International Journal of Engineering & Technology, 7 (4.5) (2018) 138-142

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Investigation of Physico-Chemical Properties of Simaruoba Methyl Ester and Diesel Blends

Basavaraj R. Hosmani[1*], Vadiraj V. Katti[2]

[1] *BLDEA'S VP Dr. PGH College of Engg. & Tech., Vijaypur*
[2] *KLS V.D. Rural Institute of Technology, Haliyal (India)*
**Corresponding author: brhosamani@gmail.com*

Abstract

This paper presents the experimental study of physico-chemical properties of Simarouba methyl ester and diesel blends at the different temperatures and with varying volume percentage of Simarouba methyl ester in the blend. Blends are prepared adding different volume fraction of Simarouba methyl ester to neat diesel. The percentage of Simarouba methyl ester added to diesel is 10% to 90%, the prepared blends are stirred well for mixing of methyl ester and diesel. The prepared blends are kept in closed container for 24 hours for observation of separation of blends. It is observed that there is no separation of Simarouba methyl ester and diesel. Experiments are carried out to find density, kinematic viscosity, flash point and heating value of blends. These properties are investigated using standard equipments with standard procedure. Viscosity is determined by using standard Red-Wood viscometer with standard procedure of methyl ester and diesel blends at different temperatures. It is observed that as volume fraction of Simarouba methyl ester increases in the blend density, kinematic viscosity, flash point increases and heating value decreases. The percentage decrease in kinematic viscosity is more at lower temperature compared to higher temperature. Correlations for estimation of viscosity and density of blends at different temperatures are proposed.

***Keywords**: blends, calorific value, density, Simarouba methyl ester, viscosity*.

1. **Introduction**

Petroleum reserves are depleting at faster rate because of consumption by different energy sectors such as automobiles, generator sets and other industrial applications. Consumption of energy is increasing every year by many folds because of increasing population though out the world. Energy demand in Indian industries is growing due to growth of Indian economy. India is not self sufficient in petroleum fuels [1, 2], 70-80% of the energy demand is met by importing the petroleum products. Increase in number of automobiles throughout world has compelled researchers to think of the alternate fuels which can be stored and used in automobiles [3-6]. There are many alternate energy sources available. The convenient source of alternate energy sources are, alcohols and methyl ester. Methyl esters can be derived from edible, non edible oils. The methyl esters are produced using transesterification of non edible vegetable oils using methyl or ethyl alcohols in presence of positive catalyst [7, 8]. Chain length of fatty acids of vegetable oils increases viscosity [9].

Methyl ester has many advantages they are renewable, biodegradable, non toxic [10-13]. Because of these advantages methyl ester are considered as alternate fuels for automobiles and other energy sectors such as generator and other industrial applications. The disadvantages of methyl esters are higher viscosity, poor flow properties, oxidation stability [14-17] and it starts forming gel at lower temperature [17] which may clog the fuel filter and even resist to flow from the fuel tank. Methyl esters have higher density, higher cetane number [17, 18], higher flash point and fire point compared to neat diesel. Methyl ester can mix with diesel in any volume percentage without separation [7, 10], and may be used in diesel engines without changes to engine hardware [7, 10, 19] or with minimum changes to the engine hardware.

Different sources of edible and non edible vegetable oils can be used to produce methyl ester. Soybean, Palm, Pongamia, Jatropha, and Rubber seed, Hazel nut, Rapeseed, and Canola oils can be used to produce methyl ester. Edible oil cannot be used to produce the methyl ester may cause scarcity of eatable oils [12, 20]. It may be conflicting to current social obligations and energy policies. Without affecting the edible oil market, non edible oils are considered as alternative energy source in the form of methyl esters [3]. Trees and plants of non edible oils are cultivated on large scale basis on wasteland for producing non edible oils. Using methyl ester as an alternate fuel can reduce the country's dependency on imported petroleum derived fuels, and prolong the depleting petroleum fuels [21].

