Fuel Properties of Neem Oil Biodiesel and Its Blends

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Abstract

In this research work, two step processes was carried out for biodiesel production from a non edible source of neem seed. In this pre-treatment acid esterification followed by base-transesterification reactions were employed for biodiesel production. The neem biodiesel was blended with diesel in conical flasks with continuous stirring for uniformity of mixing at a percentage volume ratio of biodiesel to diesel of 0, 30, 50, 80, 100% referred to as B0, B30, B50, B80, B100. Density, kinematic viscosity, flash point and fire point, these are the four main fuel properties that were investigated. The experimental results showed that the density, kinematic viscosity, flash point and fire point of diesel fuels are lower than the biodiesel. Therefore, the density, kinematic viscosity, flash point and fire point of the blend increases with the increase of biodiesel concentration.

Keywords: neem oil, biodiesel, fuel properties, density, kinematic viscosity, flash point, fire point.

INTRODUCTION

Increasing the consumption and price hike of petroleum fuel day to day is really problems for developing countries those are dependent on foreign suppliers. Petroleum is a fast depleting natural resource. Biodiesel has been considering as promising fuel in the situation of ever-depleting petroleum fuel. Biodiesel has several advantages over petroleum diesel, such as no net carbon contribution to the environment, a high flash point, simple technology of production, complete combustion with low sulfur exhaust and high cetane number. On the other hand, biodiesel has higher viscosity and less calorific value as compared with the diesel. Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, or animal fats. Vegetable oils are mainly classified as edible and non edible oils. Presently, non-edible oil sources such as neem, calophyllum inophyllum, jatropha and pongamia got attention for the production of biodiesel. Biodiesel is produced by dilution, microemulsion, pyrolysis and transesterification. Transesterification is the most common way to produce biodiesel. A two-step reaction system consists of acid and alkaline catalyst is recommended for conversion of biodiesel from high FFA oils. Table-1 shows the names of some important oil bearing species for biodiesel production [1].

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, Rubber seed, Linseed, Deccan hemp, Jojoba, Kusum, Orange, Sea Mango, Milk bush, Nagchampa, Tobacco seed oil, Algae, Halophytes and Xylocarpus moluccensis.

LITERATURE REVIEW

Ramachandran Kasirajan [2] manufactured biodiesel from chrysophyllum albidum seed oil by two step processes. The effects of some parameters including reaction temperature, catalyst loading, methanol-oil molar ratio, reaction time and stirring rate were studied and the optimum conditions were obtained. The highest conversion of oil to biodiesel was achieved as 99.2 wt% at the satisfying conditions of 1:9 molar ratio of oil to methanol, 1 wt% of KOH, and 500 rpm of mixing intensity with 40 min of reaction time at 65°C.

Samuel O.D et al [3] investigated transesterification process with the objective of producing highest yield of biodiesel from coconut oil by optimizing various process variables like reaction temperature, reaction time, catalyst concentration and CNO quantity. The result shows optimum CNO biodiesel yield of 96.09% was obtained with ethanol-CNO ratio 0.2 under typical transesterification reaction condition of 60°C temperature, 60min reaction duration and 1.0% alkali catalyst (NaOH) concentration.

Md. Shazib Uddin and his group [4] produced biodiesel from peanut oil by transesterification process. The reaction parameters such as methanol/oil molar ratio, catalyst concentration and reaction time were optimized for the production of peanut oil biodiesel. They reported that the optimum condition for maximum biodiesel from peanut oil was 20% methanol, 0.5% NaOH, 50°C reaction temperature and the maximum biodiesel production was 93 % by volume.

MATERIALS AND METHODS

Neem Tree

The scientific name of the neem tree is Azadirachta indica. It is one of the fastest growing trees and can reach a height of about 90-100 ft and sometimes 131 ft and its diameter may reach about 66–82 ft. The neem can be grown on saline soil, clay and alkaline conditions. A mature neem tree may produce 35–50 kg of fruit each year.

