THE CHARACTERISTICS OF A MIXTURE OF KEROSENE AND BIODIESEL AS A SUBSTITUTED DIESEL FUEL

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ABSTRAK

Karakterisasi dari sifat fisika-kimia suatu campuran biodiesel dan kerosin (minyak tanah) dilakukan untuk meneliti potensinya untuk digunakan sebagai suatu substitusi bahan bakar minyak diesel untuk pemakaian dalam negeri. Penilaian karakteristik dilakukan dengan membandingkan persyaratan standar bahan bakar minyak diesel.Karakterisasi sfat-sifat campuran biodiesel dengan kerosin adalah densitas, viskositas (kekentalan), titik tuang, titik kabut, distilasi, dan angka setana yang berhubungan dengan sifat alir dalam kedssn dingin dari biodiesel. Karakteristik sifat bahan bakar campuran biodiesel dengan kerosin diperoleh memenuhi persyaratan spesifikasi bahan bakar minyak diesel untuk proporsi pada 2,5:97,5; 5:95; 10:90; 15:85; 20:80; 30:70; dan 50:50. Biodiesel yang dicampurkan dengan kerosin mempunyai karakteristik yang banyak manfaatnya menjadi suatu substitusi bahan bakar minyak diesel. Semua karakteristik fisik-kimia campuran bahan bakar direduksi dengan peningkatanatau bertambahnya konsentrasi kerosin. Kerosin dapat berperan sebagai bahan pengencer untuk mereduksi karakteristik atau sifat alir biodiesel pada kondisi dingin.

Kata-kunsi: biodiesel, angka setana, titik kabut, sifat alir kondisi dingin, densitas, kerosin (minyak tanah), titik tuang

ABSTRACT

Physicochemical properties characterization a mixture of biodiesel and kerosene were carried out to investigate their potential use as a substituted diesel fuel for domestic purposes. The characteristic assessments were done by comparing the standard requirement for diesel fuel. The properties characterization of the biodiesel blends with kerosene were density, viscosity, pour point, cloud point, distillation, and cetane number, which is related to the cold flow properties of biodiesel. The characteristics fuel property of biodiesel blends with kerosene in proportion at 2.5:97.5, 5:95, 10:90, 15:85, 20:80, 30:70, and 50:50 was found mostly meet the requirement the specification of diesel fuel. Biodiesel is mixed with kerosene to bring many of the beneficial characteristics to be a substituted diesel fuel. Overall physicochemical characteristics of blending fuel were reduced by the increasing of kerosene concentrations. Kerosene can play a role as a diluent agent to reduce the characteristic of cold flow properties of biodiesel.

Keywords: *biodiesel, cetane number, cloud point, cold flow properties, density, kerosene, pour point, viscosity*

I. INTRODUCTION

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Petroleum is the largest single source of energy consumed by the world's population, exceeding coal, natural gas, nuclear, hydro and renewables[1]. Global demand for petroleum is predicted to increase 30% by 2035[1, 2]. Generally, the main energy resource that used in Indonesia is commonly from crude oil or fossil fuel. Energy consumption in Indonesia increases rapidly in line with economic and population growth. To fulfill domestic energy consumption, Indonesia has to import crude oil and finished petroleum products, such as gasoline and diesel oil. The supply from domestic refineries could not fulfill the need of finished petroleum product particularly diesel oil.

The shortage of petroleum resources, environmental pollution, energy security, and continuous increasing petroleum costs encourage new studies or researches to develop alternative renewable fuels. Biodiesel is a renewable resource that can be made from plant oil or vegetable oil such as palm oil, jatropha curcas, soybean, rapeseed, and sun flower. Biodiesel is a renewable liquid fuel that can be produced locally thus helping reduce the country's dependence on imported crude [3, 4].

Diesel fuels are on the heavy end of a barrel of crude oil. This gives diesel fuel its high BTU content and power, but also causes problems with diesel vehicle operation in cold weather when this conventional diesel fuel can gel. Similarly, one limitation to the use of biodiesel is the fact that it tends to gel at low temperatures. Some types of biodiesel freeze at higher temperatures than others, depending on the level of saturated components in the fuel[5-8]. Gelling can be reduced by adding a winterizing agent formulated for biodiesel and diesel fuels.