Density, viscosity and heating value are the properties of fuel to be considered for thermal efficiency of diesel engine. Higher viscosity needs an additional energy to pump the fuel, forms the larger droplet, causes poor atomization and vaporization, poor spray, increases engine deposits[4, 23], affects the engine performance and emissions [10, 23-25]. A higher density fuel injects more fuel to get the same energy output as that of neat diesel [25]. Cetane number and calorific values are depending on mass density of the fuel, higher the density, greater the cetane number [19]. Higher the cetane number of methyl ester reduces the ignition delay. Methyl ester have better lubricity properties that makes less wear of engine components due to higher viscosity of methyl ester. Higher viscosity reduces clearance between piston

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

rings and cylinder liner reduces flow of blow by gases to crank case decreases engine wear [10].

The exhaust emissions using methyl ester has shown the positive effects [10, 24] on regulated and unregulated emissions of methyl ester and diesel blends [3, 4]. Use of methyl ester blends in engines emits less HC, CO and increases oxides of nitrogen emissions [24].

Though there is much research are carried out on the engine performance using methyl-ester and diesel blends and properties of blends, but the properties of Simarouba methyl- ester and diesel blends at higher temperature region have not been carried out extensively.

The objective is to investigate experimentally effect of temperature on density, viscosity of biodiesel and diesel blends between temperatures of 25^0C - 95^0C. To estimate properties of methyl esters, neat Simarouba methyl eater (SME), neat diesel fuel, and mixture of Simarouba methyl-ester and diesel are blended in different volume fractions (10% to 90%). Properties of biodiesel are close to diesel. On the basis of experimental results, density and kinematic viscosity of blends decreases with increase in temperature. Density, viscosity, flash point increases with increase in volume fraction of methyl ester in the blends where as heating value decreases. Experimental results are compared with calculated value from established correlations.

2. Materials and Methods

Simarouba methyl ester is procured from local supplier is meeting ASTM D6751 standards and neat diesel is purchased from local petroleum diesel dealer. The test fuels are Simarouba methyl ester (100%) and blend of 10% to 90% with petroleum diesel fuel. The Simarouba methyl ester and diesel mixture are prepared in 500 ml flask. During mixing of Simarouba methyl ester and diesel fuels are stirred continuously to ensure the uniformity in the mixture of diesel and biodiesel. Mixtures are stored in the closed containers for 24 hour for observing the separation of blends. It is observed that there is no separation of blended fuels. The blends are prepared and named as per the ASTM standards of methyl ester fuels (B00-B100) [12].

Table 1: List of equipments used for testing

Properties	Equipment	Manufacturer and Model	Test Method
Kinematic Viscosity	Redwood viscometer	Advance research instruments, FRW-2	ASTM D445
Density	Relative density	--	ASTMD1298
Flash Point	Cleveland apparatus	Advance research instruments	ASTM D92
Calorific Value	Bomb Calorimeter	Advance Research Instruments, BC 80118	ASTM D240

Density is measured by gravimetric method at various temperatures. Viscosity is measured by using standard viscometer using standard test procedure. The experiments for the different blends of Simarouba methyl-ester and diesel are carried out at various temperatures and in the interval of 15^0 C. The temperature is varied by using dimmer stat which controls the flow of current to the viscometer. The measurement is carried out once the temperature is stabilized. Experiments are repeated three times for every temperature and for each blend and the average value is considered for the final experimental result. The flash point and fire point experiments are carried out using Cleveland open cup apparatus. Heating value of methyl-esters and diesel are measured using Bomb calorimeter.

3. Results and Discussions

Experiments are carried out to measure the physico-chemical properties of neat Simarouba methyl-ester and its blends with diesel and neat diesel. The important fuel properties measured are density, viscosity, flash point, fire point and heating value of Simarouba methyl-esters and their blends with diesel at various temperatures.

3.1. Influence of Temperature on Density of Blends

Density of Simarouba methyl esters and diesel blends at various temperatures for different blends measured are presented in Fig. 1. Density measurements at various temperatures are the mean of triplicate determination. The results indicate that with increase in methyl-ester volume fraction in the blends, density increases. Increase in density may be attributed to increased volume of methyl esters in the blends. Density of methyl esters and their blends decreases with increase in temperature. Decrease in density of blends with increased temperature is attributed to increase in volume of methyl ester blends. Density of methyl esters and their blends are measured and correlated by least square regression analysis. Various correlations are established and are in the form of equations (1) to (5). Regression coefficient is between 0.990 - 0.996. This shows that there is good agreement between the experimental results and calculated values.