Neem flowers, fruits and seeds

The neem buds and flowers are shown in figure-1. Neem fruit is green in colour initially and gradually turns into yellow when it is fully ripened. When ripe, it is comprises a sweet pulp enclosing a seed. The seed is composed of a shell and a kernel. Figure-2 shows fully ripened neem fruits and neem seeds.

Figure 1: Neem buds and flowers

Figure 2: Neem fruits and neem seeds.

Raw Material

Neem seeds were purchased from K.P.Traders, K.P.complex, Puthupalam, Katharipulam, Vedaraniam. The good seeds are selected and are cleaned, sun dried for two days. The dried seeds were taken for oil extraction through ordinary mechanical oil extractor.

Biodiesel production

A two-step transesterification process is developed to convert the high FFA oils to its biodiesel. The first step, acid catalyzed esterification reduces the FFA content of the oil to less than 2%. The second step, alkaline catalyzed transesterification process converts the products of the first step to its biodiesel and glycerol. Free fatty acid (FFA) percentage in neem oil is very high.

In the first step, the neem oil was poured into the reaction flask and heated. Then the mixture of methanol and sulphuric acid (1% H_2SO_4 based on oil weight) is poured into the reaction flask slowly. The mixture of neem oil, methanol, and sulphuric acid was allowed to react in the reactor at 60 °C for 1 hour under the stirrer speed of 400 rpm approximately. The reaction was stopped after 1 hour. After the reaction, the mixture was allowed to settle for 2 hours. After 2 hours, the two layers were formed from mixture. The upper layer is acid layer and the lower layer is esterified neem oil. The esterified neem oil was used to base transesterification.

In the second step, the esterified neem oil is taken in a reaction flask and heated to 60°C for about 12 minutes with continuous stirring. Then the methoxide mixture containing methanol and sodium hydroxide is poured into a reaction flask. The reaction was allowed to take place at a temperature of 60 °C and stirrer speed of 400 rpm for 1 hour. After the reaction is finished, the mixture is placed into a 24-hour separation funnel. The layer on the top is the biodiesel, while the bottom layer is the glycerin. The upper layer of the neem biodiesel was separated from the lower layer then the neem biodiesel was washed with warm water. After the washing, the neem biodiesel was subjected to a heating at $100^{O}C$ to remove excess alcohol and water.

Preparation of samples

The blends of biodiesel and diesel were prepared in glass container at room temperature. The homogeneity of the fuels was achieved by rotating agitator at medium speed for 20 minutes. The percentage of samples is given in table-2. 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.

Table -2: Percentages of biodiesel and diesel fuel used in preparing samples

Biodiesel Blends	Percentage of Biodiesel (%)	Percentage of Diesel (%)
B0	0	100
B30	30	70
B50	50	50
B80	80	20
B100	100	0

Apparatus and Measurements

Properties of the biodiesel and its blends were determined on different apparatus. Table-3 shows the list of the apparatus on which properties were tested and determined.

Table-3: Apparatus used for determination the properties

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

RESULTS AND DISCUSSIONS

The fuel properties of the diesel, biodiesel and its blends were tested. Table-4 shows the fuel properties of diesel, neem oil biodiesel and its blends.

Table 4: Fuel properties of diesel, biodiesel and its blends

Property	B0	B30	B50	B80	B100
Density (kg/m^3)	816	834	845	862	873
Kinematic viscosity (cSt)	3.36	3.86	4.30	4.88	5.28
Flash point (°C)	53	91	117	161	179
Fire point (°C)	58	98	126	171	193