There are three important cold weather parameters define operability for diesel fuels and biodiesel i.e: cloud point (temperature where crystals first appear), pour point (lowest temperature where fuel is observed to flow), and cold filter plugging point (the lowest operating temperature in which a vehicle will operate). Cold starting, clogging and storage are some serious technological disadvantages associated with biodiesel[9-11]. Use of B100 (100% biodiesel) requires some modifications in injection timing and fuel pump. The leading options to handle cold weather with diesel fuel and biodiesel are:

- Blending with kerosene,
- Utilization of an additive that enhances cold flow properties,
- Utilization of fuel tank, fuel filter or fuel line heaters,
- Storage of the vehicles in or near a building when not in use.

Since the successful implementation of kerosene to LPG conversion in Indonesia that kerosene production from oil refineries will abundant in tank storages. The abundance of this kerosene can be utilized as additive or a mixture of biodiesel to prevent the gelling of biodiesel and diesel fuel in cold climates.

This experiment intended to investigate the utilization of a mixture of biodiesel and kerosene as a substituted diesel with certain ratio and also to support Government of Indonesia for biofuel program and energy security.

II. THE OBJECTIVE OF EXPERIMENT

The purpose of this experiment is to gather data on the effect of introducing the amounts of kerosene into biodiesel as substituted diesel fuel, particularly for the cold flow characteristics.

III. MATERIALS AND METHODS

A. Materials

The biodiesel used for this experiment was produced from palm oil as feedstock by transesterification processing and the process is conducted in biodiesel pilot plant of LEMIGAS (R&D Center for Oil and Gas Technology) with 8 ton/day capacity. The biodiesel conforms to the ASTM D-6751 standard or SNI (Standar Nasional Indonesia). Kerosene was obtained by purchasing from market.

B. Methods

Biodiesel blending with kerosene was carried out in the following ratios, i.e 0:100, 2.5:97.5, 5:95, 10:90, 15:85, 20:80, 30:70 and 50:50. Blending processing of biodiesel and kerosene fuel was conducted by mixing biodiesel and kerosene through proportional blending or with certain ratio (2.5 – 50%) in laboratory.

The mixture of biodiesel and kerosene were characterized for their properties such as density (ASTM D-4052), viscosity (ASTM D-445), flash point (ASTM D-93), pour point (ASTM D-97), cloud point (ASTM D-2500), and cetane number (IQT, ASTM D-6890). The results were compared with the standard or regulated specification for diesel fuel.

IV. RESULTS AND DISCUSSION

The properties tested are the characteristics for the cold flow characteristics or problems by utilization of biodiesel or its blending with other fuel components in diesel engine, particularly density, viscosity, pour point, cloud point, flash point, distillation, and cetane number. The results of characteristic for the mixture of biodiesel and kerosene are presented in Table 1.

A. Density

Density of biodiesel blend to kerosene decreases as addition of kerosene increased or when %-volume of kerosene increased in the mixture of biodiesel and kerosene as presented in Table 1 and Figure 1. Fuel density affects engine performance because fuel injection pumps meter fuel by volume, not by mass. Density and viscosity are among of the physical properties of biodiesel fuel or as a blended fuel which are more responsible for the engine performance tests. These parameters are related to combustion process, which is highly dependent on the quality of atomization.

If the results compared with the specification of diesel fuel, range between 0.815 and 0.870, overall density results meet the standard or specification requirement of diesel fuel (on-spec.). Generally, increasing the fuel density increases the power output of a diesel engine per unit volume of fuel consumed.

B. Viscosity

The viscosity of liquid fuel is an important characteristic because it determines the flow through pipelines, injector nozzles and formation of fuel in cylinder. From the Table 1 and Figure 2, it was observed that viscosity get regularly decreases as increasing proportion biodiesel-kerosene blend. Kerosene can be as a diluent to reduce the viscosity of biodiesel.

The viscosity of biodiesel-kerosene oil blends at proportion 15:85, 20:80, 30:70 and 50:50 were found to meet the specification requirement of diesel fuel. However the flash point of blends at proportion 2.5:97.5, 5:95, and 10:90 were found greater than the maximum specification value requirement for diesel fuel or off-specification. From this comparison of viscosity it's suggest that the above blends can be used directly a fuel in high speed diesel engines with consideration of other properties.