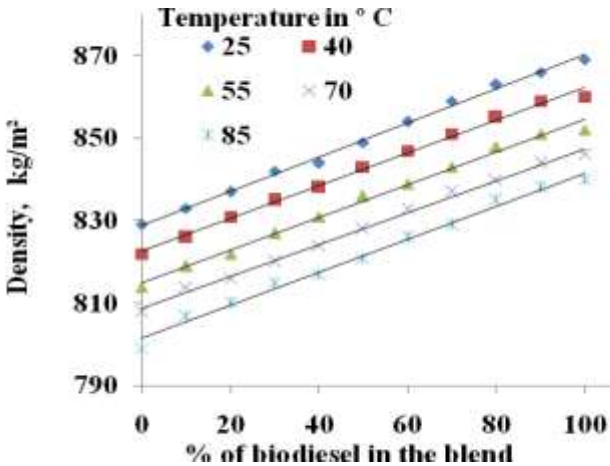

Fig. 1: Influence of temperature on density blends.

25^0 C	$\rho = 0.412x+828.9$	$0 \le x \le 100$	$R^2 = 0.996$	(1)
40^0 C	$\rho = 0.395x+822.6$	$0 \le x \le 100$	$R^2 = 0.995$	(2)
55^0 C	$\rho = 0.396x+814.9$	$0 \le x \le 100$	$R^2 = 0.993$	(3)
70^0 C	$\rho = 0.386x+808.8$	$0 \le x \le 100$	$R^2 = 0.995$	(4)
85^0 C	$\rho = 0.400x+801.5$	$0 \le x \le 100$	$R^2 = 0.990$	(5)

3.2. Influence of Temperature on Kinematic Viscosity of Blends:

Kinematic viscosity of methyl-ester-diesel blends and neat diesel are measured at various temperatures and presented in Fig. 2. Kinematic viscosity increases with increase in methyl-ester volume fraction in blends. It is indicated from the experimental results that the kinematic viscosity decreases nonlinearly with increase in temperature. The decrease in kinematic viscosity of methyl ester blend with diesel is due the decreased resistance to the flow of fuel with increase in temperatures. The viscosity of methyl ester and their blends are measured and correlated by polynomial least square regression analysis. Various correlations are established for kinematic viscosity of methyl esters-diesel blends referring to Fig.2, for different volume fractions of Simarouba methyl ester-diesel blends at various temperatures. Correlations established are in the form of equations (6) - (10). Regression coefficient R^2 is between 0.991 - 0.996 at different temperatures. It shows better agreement between the measured values and calculated results.

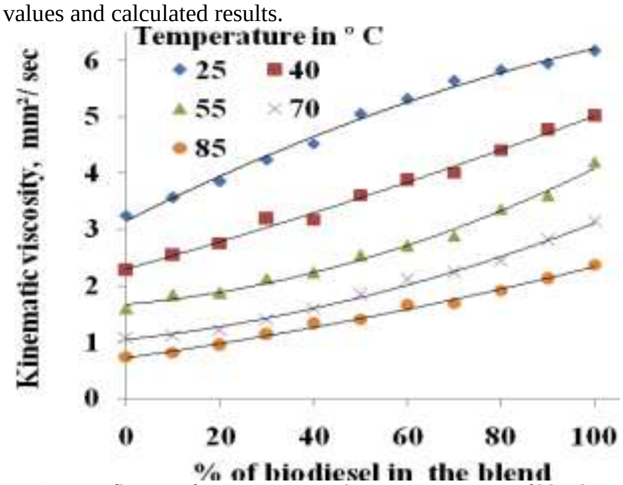

Fig. 2: Influence of temperatures on kinematic viscosity of blends.

It can be observed from the figure that decease in kinematic viscosity of blends at lower temperature is higher compared to higher temperatures. This may be attributed to decreased resistance of flow at higher temperatures.