Density

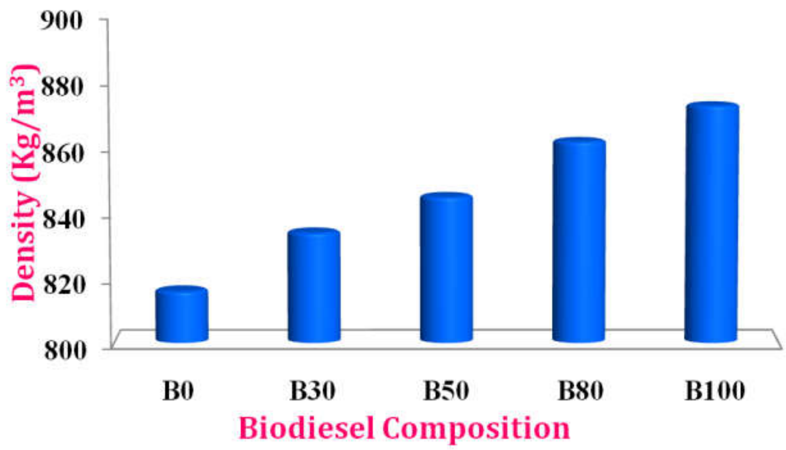

Figure 3: Density of diesel, biodiesel and its blends

The density was determined using the mass of each sample at constant volume. Figure-3 depicts the relationship between density and different blends of biodiesel. The density of B100 is higher than those of the fuel types (B30, B50 and B80) and B0. The density of the blends increased with the increase of biodiesel concentration in the fuel blend. P. Senthilkumar [1] prepared biodiesel from sunflower oil by transesterification process. The sunflower biodiesel was blended with diesel by various percentages such as B0, B25, B50, B75 and B100. The blends were prepared on a volume basis. The results showed that the density of the blend increases with the increase of biodiesel concentration. R. Gabriel et al [5] investigated viscosity and density behavior of biodiesel from chichá (Sterculia striata) and its blends with diesel. Six different fuel blends (10, 15, 20, 40, 60 and 80% by volume blending with diesel) were prepared. The density values of chichá biodiesel and its blends were measured at room temperature. Results indicated that the density of biodiesel blends increases as the percentage of chichá biodiesel increases in the blends.

Kinematic Viscosity

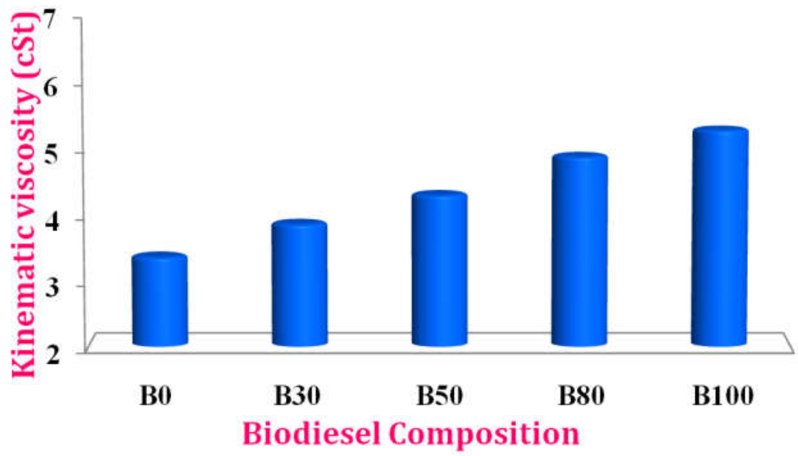

Figure 4: Kinematic Viscosity of diesel, biodiesel and its blends

Variation of kinematic viscosity for different fuel is presented in figure-4. B100 has kinematic viscosity of 5.28cSt which is 1.57 times higher than the diesel. Figure-4 indicates that kinematic viscosity increases with the increase in percentage of biodiesel in the blend. Biodiesel is generally more viscous than diesel fuel because of its polar molecules, which have stronger interparticle forces. T. M. Yunus Khan [6] produced biodiesel from karanja oil by a direct transesterification method. The blends prepared were B10, B20, B40, B60, B80 along with pure biodiesel. The fuel properties of karanja biodiesel along with different biodiesel-diesel blends were studied and compared. The results showed that the kinematic viscosity of biodiesel blend increases as the percentage of karanja oil biodiesel increases in the blends. The fuel properties of mahua oil biodiesel and its blends were investigated by P. Senthilkumar [7]. The blends (B20, B50 and B75) were prepared on a volume basis and their kinematic viscosities were measured by following ISO test method. The experimental results showed that the value of kinematic viscosity of mahua oil biodiesel blends increases as the percentage of biodiesel increases in the blends.

