International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Characterization of the Physicochemical Property of Blend of Butanol and Octanol with Biodiesel

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***Abstract:** Energy is the major concern around the world not because it is limited availability of petroleum fuel but also due to its environmental effects, greenhouse gas emissions and ozone layer depletion. The compression ignition engine widely used in the agriculture, transportation, electric generation sector which mainly driven by fossil diesel. To counter the cause produce by fossil diesel use and its limited resources, bio-derived fuel may play a major role to fulfill the requirement. But, it has been observed that higher viscosity of biodiesel leads to poor atomization and improper mixing of fuel with air. The poor Combustion, higher viscosity, higher emission of NO_x, low break thermal efficiency of biodiesel, the high cost of production are the main impediment in the preferment of the use of bio-diesel. To mitigate the problem of use of biodiesel blending of higher alcohol in biodiesel may offer a potential solution. Hence in this study Jatropha biodiesel has been blended with n-butanol and n-octanol alcohol by volume 10%, 20%, and 30%. i.e. JME90B10, JME80B20, JME70B30, JME90O10, JME80O20, JME70O30 and evaluate the physicochemical properties i.e. Kinematic viscosity, calorific value, cetane index, cold flow property and oxygen stability as per ASTM standard and compare with diesel and biodiesel. However, blends have a higher viscosity than diesel. But this fuel is bio-degradable in nature, help to diminish carbon footprint and has low emission outlines as compared to petroleum diesel. Usage of a combination of bio-fuel will allow a balance to be sought between agriculture, industrialization, transportation and the environment. GC-MS analysis of JME show 29.64% saturated acid and 69.25% of mono unsaturated acid. The properties of biodiesel depend upon the variation of acid percentage. Overall property of blend comparable with fossil diesel it may substitute the diesel.*

***Keywords:** B -n-butanol, GS-MS – Gas Chromatography – mass Spectrometry, GHG – Green House Gas, JME – Jatropha Methyl ester, O – n-octanol .*

I. INTRODUCTION

Compression ignition engine widely uses in industries, transportation, electric generation and agriculture sector because of their high efficiency and robust structure. The fast depletion of fossil fuel and concern of greenhouse gas emission, health threat due to pollution from the use of fossil fuel is the main concern that leads to a search for an alternative and clean renewable fuel.

Revised Manuscript Received on October 30, 2019.
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Bio-fuel is one of the promising alternative renewable resources for compression ignition engine. Basically, it is a mono-alkaline ester of long chain fatty acid derived from vegetable oil by different method i.e. esterification, trans-esterification, pyrolysis etc. [1]**.** Recently production of biodiesel has been attracting the researcher worldwide to fulfill the energy requirement by providing alternative fuel as well as deficit the foreign currency and also for export, for that country who import the fossil fuel. The major concern of cultivation of biofuel crops is food versus oil.

The world confronted on many fronts, depletion fossil fuel reservoir, the GHG emission, globalwarming and Millions of people undernourished, at the same time challenge of nature conservation**.** [2]. The balance must be required between the use of fossils fuel precisely as well search and development of alternative fuel for sustainable development of the society. The search of the specific inedible plant who should have low production cost, high oil contains, and cultivated in barren land have been intensified. Biodiesel produced from jatropha, Karanja, thumba, kushum can be an idle renewable fuel. Which may able to substitute the diesel.[3]. The straight vegetable oil consists of three main types of fatty acids that can be present in a triglyceride: saturated (Cn:0), monounsaturated (Cn:1) and polyunsaturated with two or three double bonds (Cn:2,3). [4].