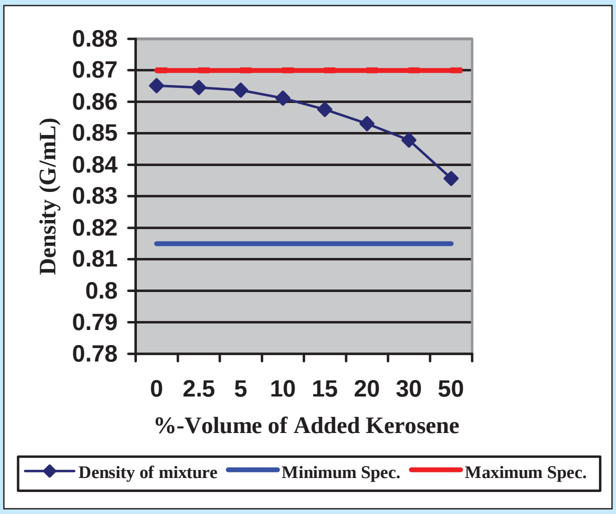

Figure 1
Density of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

Table 1
Characteristic of a mixture of biodiesel and kerosene at proportion 2.5 to 50% kerosene content

Properties	Mixed Ratio of Kerosene and Biodiesel									Standard Specification
	Unit	0:100	2.5:97.5	5:95	10:90	15:85	20:80	30:70	50:50	100:0	
Density	g/ml	0.8651	0.8645	0.8637	0.8612	0.8576	0.8530	0.8478	0.8357	0.8067	0.815-0,870
Viscosity	cSt	5.72	5.69	5.63	5.32	4.89	4.69	4.15	3.06	1.36	2-5
Flash Point	°C	160	130	106	93	85	77.5	69.5	61.8	47.8	Min 60 (Diesel fuel) Min 100 (Biodiesel)
Pour Point	°C	12	11	10	9	7	5	3	-1	< -7	Max 18 (Diesel Fuel)
Cloud Point	°C	13	12	12	11	9	8	5	2	-	Max 18 (as Biodiesel)
Cetane Number		67.07	66.16	64.68	63.92	62.85	60.64	56.30	50.23	-	Min 48
Distilation, T95	°C	>371	>371	>371	>371	>371	>371	- *)	- *)	248	Max 370

Note: *) = unable to perform distillation for determination of T95 due to bumping

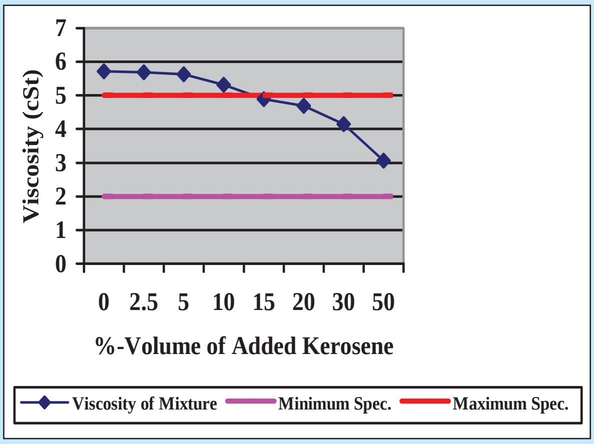

Figure 2
Viscosity of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

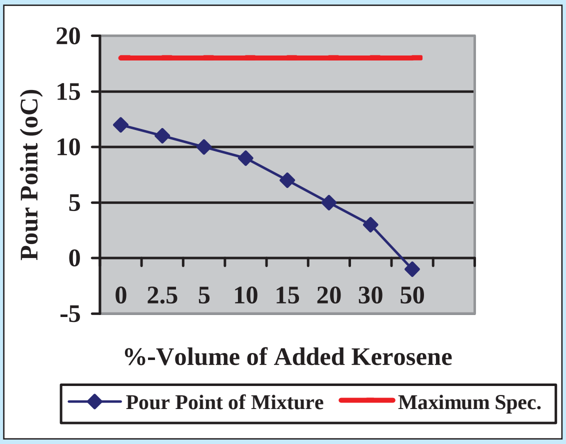

Figure 3
Pour point of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

C. Pour point

Pour point and cloud point have been routinely used to characterize the cold flow operability of diesel fuels in the petroleum industry. Pour points are useful or a good indicator for characterizing the suitably of a fuel for large storage and pipeline distributions[12].

