biodiesel was subjected to a heating at 105$^O$C to remove excess alcohol and water.

**Preparation of biodiesel-diesel blends**

The fuel blends in this report were labeled as BX, where B represents biodiesel and X represents the volume percentage of biodiesel in each fuel blend. For example, B25 represents a fuel blend that contains 25% biodiesel and 75% diesel by volume. Several biodiesel-diesel blends were created using 25, 50 and 75 volume % biodiesel, labeled as B25, B50 and B75 respectively. Fuel blends were obtained by uniform mixing. The pure biodiesel was labeled as B100, and the pure diesel was labeled as B0. The blend compositions of all of the fuel samples are given in Table-2.

**Table 2: Blend fuel compositions (% vol)**

| Type of fuel | Fuel description | Fuel samples |
|---|---|---|
| Diesel | 100% diesel | B0 |
| Diesel- Biodiesel blend | 75% diesel+25% Biodiesel | B25 |
| Diesel- Biodiesel blend | 50% diesel+50% Biodiesel | B50 |
| Diesel- Biodiesel blend | 25% diesel+75% Biodiesel | B75 |
| Biodiesel | 100% Biodiesel | B100 |

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## IV. RESULTS AND DISCUSSION

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

**Table 3: Fuel properties of diesel, biodiesel and its blends**

| Properties | Density ($gm/cm^3$) | Kinematic viscosity ($mm^2/s$) | Flash point ($^OC$) | Fire point ($^OC$) |
|---|---|---|---|---|
| B0 | 0.811 | 3.29 | 53 | 59 |
| B25 | 0.825 | 4.02 | 62 | 68 |
| B50 | 0.839 | 4.78 | 71 | 78 |
| B75 | 0.852 | 5.82 | 113 | 121 |
| B100 | 0.866 | 6.36 | 180 | 189 |

### Density

Variation of density for different fuel is presented in figure-1. B100 has density of 0.866 which is 1.067 times higher than the diesel. Figure-1 indicates that density increases with the increase in percentage of biodiesel in the blend. The densities of biodiesel are generally higher than those diesel fuels. They depend on their fatty acid composition and the purity of the feedstock. T.Elangovan et al [6] investigated fuel properties of biodiesel from calophyllum inophyllum oil and its blends with diesel. Four different fuel blends (20, 40, 60 and 80% by volume blending with diesel) were prepared. The density values of calophyllum inophyllum biodiesel and its blends were measured at room temperature. Results indicated that the density of biodiesel blends increases as the percentage of calophyllum inophyllum biodiesel increases in the blends due to the higher values of biodiesel than that of diesel. Mohammad Anwar et al [7] prepared biodiesel from papaya seed oil by transesterification process. The carica papaya biodiesel was blended with diesel by various percentages such as B0, B5, B10, B20 and B100. The blends were prepared on a volume basis. The results showed that the density of diesel fuels (B0) is lower than the carica papaya biodiesel (B100). Therefore, the density of the blend increases with the increase of biodiesel concentration.

