Journal of Manufacturing Engineering, June 2022, Vol. 17, Issue. 2, pp 068-072

PHYSICAL CHARACTERISTICS OF TERNARY BLENDS OF BIODIESEL

*Asha V and Sudalaiyandi K

Department of Mechanical Engineering, National Engineering College, Kovilpatti, Tamil Nadu-628503, India

ABSTRACT

Fossil fuels are being gradually exhausted and need to go to new energy options. The vegetable oils are significant resources for biodiesel production and the best alternative for diesel from crude oil. This research aims to study the physical characteristics of diesel in combination with linseed oil, waste cooking oil and rubber seed oil as ternary blend biodiesels. Ternary blends mean a combination of diesel, biodiesel-1 and biodiesel-2. Four ternary blends have been prepared in various proportions from linseed and rubber seed oil, and another four ternary blends have been prepared from linseed and waste cooking oil. These three oils have relatively similar physical characteristics, non-edible. Physical characteristics tests were carried out using ternary biodiesel mixtures. The experimental study has shown the physical characteristics of the ternary blend by comparing the blends' kinematic viscosity, density, flash point and fire point. The blend of 95% diesel, 2.5% linseed and 2.5% rubber seed biodiesel gives better physical characteristics. By analysing the graph, the particular blends give similar physical characteristics to diesel. So the blend of linseed and rubber seed oil gives the best physical characteristics compared to other blends. It has lower viscosity values, nearly the same as diesel. So it does not affect the performance of an engine.

Keywords: *Ternary Blends, Biodiesel and Physical Characteristics.*

1. Introduction

Biodiesel can be used in a blend with diesel fuel. Blends correspond to the percentage of biodiesel in the blended fuel. For example, a 20% blend of biodiesel with 80% diesel fuel is called B20. When biodiesel is first used in a vehicle, it may release fuel tank deposits, leading to fuel filter plugging. After this initial period, a user can switch between biodiesel and petroleum diesel whenever needed or desired, without modification. The transesterification process can produce biodiesel. The vegetable oil or animal fats are subjected to a chemical reaction. In that reaction, the vegetable oil or animal fats are reacted in the presence of a catalyst with an alcohol to give the corresponding alkyl esters of the FA mixture found in the parent vegetable oil or animal fat. Biodiesel can be produced from a great variety of feedstocks. These feedstocks include the most common vegetable oils, animal fats, and waste oils. The physical characteristics of ternary blends of biodiesel are compared with other ternary blends of biodiesel. Linseed, rubber seed and waste cooking oil are selected to produce biodiesel. Biodiesel blends of linseed and rubber seed oils are group 1. Biodiesel blends of linseed and waste cooking oils are group 2. The four combinations of blends were prepared for each group of biodiesel. Four methods of reducing high viscosity of vegetable oils to enable their use in common diesel engines without operational problems such as engine deposits have been investigated: blending with petro diesel, pyrolysis, micro emulsification and transesterification. The most commonly prepared esters are methyl esters, largely because methanol is the least expensive alcohol, although there are exceptions in some countries. Sudalaiyandi et al. [1] used as diesel fuel from vegetable oil and animal fat. This research aims to study the efficiency and emission of diesel in combination with linseed and rubber seed oil as biodiesel simultaneously. Five ternary blends have been prepared in various proportions from linseed and rubber seed oil. These two oils have relatively similar physical characteristics, and these two oils are not edible. Atabani et al. [2] found that feedstock alone represents more than 75% of the overall biodiesel production cost. Therefore, selecting the best feedstock is vital to ensure low production costs. It has also been found that continuity in the transesterification process is another choice to minimise the production cost. Biodiesel is currently not economically feasible, and more research and technological development are needed. Thus supporting policies are essential to promote biodiesel

*Corresponding Author: antoasha2022@gmail.com

research and make their prices competitive with other conventional energy sources. Currently, biodiesel can be more effective if used as a complement to other energy sources.