Flash Point

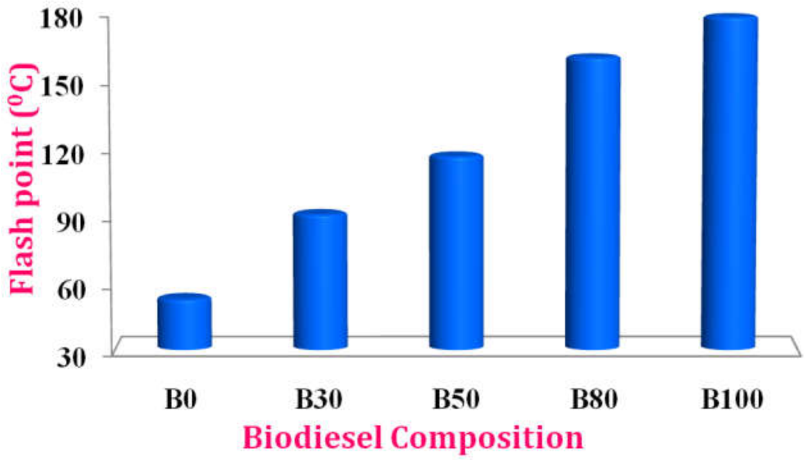

Figure 5: Flash point of diesel, biodiesel and its blends

The flash point is the temperature at which the fuel will start to burn when it comes to contact with fire. It is an important parameter from the safety point of view such as safe for transport, handling, storage purpose and safety of any fuels. The variation of flash point for different blends is as shown in figure-5. As shown in figure-5, the flash point of the biodiesel-diesel fuel blends increased gradually with an increasing the percentage of biodiesel. P. Senthilkumar [8] produced biodiesel from neem oil by a two-step transesterification method. The neem biodiesel was blended with diesel by various proportions such as B0, B25, B50, B75 and B100. The fuel properties of biodiesel and its blends were measured. The results revealed that the flash point increases with increase in biodiesel composition. Mert Gülüm et al. [9] researched density, flash point and heating value of diesel, corn oil biodiesel and its blends. The corn oil biodiesel was blended with diesel by various proportions such as B0, B5, B10, B15, B20, B50, B75 and B100. They reported that the flash point increases with increase in biodiesel composition.