Jatropha is one of the most versatile inedible oil for manufacturing of biodiesel which is supported by Indian Government. Recently trial of JME as an aviation fuel also boost its presence as alternative fuels and make space as a substitute of aviation fuel. The cultivation of jatropha yields are, 1200 to 1500 Kg, per hectare. The oil content in seeds are around 35% and oil extracted from the seeds has approximate 24.6% of crude protein and 47.2% crude fat,and its fatty structure allows to easy conversion to bio-fuel with low cost compared to other vegetable oil. [3]-[5]. Though it has a distinct advantage, on the other hand, it contains some drawback like high viscosity, gum formation characteristics and high cold filter plugging temperature which may cause cold start problem in automotive engines. To reduce the viscosity of vegetable oil esterification has been done to convert it to bio-diesel but it is still higher than diesel. There is also another process to be explored to reduce the viscosity. It has been observed that the physicochemical property of biodiesel is comparable with the diesel. Bio alcohol successes fully used in many countries in substitute of gasoline or blend with gasoline in spark ignition engine however it can also use with blend with diesel and biodiesel in a diesel engine. The properties of biodiesel are going to rise and improving combustion and diminishing the emission due to the blending of alcohol.

The soot emission by usage of biofuel is lower than diesel because biodiesel has not contained aromatic species which is known as precursors of soot formation. [6].

Lapuerta et.al [7] observed that the blend of biodiesel and higher alcohol show a higher flash point, higher solubility, good oxygen stability,and better lubricity and suggested that use of bio-diesel blend with higher alcohol as a substitute of diesel. The main benefit of the use of both type of biofuel is cent percent renewable**.** From last three decade, most of the studies were conducted with lower alcohol but nowadays focus has been made on the use of a blend of higher alcohol i.e. n-butanol, n-octanol blend with biodiesel because it has better properties such as higher calorific value, higher cetane number along with higher viscosity han diesel. However higher alcohol solve the problem of, instability of biodiesel and improve the cold filter plugging point.

II. MOTIVE OF RESEARCH

During the literature review, it has been observed that very few works found on the use of higher alcohol with a blend of biodiesel. The need of the days are cent percent substitution of petroleum diesel is required which can be fulfill by use of a blend of biofuel i.e. biodiesel and bio-alcohol.

Method and Resources availability

The n-butanol and the n-octanol were procured from local chemist shop of laboratory grade and straight Jatropha vegetable oil abstracted from seed collected from DTU Jatropha plantation field. Biodiesel produces in the lab by esterification followed by trans-esterification of SVO. The produce JME, blended with n-butanol and n-octanol distinctly in the ratio of 10%, 20% and 30% respectively by volume. The objective of this work was to compare the physicochemical properties of biodiesel blended with higher bio-alcohol with the diesel as explained in Figure-1.

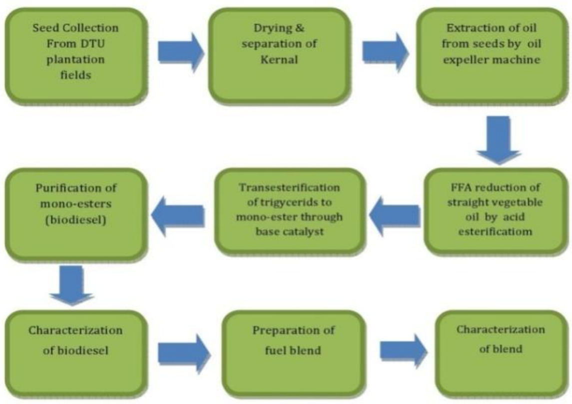

Figure1. Flow chart of biodiesel production.

The fatty acid composition of Jatropha methyl ester

To identify the fatty acid composition of JME in this research GC-MS analysis is carried out. Which is depicted in Table I and GC-MS graph shown in Figure 2.

Table I. GC-MS analysis of Jatropha oil methyl ester.