Allen et al. have predicted the viscosity and surface tension of pure biodiesel fuels at 400C from their respective fatty acid compositions. Their results show that biodiesels' viscosity and surface tension could be up to 120% and 22% higher than that of diesel, respectively. A blend of pure biodiesels with diesel fuel can be used to reduce the viscosity, density or surface tension of biodiesel fuel. Abedin et al. [3] have presented methods to predict kinematic viscosities and densities of blends of soybean biodiesel with diesel fuel at temperatures up to 1000C. Poling et al. have documented techniques to estimate the surface tension of mixtures. The above literature techniques are helpful in estimating the atomisation properties of biodiesels and their blends with diesel fuel. Elkotb et al. [4] suggested, that for an analytical study of atomisation in a diesel engine involving variations in viscosity, density, and surface tension, the SMD correlation suggested is applicable also to biodiesel and their blends since the correlation was derived from dimensionless analysis, which is a standard scaling method in single-phase flows. The current study falls under this fluid flow category. The SMD correlation can be used to compare the effect of the respective fuel physical properties on their atomisation characteristics. Allen et al. [5] presented SMDs of some biodiesels at 400C from an experimentally determined correlation, viscosity and surface tension function only. Their results showed that the SMDs of biodiesels could be 5- 40% higher than that of diesel fuel.

According to the literature studies, biodiesel has the potential to replace diesel. The economic and available source needs to be identified, and it also needs to be tested. This work compares the two combinations of blends and finds which blend has better physical characteristics.

2. Materials and Methods

The main objective of this work, produce biodiesel from Linseed, Rubber seed and Waste cooking oil through a transesterification process. Prepare the two combinations of ternary blends and compare the physical characteristics of ternary blends of group 1 and group 2. The combination of Linseed and Rubber seed oil blends was named as group 1, and the combination of Linseed and Waste cooking oil blends was named as group 2.

2.1 Production of Linseed Biodiesel

For the alcohol, methanol has been used with Potassium hydroxide as a catalyst. Transesterification was carried in the following ratio initially for 800ml. Take 800 ml of raw linseed oil in a beaker. Take 160ml of methanol in another beaker and dissolve 10-gram KOH in it. The raw linseed oil was then mixed with methanol containing dissolved KOH in the following ratio, raw linseed oil 800ml + methanol 160ml + Potassium Hydroxide 10.4g. The above mixture is maintained at a temperature of 60 degree Celsius for 2 hours with a magnetic stirrer[1]. After heating the mixture, it was allowed to continue cooling for 24 hours at atmospheric temperature. The transesterification setup is shown in figure 1. The presence of glycerine was observed at the bottom of the flask, which was removed manually, is shown in figure 2. The amount of glycerine separated after transesterification is measured using an electronic balance. From the production of linseed biodiesel, we get 500ml of linseed biodiesel and 235 ml of glycerine with impurities.

Fig. 1 The transesterification setup

Fig. 2 Glycerine Separation

2.2 Production of Rubber Seed Biodiesel

For the alcohol, methanol has been used with Potassium hydroxide as a catalyst. Transesterification was carried in the following ratio initially for 400ml. Raw rubber seed oil + methanol (25% by volume of rubber seed oil) + diluted 0.1 N KOH solution (25% by volume of rubber seed oil) + 10 ml of H2SO4. Dilute 0.1 N KOH solution was prepared by dissolving 4 grams of KOH pellet in 1000ml distilled water. The raw linseed oil was then mixed with methanol and diluted 0.1 N KOH in the following ratio, 400 ml of raw rubber seed oil + 100ml of methanol + 9ml of dilute 0.1 N KOH solution + 10ml of H2SO4. The above mixture is maintained at a temperature of 60 degree Celsius for 1 hour and 30 min in the three-way flask. After heating the mixture, it was allowed to continuous cooling for 48 hours at an atmospheric temperature[5]. The presence of glycerine was observed at the bottom of the flask and removed manually. The amount of glycerin separated after transesterification is measured using an electronic balance. From this production of rubber seed oil, we get 220 ml of rubber seed biodiesel and 210 ml of glycerine with impurities.