Fire Point

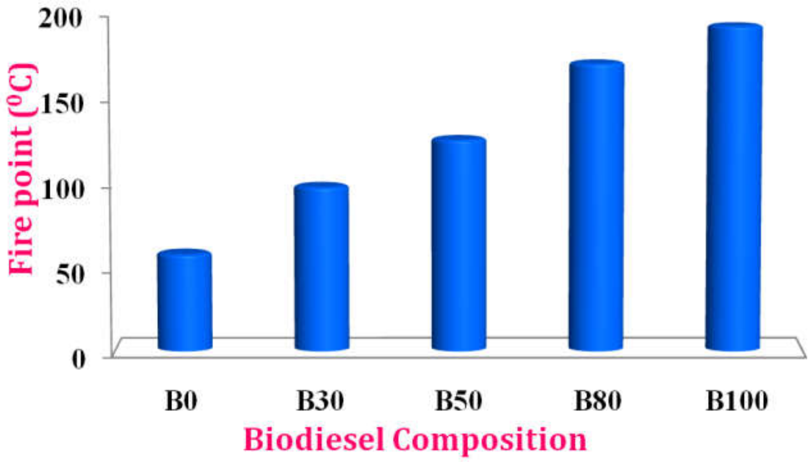

Figure 6: Fire point of diesel, biodiesel and its blends

The fire point is the lowest temperature at which the vapors keep burning after the ignition source is removed. It is higher than the flash point, because at the flash point vapor may not be produced fast enough to sustain combustion. Figure-6 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 193^{O}C measured for B100 biodiesel sample, and the minimum is 58^{O}C measured for diesel. R. Tamizh Selvan and his group [10] manufactured biodiesel from mustard seed oil by transesterification process. Blends at proportions of 5% (B5), 15% (B15), 25% (B25), 35% (B35) and 45% (B45) on volume basis were prepared to measure the fuel properties of them. The results showed that fire point increases linearly with increase in biodiesel composition. P. Senthilkumar [11] investigated fuel properties of biodiesel from calophyllum inophyllum oil and its blends with diesel. Calophyllum inophyllum oil methyl ester was prepared from crude calophyllum inophyllum oil by using transesterification process. The fuel properties of calophyllum inophyllum biodiesel and its blends were measured. Experimental results show 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).

CONCLUSION

In this investigation, the effects of biodiesel percentage on the fuel properties of blends of neem oil biodiesel with diesel fuel were experimentally investigated. The experimental results revealed that the density, kinematic viscosity, flash point, and fire point of a biodiesel blend increase as the blend proportion increases. This is because pure biodiesel (B100) has the highest density, kinematic viscosity, flash point, and fire point, while pure diesel (B0) has the lowest.

REFERENCES

1. P. Senthilkumar, "Investigation of Fuel Properties of Sunflower Biodiesel and Its Blends with Diesel," *International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)*, Vol.6, Issue 11, pp.3217-3223, November 2023.
2. Ramachandran Kasirajan, "Biodiesel production by two step process from an energy source of Chrysophyllum albidum oil using homogeneous catalyst," *South African Journal of Chemical Engineering,* 37(2021) 161-166.
3. Samuel O.D, Okwu M. O, Oreko U.O and Amosun S. T., "Optimisation of Alkaline Ethanolysis of Biodiesel Yield from Nigerian Coconut Oil using One Variable at a Time (OVAT) Approach," *Journal of Energy and Natural Resource Management*, Vol. 1, No. 3, pp.166-169, 2014.

4. Md. Shazib Uddin, Mohammad Uzzal Hossain Joarder, Achinta Kumar Sarker and Ruhul Islam, “Methyl Ester Preparation from Peanut Oil and Its Effect on DI Diesel Engine Combustion,” *International Conference on Mechanical, Industrial and Energy Engineering 2010,* 23-24 December, 2010.
5. R. Gabriel, W.T. Vieira, J.I. Soletti, L.M.O. Ribeiro and S.H.V. Carvalho, “Empirical modeling of different viscosity and density behavior of biodiesel from chichá (Sterculia striata) with diesel versus temperature variation,” *Journal of King Saud University – Science,* 32 (2020) pp.628–635.
6. T. M. Yunus Khan, “Direct Transesterification for Biodiesel Production and Testing the Engine for Performance and Emissions Run on Biodiesel-Diesel-Nano Blends,” *Nanomaterials,* 2021, 11, 417.
7. P. Senthilkumar, “Experimental Investigation on the Fuel Properties of Mahua oil Biodiesel and Its Blends,” *International Advanced Research Journal in Science, Engineering and Technology,* Vol. 9, Issue 7, pp.18-23, July 2022.
8. P. Senthilkumar, “Investigation of Fuel Properties of Neem Biodiesel and Its Blends with Diesel,” *Journal of Xidian University*, Vol.18, Issue 9, pp.1-7, 2024
9. Mert Gülüm and Atilla Bilgin, “Density, flash point and heating value variations of corn oil biodiesel-diesel fuel blends,” *Fuel Processing Technology*, 2015.
10. R. TamizhSelvan, L.Sidhharth, Vincent H Wilson, Ashutosh Das and MukeshGoel, “Studies on Physical Properties of Biodiesel and Blends from Mustard Oil,” *International Journal of Mechanical Engineering and Technology,* 8(7), pp. 1052–1059, 2017.
11. P. Senthilkumar, “Experimental Exploration of Fuel Properties of Calophyllum Inophyllum Biodiesel and Its Blends,” *Saudi Journal of Engineering and Technology,* Vol: 8, Issue: 10, pp.249-254, Oct 2023.