From the Table 1 and Figure 3, it was observed that pour point get regularly decreases as increasing proportion biodiesel-kerosene blend. The pour point of biodiesel-kerosene oil blends at all proportions (0:100, 2.5:97.5, 5:95, 10:90, 15:85, 20:80, 30:70 and 50:50) were found to meet the specification requirement of diesel fuel. Addition of kerosene can reduce the pour point of biodiesel. From this comparison of pour point it's suggest that the above blends can be used directly as a fuel in high speed diesel engines with consideration of other properties.

D. Cloud Point

Cloud points are useful as fuel quality control specifications for refiners when blending fuels during the cold climate, also as low temperature operability indicators for diesel-powered operators when using in cold ambient temperatures. The cloud point is a good parameter for quality control in the operation of diesel engines in low temperatures[12].

The characteristic results of cloud point values for the biodiesel blended fuels with kerosene are shown in Table 1 and Figure 4. The results revealed a decrease in cloud point as the kerosene content increased.

SAE (Society of Automotive Engineers), an accreditation organization for automotive fuels and other products, reported that cloud point a mixtures of Soybean biodiesel and kerosene with 50% by volume of kerosene resulting at temperature -25°C[13]. However the cloud point of this experiment for a mixtures of Palm biodiesel and kerosene with 50% by volume of kerosene resulting at temperature -1°C. The difference of those results due to their high degree of saturation, whereas palm biodiesel more saturated than soybean biodiesel. Saturated fatty acids have higher melting points and temperatures of crystallization and in cold temperature they will crystallize before the mono-unsaturated and poly-unsaturated fatty acids[14]. Imahara *et al*. reported that saturated acid esters have a very significant effect on the cold flow of biodiesel; in particular, biodiesel with higher percentages of saturated fatty esters has higher cloud points[15].

E. Flash Point

Flash point is the property of fuel which shall be considered in assessing the flammability and hazard of fuel. The flash point of a fuel is the lowest temperature at which the fuel can form an ignitable mixture with air. Flash point indicates presence of volatile material in fuels. The characteristic results of flash point values for the biodiesel blended fuels with kerosene are shown in Table 1 and Figure

5. The results revealed a decrease in flash point as the kerosene content increased. A higher flash point indicates that biodiesel is less flammable than petroleum diesel; hence, biodiesel is safer to handle.

The flash point of biodiesel-kerosene oil blends at all proportions (0:100, 2.5:97.5, 5:95, 10:90, 15:85, 20:80, 30:70 and 50:50) were found to meet the specification requirement of diesel fuel. Addition of kerosene can reduce the flash point of biodiesel. From this comparison of flash point it's suggest that the above blends can be used directly as a fuel in high speed diesel engines with consideration of other properties.

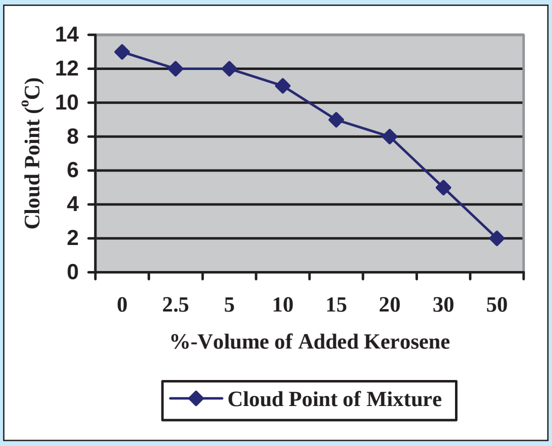

Figure 4
Cloud point of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

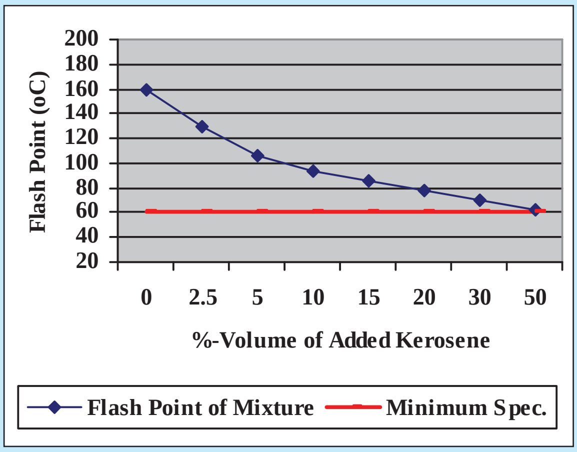

Figure 5
Flash point of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

Talkit and Mahajan reported that kerosene used as a diluent agent for reduction flash point and viscosity of soybean oil to meet the diesel fuel specification requirement with proportions of 30% and 40% kerosene content[16].