Fatty Acid (xx, y)	Chemical formula	Systematic name	Weight %
Myristic acid (C14:0)	$C_{14}H_{28}O_2$	TETRADECANOIC ACID	0.07
Palmitic acid (C16:0)	$C_{16}H_{32}O_2$	HEXADECANOIC ACID	19.15
Arachidic acid (C20:0)	$C_{20}H_{40}O_2$	EICOSANOIC ACID	0.26
Palmitoleic acid (C16:1)	$C_{16}H_{30}O_2$	9-HEXADECENOIC ACID	0.99
Oleic Acid (C18:1)	$C_{18}H_{34}O_2$	9-OCTADECENOIC ACID	68.26
Octadecanoic(C18:0)	$C_{19}H_{38}O_2$	METHYL STEARATE	10.16
Others			1.11
Saturated acid			29.64
Mono-unsaturated acid			69.25

The properties of biodiesel mainly depend upon the fatty acid composition of feedstock and it is define by type and percentage of the fatty acid composition. Generally, inedible oil biodiesel has C_{16} to C_{18} acids. The composition of fatty acid in biodiesel has affected the quality of biodiesel. The tested sample of JME has 29.64% saturated acid and 69.25% of mono unsaturated acid.

The presence of monosaturated fatty acid in a biodiesel blend at low temperature may have improved ignition quality, oxygen stability, and fuel flow properties. Many researchers found that fuel stability and fuel flow properties improve due to the presence of capric acid. It has been observed that the properties of biodiesel i.e. viscosity, freezing point increase with the increase in carbon chain length and decrease with the increase of double bond chain. Fattah et.al. reported that the fuel Cetane number, cloud point and stability increase with the presence of saturated fatty acid alkyl ester in fuel.[8].

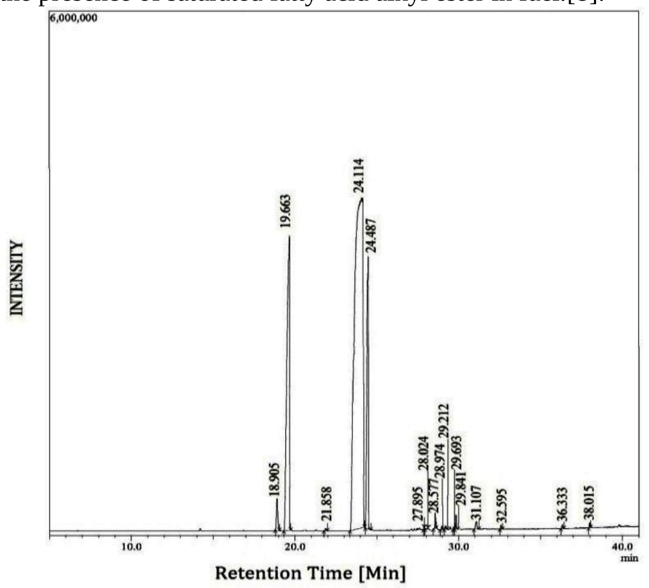

Figure 2. Fatty acid profile by GC-MS.

Preparation of blends with higher Alcohol

The table III depicted the property of tested fuel i.e. Diesel, JME, n-Butanol, n-Octanol and blends of JME, n-Butanol, and JME, n-Octanol. The six different samples had been prepared in the present work by blending of JME with n-Butanol and JME with n-Octanol on volume basis 10%, 20% and 30% which are named as JME90B10, JME80B20, JME70B30, JME90O10, JME80O20 and JME70O30 and measured as per ASTM testing method and depicted in table II. It was observed that the properties of all blends are similar in -range with fossils diesel.

Table II. Classification of Tested Fuels.

Classification of Test Fuel	Composition
D100	100% Diesel
JME100	100% Jatropha biodiesel
B100	100% n-butanol
O100	100% n-Octanol
JME90+B10	Jatropha biodiesel 90%+n-butanol 10%
JME80+B20	Jatropha biodiesel 80%+n-butanol 20%
JME70+B30	Jatropha biodiesel 70%+n-butanol 30%
JME90+O10	Jatropha biodiesel 90%+n-octanol 10%
JME80+O20	Jatropha biodiesel 80%+n-octanol 20%
JME70+O30	Jatropha biodiesel 70%+n-octanol 30%

Characterization of the fuel blend

Characterization of fuel blend depends upon the various properties which can be measured by various standard .The properties may be enhanced by various method one of that blending of other biofuels. The fuel properties of biodiesel are characterized by various standard organizations i.e. The ASTM D6751, EN 14214 and IS 15607.

the density of biodiesel .since fuel is measured in volume hence higher density made more energy in the same volume. The higher alcohol has high density than lower alcohol however blend of higher alcohol made availability of more mass of fuel in the same volume. Hence break specific fuel consumption is going to decrease by blending of higher alcohol. The variations of density of blends depicted in Fig. 3.