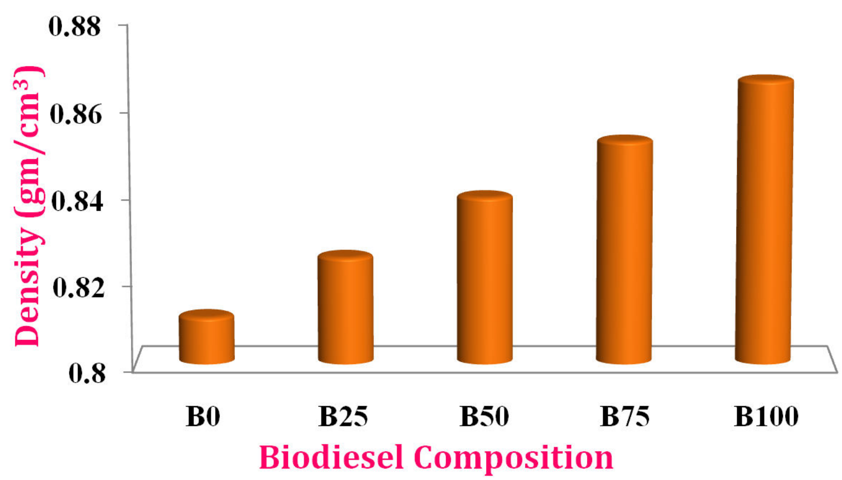


**Figure 1: Density of diesel, biodiesel and its blends**

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**Kinematic viscosity**

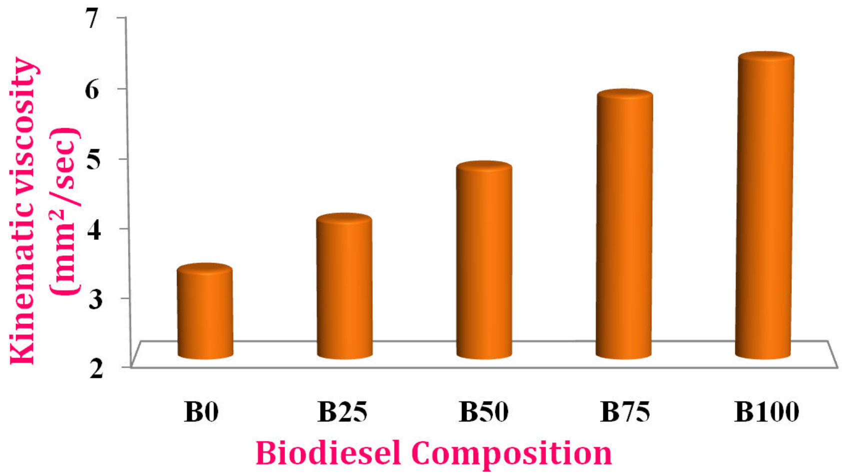


**Figure 2: Kinematic viscosity of diesel, biodiesel and its blends**

Figure-2 depicts the relationship between kinematic viscosity and different blends of biodiesel. 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 biodiesel kinematic viscosity was seen to be 6.36mm$^2$/s, which is noticed as 93 percent higher than diesel. Osman Gokdogan et al [8] researched the thermophysical properties of castor oil biodiesel and its blends. Nine different fuel blends (2, 5, 10, 20, 30, 40, 50, 60 and 75% by volume blending with diesel) were prepared. Kinematic viscosity of the prepared samples was determined. The results revealed that the value of kinematic viscosity of biodiesel blends increases as the percentage of biodiesel increases in the blends. The fuel properties of calophyllum inophyllum biodiesel and blends were investigated by R. Suresh [9]. The blends (B30, B50 and B70) were prepared on a volume basis and their kinematic viscosities were measured by following ISO test method. The experimental results showed that the kinematic viscosity of biodiesel blends increases as the percentage of calophyllum inophyllum biodiesel increases in the blends.