2.3 Production of Waste Cooking Biodiesel

For the alcohol, methanol has been used with Potassium hydroxide as a catalyst. Transesterification was carried in the following ratio initially for 800ml. Take 800 ml of raw waste cooking oil in a beaker. Take 160ml of methanol in another beaker and dissolve 10-gram KOH in it. The raw waste cooking oil was mixed with methanol containing dissolved KOH in the following ratio, Raw waste cooking oil 800ml + methanol 160ml + Potassium Hydroxide 10.4g. The above mixture is maintained at a temperature of 60 degree Celsius for 2 hours with a magnetic stirrer. After heating the mixture, it was allowed to continue cooling for 24 hours at atmospheric temperature. The presence of glycerine was observed at the bottom of the flask, and it was removed manually[6]. The amount of glycerine separated after transesterification is measured using an electronic balance. From this production of waste cooking oil, we get 780 ml of waste cooking biodiesel and 180 ml of glycerine with impurities.

2.4 preparation of ternary blends of biodiesel

Linseed, Rubber seed and waste cooking oils have high FFA content; therefore, the biodiesel derived from those oils has viscosity comparatively similar to the diesel fuel, giving better atomisation characteristics. The ternary blends are because the linseed oil has low viscosity, and economically availability is less than rubber seed oil and waste cooking oil [7]. Therefore blending these biodiesels with diesel gives good economic feasibility.

The following ternary fuel blends were prepared

GROUP 1 (biodiesel blends of linseed and rubber seed oil)

i. 95% Diesel + 2.5% Linseed biodiesel + 2.5% Rubber seed biodiesel.
ii. 90% Diesel + 5% Linseed biodiesel + 5% Rubber seed biodiesel.
iii. 85% Diesel + 7.5% Linseed biodiesel + 7.5% Rubber seed biodiesel.
iv. 80% Diesel + 10% Linseed biodiesel + 10% Rubber seed biodiesel.

GROUP 2 (biodiesel blends of linseed and waste cooking oil)

i. 95% Diesel + 2.5% Linseed biodiesel + 2.5% Waste cooking biodiesel.
ii. 90% Diesel + 5% Linseed biodiesel + 5% Waste cooking biodiesel.
iii. 85% Diesel + 7.5% Linseed biodiesel + 7.5% Waste cooking biodiesel.
iv. 80% Diesel + 10% Linseed biodiesel + 10% Waste cooking biodiesel.
v. The various ternary blends of biodiesel as shown in figure 3 and 4.

Fig. 3 Blends of biodiesel - Group 1

Fig. 4 Blends of biodiesel - Group 2

3. Result and Discussion

The analytical study of physical characteristics for linseed biodiesel, rubber seed biodiesel and waste cooking biodiesel and ternary blends of these oils with diesel were done. The biodiesels were produced, and ternary blends were prepared in two combinations. These were tested experimentally to compare with the analytical values. The experimental evaluation found the atomisation characteristics of petroleum diesel, biodiesels and ternary biodiesel blends. And the determinations of kinematic viscosity, density, flash and fire point. The density measurement equipment observes the values by hydrometer, viscosity measurement by redwood viscometer and flash and fire point by Cleveland apparatus.

3.1 Kinematic viscosity

Kinematic viscosity is the ratio of - absolute (or dynamic) viscosity to density - a quantity in which no force is involved. Kinematic viscosity can be obtained by dividing the absolute viscosity of a fluid by the fluid mass density. Based on the theoretical evaluation, the kinematic viscosity of linseed and rubber seed oil biodiesels at 700C was calculated as 11.31 (cSt) and 10.81(cSt), respectively. The obtained kinematic viscosity values were Comparatively higher than the kinematic viscosity of diesel (7.454 cSt). Blending was done to lower the kinematic viscosity value. Based on the theoretical evaluation, the kinematic viscosity of linseed and waste cooking oil biodiesels at 700C was calculated as (11.96 cSt) and (11.42 cSt), respectively. Lending was done to lower the kinematic viscosity value. The ternary blend having 95% diesel, 2.5% linseed biodiesel, and 2.5% waste cooking oil biodiesel gives (10.04 cSt.) comparatively similar kinematic viscosity to diesel. The group 1 blend gives a higher kinematic viscosity than the group 2 blend. The values are nearly the same as the diesel kinematic viscosity values range. The variation of kinematic viscosity of diesel, biodiesel and ternary biodiesel blends is shown in Figure 5.