Kinematic viscosity

It is an important property which can affect poor fuel injection system of CI engine. Higher viscosity leads to poor atomization, small injection spray angle, larger droplet size, poor vaporization and greater in cylinder penetration of the fuel. These can lead to the formation of engine deposition, poor combustion, and higher emission. High value of viscosity of biodiesel has generates more problem in cold climates because variation in viscosity is directly associated with temperature. The higher value of viscosity of biodiesel compare than petroleum diesel is the main obstruction of use of neat biodiesel which can be improved by blending of butanol and octanol without compromising of other properties as depicted in Figure4.[9],[10].

Table III. The blending of Jatropha Methyl Easter, n-Butanol and n –Octanol.

Parameter	D-100	JME-100	B-100	O-100	JME90 B10	JME80 B20	JME70 B30	JME90 O10	JME80 O20	JME70 O30
Density at 15°C(Kg/cum)	823.02	880.02	807.58	827.29	871.85	865.68	858.18	873.89	868.78	863.85
K.Viscosity at 40°C (mm^2/s)	2.70	5.936	2.65	5.59	5.58	5.17	4.95	5.80	5.83	5.69
Cal. value (MJ/Kg)	45.66	40.26	33.54	38.48	39.42	38.87	38.244	40.01	39.85	38.96
Cetane index	46	51	17	39	47.2	43.9	40.8	49.2	48.1	46
CFPP (°C)	-15	-8	-51	-15	-11.5	-16.2	20.25	-8.1	-8.9	-9.3
Flash point (°C)	61	168	32	80	153.5	140.2	126.5	158.6	150.2	141.1

The properties of the blend Density

The density of fuels depends upon the molecular weight of fuel. It is measured by using the ASTM standard D1298. Higher molecular weight of biodiesel is a major contributor for higher

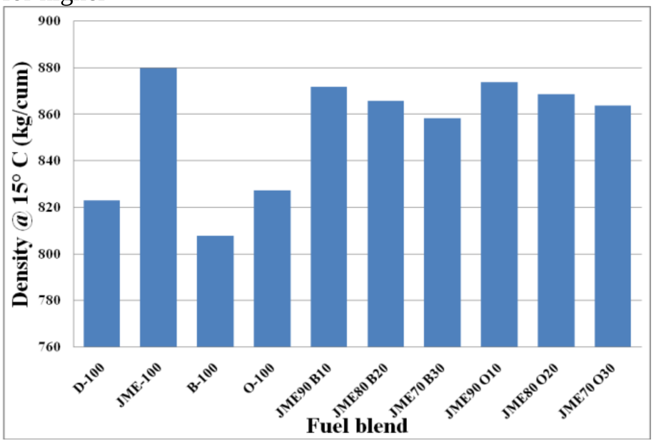

Figure 3. Change in density due to the blending of alcohols.

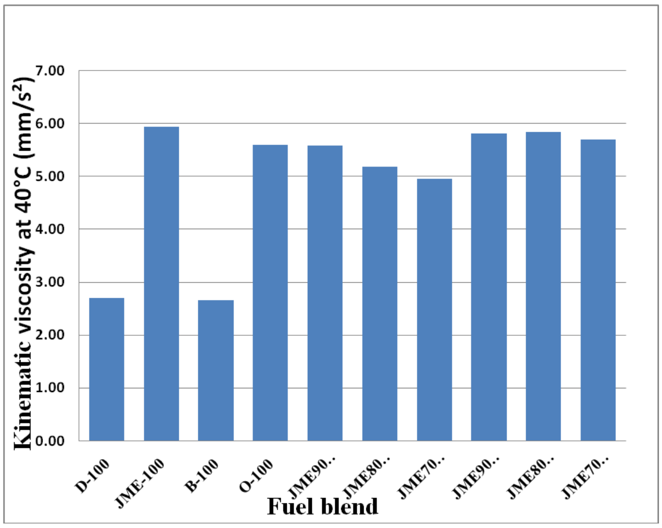

Figure 4. Change in kinematic viscosity due to the blending of alcohols.