25^0 C	$v = -0.000011x^2 + 0.04181x + 3.153$	$0 \le x \le 100$	$R^2 = 0.993$	(6)
40^0 C	$v = 0.00004x^2 + 0.02341x + 2.296$	$0 \le x \le 100$	$R^2 = 0.993$	(7)
55^0 C	$v = 0.00017x^2 + 0.00739x + 1.667$	$0 \le x \le 100$	$R^2 = 0.991$	(8)
70^0 C	$v = 0.00012x^2 + 0.00934x + 1.037$	$0 \le x \le 100$	$R^2 = 0.996$	(9)
85^0 C	$v = 0.00004x^2 + 0.01172x + 0.723$	$0 \le x \le 100$	$R^2 = 0.995$	(10)

'x' is volume fraction of methyl-ester in blends.

3.3. Influence of Volume Fraction of Biodiesel on Flash Point and Heating Value of Blends:

The variation of flash point and heating value for different blends are shown in Figs. 3 and 4. There is an increase in flash point with increase in volume fraction of methyl ester in blends. It is indicated from results that flash point of blends increases linearly. Flash point of methyl ester-diesel blends are much higher compared to diesel. With increase in methyl-ester volume fraction in blends, heating value decreases. The decrease in heating value is linear. Correlations established are in the form of equations (11) and (12). Regression coefficients are 0.994 and 0.997 for flash point and heating value respectively.

$FP = 1.686x + 54.40$	$0 \le x \le 100$	$R^2 = 0.994$	(11)
$HV = -0.0045x + 45.10$	$0 \le x \le 100$	$R^2 = 0.997$	(12)

'x' is the volume fraction of methyl ester in blends.

It is observed from figures that density, viscosity and flash point increases with increase in volume percentage of Simarouba biodiesel in blends, where as heating value decreases.

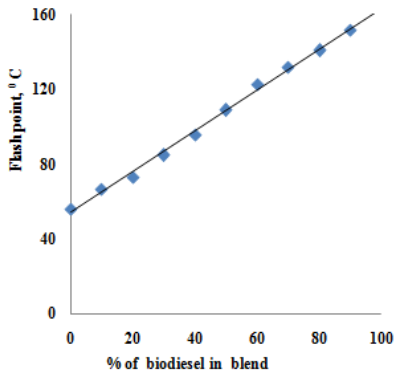

Fig. 3: Influence of volume fraction of biodiesel on flash point of blends.

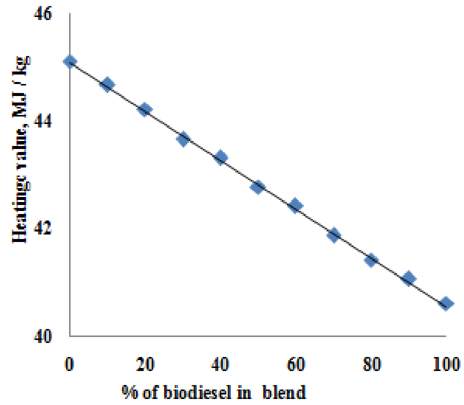

Fig. 4: Influence volume fraction of biodiesel on heating value of blends

3.4. Influence of Viscosity on Density, Flash Point and Heating Value of Blends:

Fig.5 shows variation of density of methyl-ester-diesel blends for various viscosities of blends. It is indicated from the figures that with increase in viscosity density of blends increases. The mathematical relation is established between viscosity and density, straight line fit method is used. From mathematical relation the density of methyl-ester-diesel blends can be estimated.

Fig.6. shows the variation in flash point of methyl-ester-diesel blends and neat diesel with change in kinematic viscosity. It may be observed that flash point of blends increase with increase in viscosity of methyl-esters-diesel blends. The mathematical relation is established for the viscosity and flash point of methyl-ester-diesel blends, straight line fit method is used. Mathematical relation is used to validate the flash point of methyl-ester-diesel blends.

Fig.7 shows the change in heating value of methyl-ester-diesel blends with change in kinematic viscosity. It is observed from figure that with the increase in kinematic viscosity of blends heating value decreases. Mathematical relation is established between kinematic viscosity and heating value of the blends, to verify heating value of methyl-ester-diesel blends. Correlations established are in the form of equations (13) to (15).