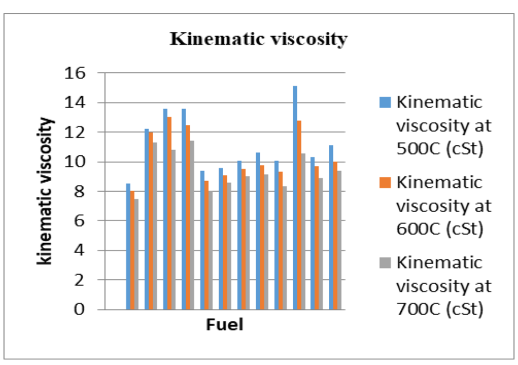

Fig. 5 Variation of kinematic viscosity of diesel, biodiesel and ternary biodiesel blends

3.2 Density

The density (more precisely, the volumetric mass density, also known as specific mass), of a substance, is its mass per unit volume. The symbol most often used for density is ρ (the lower-case Greek letter rho), although the Latin letter D can also be used. Mathematically, density is defined as mass divided by volume. Based on the evaluation, the density of linseed and rubber seed oil biodiesels were calculated as 892 kg/m3 and 890 kg/m3, respectively. The obtained density values were comparatively higher than the density of diesel (825 kg/m3). Blending was done to lower the density value. The ternary blend having 95% diesel, 2.5% linseed biodiesel, and 2.5% rubber seed biodiesel gives (830 kg/m3) a comparatively similar density to diesel (825 kg/m3). Based on the theoretical evaluation, the density of linseed and waste cooking oil biodiesels were calculated as 858 kg/m^3 and 865 kg/$m^{3,}$ respectively. The obtained density values were comparatively higher than the density of diesel (850 kg/m3). The ternary blend having 95% diesel,25% linseed biodiesel, and 2.5% waste cooking oil biodiesel gives (810 kg/m3) a comparatively similar density to diesel (850 kg/m3). The density value of blend 1 (group 1) is nearly identical to diesel density. The linseed and rubber seed oil composition gives similar density values of diesel compared to the group 2 blend. The variation in density of diesel, oils, biodiesels and ternary blends of biodiesel are illustrated in Figure 6.

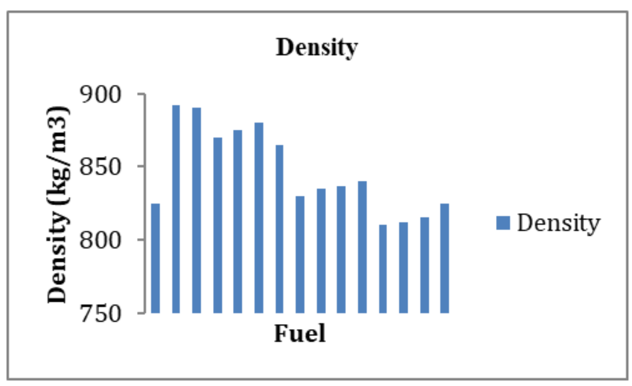

Fig. 6 Variation in density of diesel, oils, biodiesels and ternary blends of biodiesel

3.3 Flashpoint and Fire point

In group 1, the flash and fire point of the biodiesel in which the blend 1 flash and fire points are 48 and 52°C, which is nearly similar to the diesel 48°C, and 50°C, respectively. Furthermore, blend 2 and 3 match the properties of flash and fire points of diesel. In group 2, the flash and fire point of the biodiesel in which the blend 3 flash and fire points are 53 and 55°C, which is nearly similar to the diesel 48°C, and 50°C, respectively. Also, blend 1 and 2 match the properties of flash and fire points of diesel. The group 1 flash and fire point values are nearly identical to diesel. So group 1 biodiesel blends give a similar flashpoint and fire point values compared to group 2 biodiesel blends. The variation in flash point and fire point of diesel, biodiesel and ternary biodiesel blends are shown in Figure 7.