Calorific value

The calorific value is defined in terms of the number of heat units liberated when a unit mass of fuel is completely burnt in a calorimeter under specified conditions.

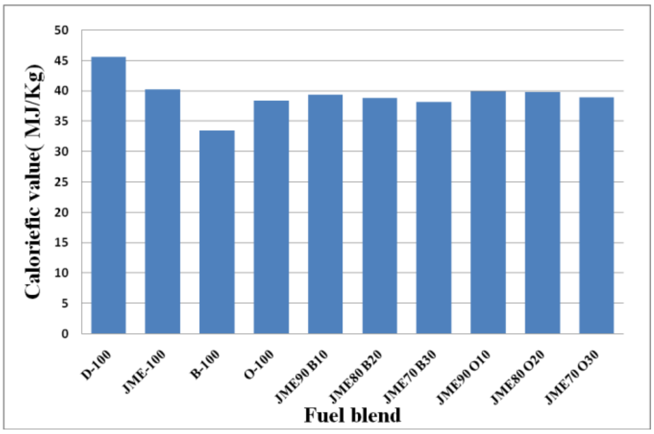

Figure 5. Change in calorific value due to the blending of alcohols.

The calorific value of the fuel was determined with the Isothermal Bomb Calorimeter as per the ASTM D240 standards. Biofuel normally has lower calorific value than diesel fuel because of its have higher Oxygen contain.[11]**.** N-Butanol and n-octanol have higher calorific value than lower alcohol hence the calorific value of blend oil improve which enhance the biodiesel properties than a blend of lower alcohol. The change in calorific value of blend of higher alcohol with biodiesel has been depicted in Figure 5.

Cetane Index

It is the most important properties of CI engine fuel for ignition quality, which can be measured by ASTM D613 test method. The diesel fuel has lower cetane number than biodiesel .The biodiesel has higher CN due to its longer fatty acid carbon chains. The higher the CN, shorter the ignition delay result in better combustion of fuel. [12]-[14]. The variation in cetane index of blend has been depicted in Figure 6.

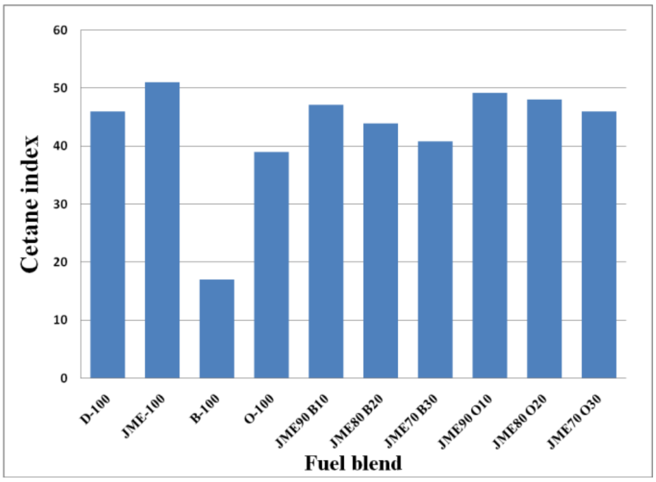

Figure 6. Change in cetane index due to the blending of alcohols.

Cold filter plugging point

There are one of the measure problem to use of biodiesel as a fuel in C I engine is cold flow property .The main reason for poor cold flow properties due to the availability of long-chain fatty acid ester in biodiesel. When biodiesel is use in mild weather countries, the plugging problem would appear as a result of its saturated fatty acid ester contents. This property was measured by CFPP METER NEWLAB 200 as per ASTM D 6371 standard.