**Flash point**

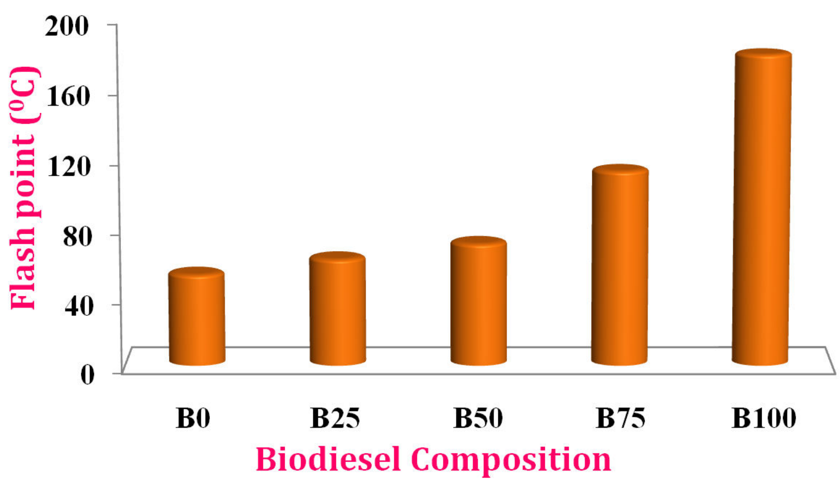


**Figure 3: Flash point of diesel, biodiesel and its blends**

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Flash point of a fuel indicates the temperature at which the fuel ignites when exposed to a flame. The variation of flash point and biodiesel blends is depicted in figure-3. The relation between flash point and the percentage of biodiesel in the sample shows increase the flash point as the percentage of biodiesel increases in the sample, this because biodiesel is more flash point than diesel. Appese .S.D et al [10] measured viscosity, specific gravity, calorific value, flash point of neem oil bio-diesel and its blends with diesel. The neem oil biodiesel was blended with diesel by various proportions such as B0, B20, B40, B60, B80 and B100. They conclude that that the flash points of biodiesel–diesel fuel blend increased as the percentage of biodiesel increased. Dhruva D et al [11] investigated fuel properties of biodiesel from rice bran oil and its blends with diesel. Rice bran oil methyl ester was prepared from crude rice bran oil by using three stage transesterification processes. Fuel properties such as viscosity, gross calorific value, flash and fire points were compared with conventional diesel oil. Experimental results show that the flash point increases linearly with increase in biodiesel composition. The highest flash point is found to be associated with pure biodiesel (B100), and the lowest with pure diesel (B0).

**Fire point**

Fire point is the property whose value is more than flash point because it reflects the situation at which vapor burns constantly for at least five seconds. The fire point is always observed to be higher than flash point by around 5 to 12$^{o}$C. Figure-4 depicts the relationship between fire point and different blends of biodiesel. It is clearly shown that the rise of the biodiesel content in the fuel blend increases the fire point of the fuel. The maximum fire point is 189$^{O}$C measured for B100 biodiesel sample, and the minimum is 59$^{O}$C measured for diesel. Kuber Singh Mehra et al [12] prepared biofuel from sesame oil by transesterification process. Experimentations were conducted on six samples on the basis of volume % for sesame oil biodiesel and diesel blends in the step of 20 varying from 0% (diesel) to 100% (sesame oil biodiesel). The results revealed that the values of fire point of biodiesel blends increases as the percentage of sesame oil biodiesel increases in the blends. Nithyananda B S et al [13] determined properties of diesel, pongamia biodiesel and its blends. Biodiesel blends of pongamia methyl esters with diesel on 10, 20, 30, 40 and 50% volume basis was prepared and fuel properties are measured. They conclude that the fire point increases linearly with increase in biodiesel composition.

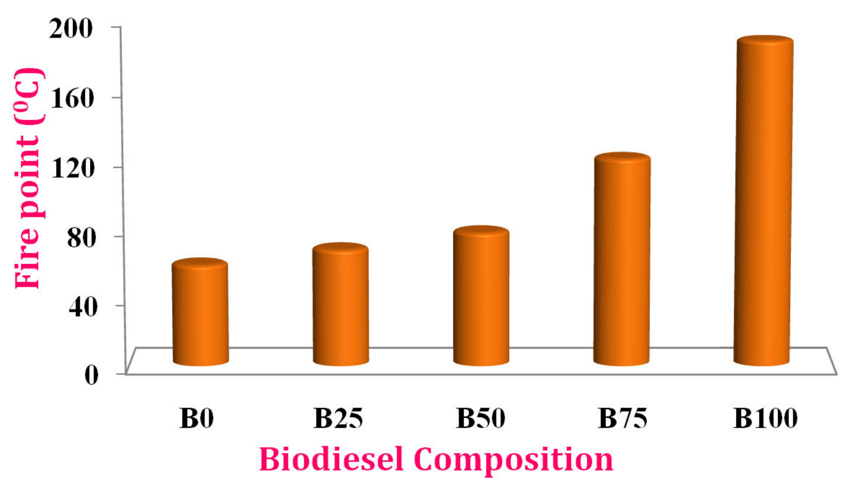


**Figure 4: Fire point of diesel, biodiesel and its blends**

## V. CONCLUSION

The sunflower biodiesel is developed from raw sunflower oil purchased from the market. Fuel properties such as density, kinematic viscosity, flash and fire point of diesel, sunflower biodiesel and their blends with diesel were experimentally investigated. The density, viscosity, flash point and fire point of diesel fuels are lower than the sunflower biodiesel. The

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values of density, kinematic viscosity, flash point and fire point of biodiesel blends increases as the percentage of biodiesel increases in the blends.

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