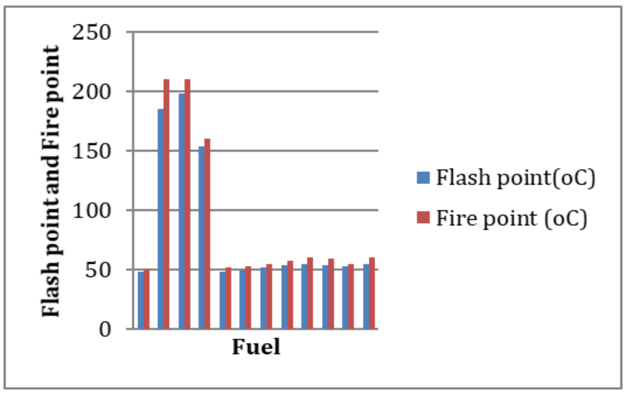

Fig. 7 Variation in flash point and fire point of diesel, biodiesel and ternary biodiesel blends

By comparing the blends' kinematic viscosity, density, flash point, and fire point, the particular blends of 95% diesel, 2.5% linseed and 2.5% rubber seed biodiesel gives better physical characteristics. By analysing the graph, the particular blends give similar physical characteristics to diesel. So the blend of linseed and rubber seed oil gives the best physical characteristics.

4. Conclusion

An experimental evaluation of viscosity, density and flash point effect for biodiesels of linseed and rubber seed oils, waste cooking oil and eight ternary biodiesel blends were performed. The physical characteristics of diesel in combination with linseed, rubber seed and waste cooking oil as ternary blend biodiesels. Ternary blends mean a combination of diesel, biodiesel-1 and biodiesel-2.

Four ternary blends have been prepared in various proportions from linseed and rubber seed oil and another four ternary blends have been prepared in various proportions from linseed and waste cooking oils. These three oils have relatively similar physical characteristics, non-edible and also have low viscosity. The physical characteristics analysis showed that linseed and rubber seed oil biodiesels have larger drop sizes than diesel. The ternary blend having 80% diesel,10% linseed biodiesel, and 10% rubber seed biodiesel gives physical characteristics comparable to diesel. It was found that viscosity has the most considerable contribution of 90% on physical characteristics compared to density and kinematic viscosity, which contribute to less than 2%. Hence the fuel viscosity should be the first preference of physical property to improve atomization in an engine. From the experimental, the blend combination of 95% diesel, 2.5% linseed biodiesel and 2.5% rubber seed biodiesel gives better physical characteristics than other blends. The viscosity, density, flash and fire point values give the similar physical characteristics of diesel.

References

1. *Sudalaiyandi K, Karthick alagar, vigneshkumar, manoj Praveen, P madhu, Performance and emission characteristics of diesel engine fueled with ternary blends of linseed and rubber seed oil biodiesel, Fuel, Volume 285, 1 February 2021, 119255.*
2. *A.E.Atabani, A.S.Silitonga, Irfan Anjum Badruddin, T.M.I.Mahlia, H.H.Masjuki, S.Mekhilef, A comprehensive review on biodiesel as an alternative energy resource and its characteristics. Renewable and sustainable energy reviews 16(2012) 2070-2093.*
3. *M.J.Abedin Allen CAW, Watts KC, Ackman R. Predicting the surface tension of biodiesel fuels from their fatty acid ester composition. J Am Oil Chemist Soc 1999;76(3):317–23.*
4. *Elkotb MM, Fuel atomisation for spray modeling. Progr Energy Combust Sci 1982;8(1):61–91.*
5. *Allen CAW, Watts KC. Comparative analysis of the atomisation characteristics of fifteen biodiesel fuel types. Am Soc Agric Engrs 2000;43(2):207–11.*
6. *M.J.Abedin, H.H.Masjuki, M.A.Kalam, A.Sanjid, S.M.Ashrafur Rahman,I.M.Rizwanul Fattah, Performance, emission and heat losses of palm and jatropha biodiesel blends in a diesel engine. Industrial crops and products 59(2014) 96-104.*
7. *Savita Dixit, Sangeeta kanakraj, A. Rehman, Linseed oil as a potential resource for bio-diesel: A review.Renewable and Sustainable Energy Reviews 16 (2012) 4415–4421.*