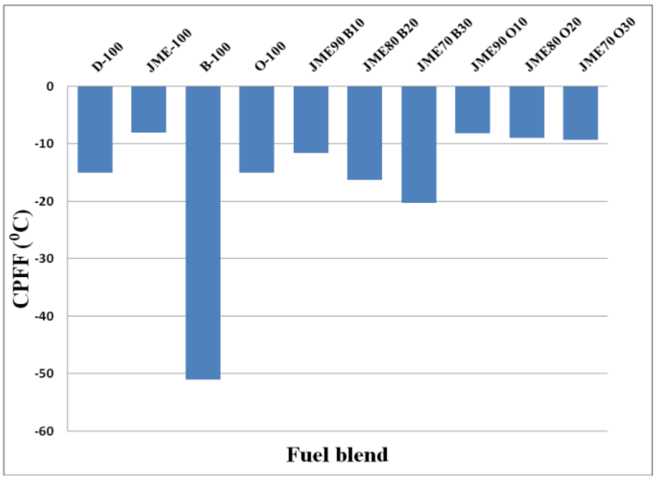

Figure 7. Change in CFPP due to the blending of alcohols.

The crystallization of the saturated fatty acid at lower temperature climates causes fuel starvation and create the starting and operating problem as solidified materials clog to fuel lines filter and the injector. However, n-butanol and n-octanol would reduce the problem due to lower CFPP than biodiesel and their better miscibility.[7],[15] It was observed that the improvement of CFPP properties by blending of butanol in biodiesel compare than ethanol due to better miscibility properties of higher alcohol. It has been shown in Figure 7.

Flash point

This property show the flammable characteristic of fuel,

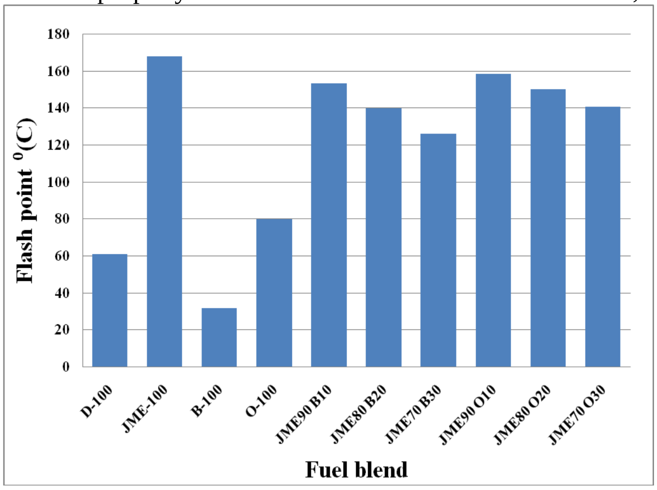

Figure 8. Change in Flash Point due to the blending of alcohols.

the flash point of all biodiesel is lowered by transesterification but still its higher than that of mineral diesel [16]. Hence it is safer to store, distribution and transportation than diesel. It has been measured by using of ASTM D93 standard .However, the chemical compositions of the biodiesel, number of double bonds, and carbon atoms, have influenced the flash point of fuel. [12]. The variations in flash point due to blending are depicted in Figure 8.

Oxygen Stability :-

This is another main apprehension of the use of biodiesel is the poor quality of oxygen stability. The Oxygen stability is measured by oxidation stability analyzer machine Rancimat model 873 of Metrohm**.** The biofuel in which available unsaturated Fatty acid reacts with surrounding oxygen available in the atmosphere and formed aldehydes hydroperoxide, insoluble gum formation sediment and carboxylic acid. The performance of engine has been deteriorating due to filter plugging, injector falling, and deposition in the engine cylinder. Caused due to availability of aldehydes hydroperoxide, insoluble gum formation sediment and carboxylic acid in fuel [17].