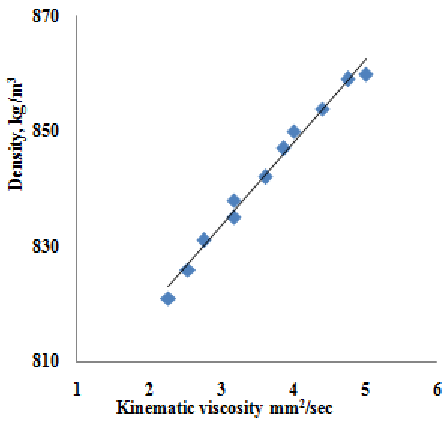

Fig. 5: Influence of viscosity on Density of blends

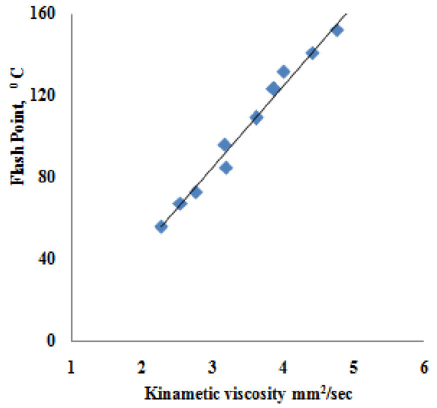

Fig. 6: Influence of viscosity on flash point of blends

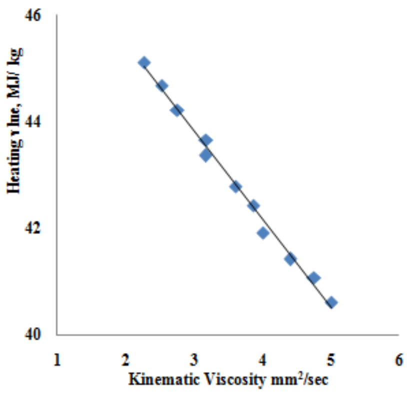

Fig. 7: Influence of viscosity on heating value of blends

Density	$\rho = 14.43672x + 790.13$	$1 \leq x \leq 6$	$R^2 = 0.987$	(13)
Flash point,	$FP = 39.63928x - 33.93$	$1 \leq x \leq 6$	$R^2 = 0.988$	(14)
Heating value,	$HV = -1.652x + 48.79$	$1 \leq x \leq 6$	$R^2 = 0.992$	(15)

'x' is the viscosity of methyl ester in mm^2/sec.

4. Conclusion

Experiments are carried out to measure the physico-chemical characteristics of neat Simarouba methyl-ester and its blends with diesel and neat diesel. Properties of blends measured are density, viscosity, flash and fire point and heating value of Simarouba methyl-ester-diesel blends at various temperatures.

Density and viscosity of blends are increases with increase in volume fraction of methyl-esters in the blends and also decreases with increase in temperature. Decrease in viscosity is higher at lower temperatures compared to higher temperature. Flash point of blends increases with increases in volume fraction of methyl-ester in blends. Heating value of blends decreases with increased volume fraction of methyl-esters. Mathematical relations are established for density, kinematic viscosity, flash point and heating value of methyl-ester-diesel blends. Regression coefficient is higher (R^2) for established mathematical relations for various blends at various temperatures. Experimental results are in good agreement with calculated values from established mathematical relations. Property of methyl-esters-diesel blends is within the limits of ASTM and European standards. Flash point of methyl-ester is almost three times higher as compared to diesel. Heating value of methyl-esters is 10 to 15 % lesser than petroleum diesel. From the comparison of all the properties, 40% volume fraction of Simarouba methyl ester blend with diesel and can be used in engines testing without modification.

References:

[1] Joshi RM, Pegg MJ (2007) Flow properties of methyl ester fuel blends at low temperatures. *Fuel* 86, 143–151.

[2] Ravinranath NH, Balachandra P (2009), Sustainable Bioenergy for India; technical, economic and policy analysis. *Energy* 34(8), 1003-13.

[3] Srivastava A, Prasa R (2000), Triglycerides-based diesel fuels. *Renewable and Sustainable Energy Reviews* 4, 111-133.

[4] Balat M, Balat H (2008), A critical review of bio-diesel as a vehicular fuel. *Energy Conversion and Management* 49, 2727–2741.

[5] Demirbas A (2007), Importance of methyl ester as transportation fuel. *Energy Policy* 35, 4661–4670.