F. Cetane Number

Cetane number is a measure of a fuel's ignition delay. This is the time period between the start of injection and start of combustion (ignition) of the fuel. In a particular diesel engine, higher cetane fuels will have shorter ignition delay periods than lower cetane fuels.

The characteristic results of cetane number values for the biodiesel blended fuels with kerosene are shown in Table 1 and Figure 6. The results revealed a decrease in cetane number as the kerosene content increased. The cetane number of biodiesel-kerosene oil blends at all proportions (0:100, 2.5:97.5, 5:95, 10:90, 15:85, 20:80, 30:70 and 50:50) were found to meet the specification requirement of diesel fuel. Cetane number should not be considered alone when evaluating diesel fuel quality. Another properties also very important and should be included such as density, flash point, stability, distillation range, etc. In colder weather, cloud point and pour point may be critical factors.

Refiners and marketers measure the fuel's cetane number to determine how readily the fuel ignites in the engine. Fuels with big cetane numbers ignite more readily, providing shorter ignition-delay periods. Fuel

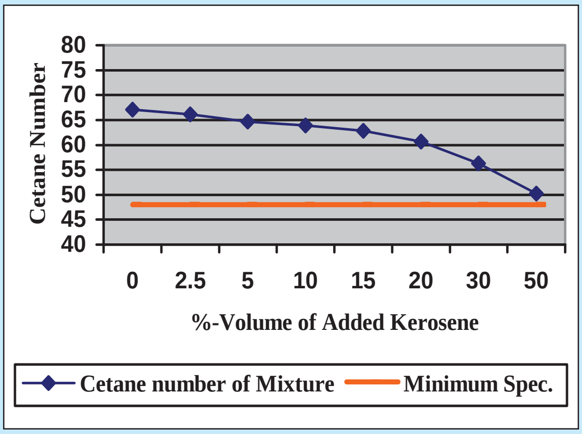

Figure 6
Cetane number of the mixture of biodiesel and kerosene with concentration of kerosene from 2.5% to 50% volume

with cetane number lower than minimum engine requirements can cause rough engine operation. Such fuel is more difficult to start, especially in cold weather or at high altitude. As a comparison, a minimum cetane number of 40 is specified for diesel fuels in the United States and 50 in Europe, as well as most other parts of the world. Cetane numbers higher than 50 provide the optimum operation and low particulate matter (PM) emissions.

G. Distillation

The volatility characteristics of diesel fuel are expressed in terms of the temperature at which successive portions of the fuel are distilled from a sample of the fuel under controlled heating in a standardized apparatus (ASTM D-86).

The characteristic results of distillation T95 values for the biodiesel blended fuels with kerosene are shown in Table 1. The results value greater than 371^{o}C for 0:100, 2.5:97.5, 5:95, 10:90, 15:85, and 20:80 proportions, and these values do not meet the specification requirement (maximum 370 ^{o}C). However, there are no value for proportions at 30:70 and 50:50 because of unable to perform distillation (due to bumping when conducting the test). Biodiesel does not have a traditional petroleum distillation characteristic, however, the addition of biodiesel to petroleum diesel or kerosene in a blend can result in an increase in T95 distillation temperature. Higher volatility, as represented by a lower T95 temperature, generally provides better engine performance, while lower volatility generally provides better fuel economy.

The distillation or boiling range of fuel depends on the fuel's chemical composition and, therefore, influences other properties such as viscosity, flash point, auto ignition temperature, cetane number and density. The boiling range influences parameters that are important for the operating behavior of the diesel fuel. Changing the boiling range usually affects more than one fuel property. For example, extension of the boiling range towards lower temperatures leads to a fuel that has better low temperature properties such as pour and cloud point, but the cetane number is reduced. When the boiling range is moved toward higher temperatures, refiners can include heavy compounds in their final diesel blend, thereby increasing their yield of diesel fuel. However, the heavier compounds in this fuel could produce increased soot and cause injection nozzle choking.