III. RESULT AND DISCUSSION

The various physicochemical properties of blends by volume 10%, 20% and 30% n-butanol and n-octanol separately with biodiesel were measured as per ASTM standards,. It was observed that properties of biodiesel, blend with n-butanol and n-octanol comparable with petroleum diesel. The blend of biodiesel with n-octanol show better charecteristic than biodiesel n-butanol blend due to higher calorific value and cetane number. Kumar and Sidharth observed similar trend by use of tertiary blend diesel, biodiesel and octanol.[18],[19]. It has been observed that blend of butanol and biodiesel properties comparable with diesel found that by addition of butanol in biodiesel, NO_x emission reduce due to cooling effect of butanol and longer ignition delay and similar result was found by Ashok et.al. [20], when use blend of n-octanol and biodiesel. Nanthagopal et.al. was examined that the properties of blend of biodiesel and octanol comparable with fossil diesel and also observed that , the NO_x emissions of the higher alcohol blend with biodiesel fuel is reduced and this might be due to the low-temperature combustion is prevailed in the higher alcohol blends [21].

IV. CONCLUSIONS

The present work evaluates the feasibility to overcome the associated problem in use of biodiesel due to higher value of viscosity, CFPP, and inferior ignition quality, more emission of NO_X and open the path to provide the cent percent substitute of diesel with biofuel. Although some property of blend is worthy and some of poor compare than neat biodiesel .However blended fuel properties i.e. colorific value lower than diesel and kinetic viscosity higher than diesel while some properties show better than diesel i.e higher density may reduce the specific fuel consumption. By blending of n-butanol or n-octanol, the higher value of latent heat of evaporation of alcohol may increase the ignition delay and reduce the combustion temperature. This cooling effect is very noticeable on the reducing of emissions of NO_x compare to neat biodiesel.

1. Lower value of CFPP enhances the properties of fuel which may facilitate to use the fuel in low-temperature climate, higher flash point provide better safety in transportation and distribution of fuel. The cent percent substitute of diesel through biofuel have reduced the emission as well as a carbon footprint.
2. The tested properties of blend of n-butanol and JME, n-octanol and JME are found to be reasonable agreement with ASTM 6751 standard. It is observed from Table III .It is also mentionable that all properties of the blend were comparable with petroleum diesel which can substitute the diesel.

REFERENCES

1. Atabani AE, Silitonga AS, Ong HC, Mahlia TMI, Masjuki HH, adruddin IA, (2013). Non-edible vegetable oils: A critical evaluation of oil extraction, fatty acid compositions, biodiesel production, characteristics, engine performance and emissions production. Renew Sustain Energy Rev 2013;18:211–45. doi:10.1016/j.rser.2012.10.013.
2. Castro Gonzáles NF.(2016). International experiences with the cultivation of Jatropha curcas for biodiesel production. Energy 2016;112:1245–58. doi:10.1016/j.energy.2016.06.073.
3. Laviola BG, Rodrigues EV, Teodoro PE, Peixoto L de A, Bhering LL.(2017). Biometric and biotechnology strategies in Jatropha genetic breeding for biodiesel production. Renew Sustain Energy Rev 2017;76:894–904. doi:10.1016/j.rser.2017.03.116.
4. Ramos MJ, Fernández CM, Casas A, Rodríguez L, Pérez Á. (2009).Influence of fatty acid composition of raw materials on biodiesel properties. Bioresour Technol 2009;100:261–8. doi:10.1016/j.biortech.2008.06.039.
5. Kumar P, Sharma MP, Dwivedi G.(2016). Impact of ternary blends of biodiesel on diesel engine performance. Egypt J Pet 2016;25:255–61. doi:10.1016/j.ejpe.2015.06.010.
6. Preuß J, Munch K, Denbratt I.(2018). Performance and emissions of long-chain alcohols as drop-in fuels for heavy duty compression ignition engines. Fuel 2018;216:890–7. doi:10.1016/j.fuel.2017.11.122.
7. Lapuerta M, Rodríguez-Fernández J, Fernández-Rodríguez D, Patiño-Camino R.(2018). Cold flow and filterability properties of n-butanol and ethanol blends with diesel and biodiesel fuels. Fuel 2018;224:552–9. doi:10.1016/j.fuel.2018.03.083.
8. Conversion E, Fattah R. (2016). Production and comparison of fuel properties , engine performance , and emission characteristics of biodiesel from various non- edible vegetable oils : A review 2016;80:202–28. doi:10.1016/j.enconman.2014.01.037.
9. Saxena P, Jawale S, Joshipura MH. (2013). A review on prediction of properties of biodiesel and blends of biodiesel Procedia Eng 2013;51:395–402. doi:10.1016/j.proeng.2013.01.055.