[6] Narayanasamy M Hashimb H Yunusb NA (2015), Computational and Experimental Investigations on Tailormade Biofuel Blend Properties, Energy Procedia 75, 23 – 29.

[7] Moser BR (2009), Methyl ester production, properties, and feed stocks. *Springer in Vitro Cell.Dev.Biol.—Plant* 45, 229–266.

[8] Baroutian S Shahbaz K Mjalli FS Hashim MA and AlNashef IM (2012), Densities and Viscosities of Binary Blends of Ethyl Esters and Ternary Blends of + Ethyl Esters + Diesel Fuel from T = (293.15 to 358.15) K. *Journal of Chemical & Engineering Data* 57, 1387-1395

[9] Demirbas A (2008), Biofuels sources, biofuel policy, biofuel economy and global biofuel projections. *Energy Conversion and Management* 49, (2106–2116.

[10] Agarwal AK (2007), Biofuels (alcohols and methyl ester) applications as fuels for internal combustion engines. *Progress in Energy and Combustion Science* 33, 233–271.

[11] Yang Z. Hollebone BP Wang Z Yang C Landriault M (2013), Effect of storage period on the dominant weathering processes of methyl ester and its blends with diesel in ambient conditions. *Fuel* 104, 342–350.

[12] Demirbas A (2003), Methyl ester fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterification and other methods: a survey. *Energy Conversion and Management* 44, 2093–2109.

[13] Demirbas A (2005), Methyl ester production from vegetable oils via catalytic and non-catalytic supercritical methanol transesterification methods. *Progress in Energy and Combustion Science* 31, 466–487.

[14] Moser BR Vaughn SF (2010), Evaluation of alkyl esters from Camelina sativa oil as methyl ester and as blend components in ultra low-sulfur diesel fuel. *Bioresource Technology* 101, 646–653.

[15] Sahoo PK Das LM. Babu MGK Arora P Singh VP Kumar NR Varyani TS (2009) Comparative evaluation of performance and emission characteristics of jatropha, karanja and polanga based methyl ester as fuel in a tractor engine. *Fuel* 88, 1698–1707.

[16] Zuleta EC Rios LA Benjumea P N (2012), Oxidative stability and cold flow behavior of palm, sacha-inchi, jatropha and castor oil methyl ester blends. *Fuel Processing Technology* 102, 96–101.

[17] Knothe G (2005), Dependence of methyl ester fuel properties on the structure of fatty acid alkyl esters. *Fuel processing Technology* 86, 1059-1070.

[18] Candeia RA Silva MCD Carvalho Filho JR Brasilino MGA Bicudoa TC. Santosa IMG Souza AG (2009), Influence of soybean methyl ester content on basic properties of methyl ester–diesel blends. *Fuel* 88, 738–743.

[19] Keskin DA Koca A Gürü M (2007), Alternative fuel properties of tall oil fatty acid methyl ester–diesel fuel blends. *Bioresource Technology* 98, 241–246.
[20] Bharathiraja M Manikalithas P and Venkatachalam V (2014), Experimental investigation of performance and emission characteristics of non-preheated and preheated Karanja oil blend as alternate fuel in the compression-ignition engine. *International Journal of Ambient Energy* 35(2), 71–79.
[21] Mofijurn M Masjuki HH Kalam MA Hazrat MA Liaquat AM Shahabuddin M Varman M (2012), Prospects of methyl ester from Jatropha in Malaysia. *Renewable and Sustainable Energy Reviews* 16, 5007–5020.
[22] Ejim EC Fleck BA Amirfazli A (2007), Analytical study for atomization of and their blends in a typical injector: Surface tension and viscosity effects *Fuel* 86 1534–1544.
[23] Tat ME Gerpen JV (2000), The specific gravity of methyl ester and its blends with diesel fuels. *J Am Oil Chem Soc*. 77, 115–19.
[24] Ng JH Ng HK Gan S (2011), Engine-out characterization using speed–load mapping and reduced test cycle for a light-duty diesel engine fuelled with methyl ester blends. *Fuel* 90, 2700–2709.
[25] Canakci M (2007), Combustion characteristics of turbocharged DI compression ignition engine fueled with petroleum diesel fuels and methyl ester. *Bioresource Technology* 98, 1167-1175.