The back-end volatility of diesel fuel, expressed as the 90-percent or 95-percent distillation recovery temperature (T90/T95), has some effect on emissions. Bello *et al.* and Jo *et al.* reported that when the volatility is reduced, a slight increase in HC and CO emissions and a small decrease in the NO_2 emission is observed[17, 18]. Reducing the volatility does not have an effect on PM emissions. Given the small nature of these effects, diesel fuel volatility is a minor factor in determining emission performance.

H. Substituted Diesel Fuel

Based on the data obtained from the experiments, it can be concluded that the use of kerosene, as blending component into biodiesel, has a significant effect on the depression of viscosity, pour point, cloud point, flash point, and cetane number values of the mixture biodiesel and kerosene. The effect of the use of kerosene for depression purposes is significantly reduced. Biodiesel is mixed with kerosene to bring many of the beneficial characteristics to be a substituted diesel fuel.

Some researches reported that a mixture of biodiesel blends and kerosene can be utilized as fuel for diesel engine and/or domestic purposes[19, 20]. According to the "Society of Automotive Engineers (SAE), the use of kerosene as a cloud point depressant have been used for many years and historically dilutions with kerosene have been as high as 30%-40%[13]. The similar results of this experiment also exhibit that concentration of kerosene blends from 20%-50% still meet the standard requirement for diesel fuel. Physicochemical properties of kerosene can be improved to be a substituted diesel fuel by biodiesel blends at certain proportions or their properties can be improved by each other. For example the lubricity of kerosene can be improved by addition of biodiesel which has a good lubricity[21].

Improving the cold flow of biodiesel has been proven to be quite a heavy task because in most cases, it has had adverse effects on other fuel properties of the biodiesel, especially ignition quality and oxidation stability. The following methods have been employed to improve the cold flow of biodiesel[14, 22]:

a. Blending with petroleum diesel (diesel oil and kerosene addition),
b. Trans-esterification with branched chain alcohol (using isopropyl instead of methanol),

c. Winterization (It is a physical process which involves fractionating the oil to remove its high melting components).
d. Use of chemical additives (The use of cold flow improvers (CFI) is the conventional method employed to improve the cold flow of petroleum diesel).
e. Modification of fatty acid profiles of biodiesel (The modification could be by either genetic modification of the feedstock or the use of alternative feedstock).

Refer to climate condition in Indonesia that the results of this experiment indicate no problem to utilize the mixture of biodiesel and kerosene until proportion at 50% volume of kerosene, which is based on physicochemical properties.

V. CONCLUSION

On the basis of observed fuel properties for the biodiesel blended fuels with kerosene, the following conclusion may be drawn:

1. The properties tested of a mixture biodiesel and kerosene were those meet the specification requirement for diesel fuel, and consisted of: density, viscosity, pour point, cloud point, and cetane number, particularly for the cold flow characteristics.
2. Biodiesel is mixed with kerosene to bring many of the beneficial characteristics to be a substituted diesel fuel.
3. Kerosene can play a role as a diluent agent to reduce the characteristic of cold flow properties of biodiesel.
4. Physicochemical properties of kerosene can be improved to be a substituted diesel fuel by biodiesel blends at certain proportions.
5. The use of a mixture of biodiesel and kerosene as a substituted diesel fuel depends on its characteristics fuel properties, which is to meet the specification requirement of diesel fuel.
6. The fuel properties like density, flash point, viscosity, pour point, cloud point, and cetane number of biodiesel-kerosene blends at proportion 10:90, 15:85, 20:80, 30:70, 50:50 was found to be close to diesel fuel. Hence overall blend can be as an alternative fuel in diesel engines.
7. Kerosene can be utilized as blending component with biodiesel to be a substituted diesel fual.

VI. RECOMENDATION

In order to make better the utilization a mixture of biodiesel and kerosene with a maximum proportion (50% volume kerosene), it needs to perform the fuel as a substituted diesel oil by using road test or other methods.

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