10. Knothe G.(2005). Dependence of biodiesel fuel properties on the structure of fatty acid alkyl esters. Fuel Process Techno 2005; 86: 1059 – 70. doi:10.1016/j.fuproc.2004.11.002.
11. Agarwal AK.(2007). Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Prog Energy Combust Sci 2007;33:233–71. doi:10.1016/j.pecs.2006.08.003.
12. Selaimia R, Beghiel A, Oumeddour R.(2015). The Synthesis of Biodiesel from Vegetable Oil. Procedia - Soc Behav Sci 2015;195:1633–8. doi:10.1016/j.sbspro.2015.06.221.
13. Knothe G, Razon LF. Biodiesel fuels. (2017). Prog Energy Combust 2017;58:36–59.
14. Pali HS, Kumar N.(2016). Comparative assessment of sal and kusum biodiesel properties. Energy Sources, Part A Recover Util Environ Eff 2016;38:3391–6. doi:10.1080/15567036.2015.1136974.
15. Dwivedi G, Sharma MP.(2014) Impact of cold flow properties of biodiesel on engine performance. Renew Sustain Energy Rev 2014;31:650–6. doi:10.1016/j.rser.2013.12.035.
16. Sahoo PK, Das LM, Babu MKG, Arora P, Singh VP, Kumar NR, (2009). Comparative evaluation of performance and emission characteristics of jatropha, karanja and polanga based biodiesel as fuel in a tractor engine. Fuel 2009;88:1698–707. doi:10.1016/j.fuel.2009.02.015.
17. Kumar M, Sharma MP. (2016). Selection of potential oils for biodiesel production. Renew Sustain Energy Rev 2016;56:1129–38. doi:10.1016/ j.rser.2015.12.032.
18. Kumar N, Sidharth.(2018). Some Studies on use of ternary blends of diesel, biodiesel and n-octanol. Energy Sources, Part A Recover Util Environ Eff 2018;40:1721–8. doi:10.1080/15567036.2018.1486902.
19. Yilmaz N, Vigil FM, Benalil K, Davis SM, Calva A.(2015). Effect of biodiesel-butanol fuel blends on emissions and performance characteristics of a diesel engine (vol 135, pg 46, 2014). Fuel 2015;139:781. doi:10.1016/j.fuel.2014.09.019.
20. Ashok B, Nanthagopal K, Anand V, Aravind KM, Jeevanantham AK, Balusamy S. Effects of n-octanol as a fuel blend with biodiesel on diesel engine characteristics. Fuel 2019;235:363–73. doi:10.1016/j.fuel. 2018.07.126.
21. Nanthagopal K, Ashok B, Saravanan B, Korah SM, Chandra S. Effect of next generation higher alcohols and Calophyllum inophyllum methyl ester blends in diesel engine. J Clean Prod 2018;180:50–63.doi:10.1016/ j.jclepro. 2018.01.167.

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Sunil Kumar Sinha, (Ph.D scholar) working as Assistant Engineer (E&M) in Central Public Works Department of India Since 1991. It is the one of the oldest organization in India who have the professional expertise in disciplines including Architecture, Engineering, Project Management coupled with comprehensive experience in building construction and maintenance i/c power genset .CPWD has been serving the nation for last 162 years and has executed priority of works in difficult and demanding geographical and climatic conditions. My job profile is estimating, designing, executing & maintaining the modern electrical, mechanical utilities with green building concept of multipurpose building, hospitals and offices.