# Optimization of Green Liquid Fuel for Diesel Engine

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**Abstract.** By early 2023, Government of Republic of Indonesia has decided to apply a diesel fuel called B35 for petrodiesel compliment. This substance is a mixture of biodiesel and petrodiesel. The decision is made to anticipate decrease of petrodiesel reserve as well as for better environment and sustainability. Since biodiesel is produced from palm oil, ii is considered to be renewable. Biodiesel is used as an alternative liquid fuel for a diesel engine. Nevertheless, the engine is designed to utilize pure petrodiesel as fuel. Therefore, this alternative fuel must be carefully mixed and blended in order to maintain optimum performance of the engine. Objective of this research is to determine optimum composition of the mixture. Composition of both diesel fuels is altered from B0 to B50 with interval of 10 unit. Their physical properties such as density, viscosity, and flashpoint are carefully measured and calculated. The properties are compared to standard fuel of diesel engine. According to ASTM, the results of this experiment show that the optimum composition is B40.

**Keywords:** Biodiesel, Petrodiesel, Optimization, Composition.

## 1 Introduction

Demand of green fuel for diesel engine increases through the year. By early 2023, Government of Republic of Indonesia has decided to apply a diesel fuel called B35 for petrodiesel compliment. This strategic policy is understandable because this nation has abundant material, called crude palm oil (CPO), to produce more environmentally friendly liquid fuel [1]. In order to replace fossil fuel, eventually conventional diesel fuel is blended with biodiesel to create biosolar. This fuel mixture is coded B which means that B0 is fully conventional diesel fuel made of fossil fuel and B100 is fully biodiesel. Nowadays, B35 is common fuel for diesel engine and gradually it will be increased in order to have a better liquid fuel [2].

Composition of B35 is biodiesel produced from vegetable oil and petroleum oil with volume ratio of 35% and 65% respectively. In Indonesia, the vegetable oil mostly comes from crude palm oil (CPO). It is because this country produce more than 46 million tonnes of CPO by 2022. Meanwhile, application of petrodiesel is not favorable for the government because most of them is imported. Afterward, the government must subsidized the price of petrodiesel as it is delivered to users. Therefore, the decision to use B35 as diesel engine fuel has a great impact on several sectors, namely


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economy, agriculture, industry, and environment. At some point, CPO is replaced by waste cooking oil (WCO) in order to make better environment [3][4].

In economy sector, using CPO as fuel can reduce amount of imported petrodiesel and surely reduce government finance alocation for fuel subsidy. In agriculture, the decision can increase planting area for palm that causes industrial palm oil production also growing up. For the environment, application this fuel, which contains less sulphur than pure petrodiesel, on diesel engines will reduce air pollution [4][5].

Commonly, either WCO or CPO is converted into biodiesel by means of chemical reaction called transesterification [6]. Transesterification is a proses that change WCO or CPO, which is an ester compound, to another ester. WCO or CPO is reacted with methanol and a strong alkaly such as NaOH or KOH added as catalyst. This reaction is carried out at the same liquid phase and called single phase transesterification [7]. This process usually convert almost 100% of WCO or CPO to produce biodiesel (fatty acid methyl ester, FAME) as main product and glycerol as byproduct. Chemically, the reaction is shown as follow.

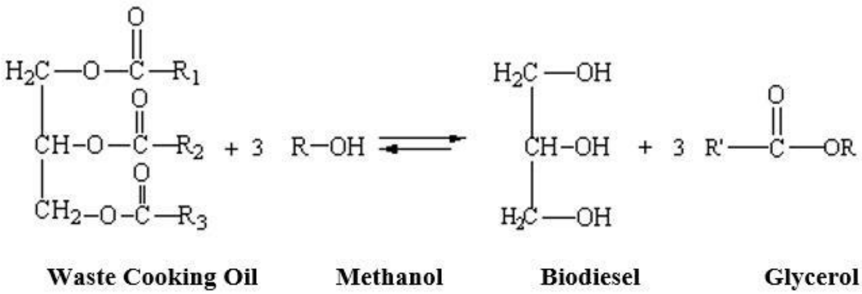


**Fig. 1.** Transesterification Reaction

## 2 Methodology

In this research, mixtures of biodiesel made from WCO and petrodiesel was set from B0 to B100. The purpose of the research was to determine a mixture with maximum content of biodiesel that applicable to ordinary diesel engine without reducing its performance significantly [8]. Therefore, physical and chemical properties of the mixtures carefully analized and compared to those of pure petrodiesel as written on standard of SNI (Standard Nasional Indonesia) or ASTM.

This experiment was started by providing one liter of WCO biodiesel and same amount of pure petrodiesel. There were also seven bottles with volume of 125 ml to contain mixtures. First bottle was filled with 100 ml of pure petrodiesel and coded as B0. Second bottle was filled with a mixture of 10 ml of the biodiesel and 90 ml of the petrodiesel and coded as B10. This procedure was the applied to next bottles accordingly. At the end, seven bottles were filled with fuel and coded with B0, B10, B20, B30, B40, B50, and B100. Picture of the filled bottles shown as follows:

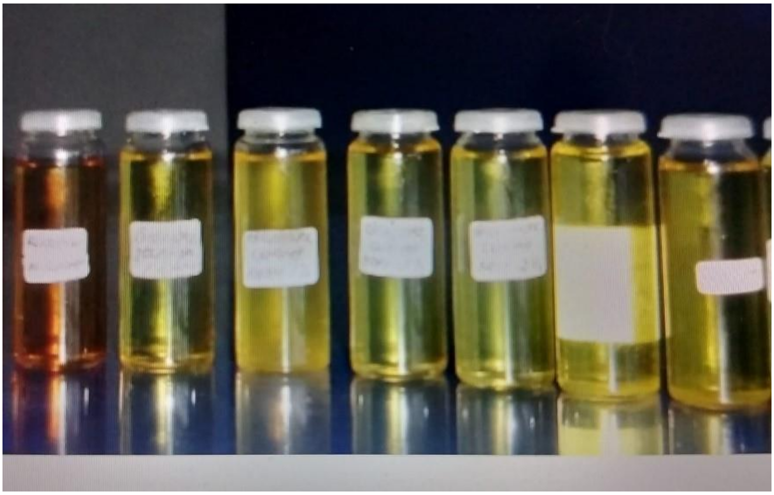

**Fig. 2.** Mixtures of B0 to B100

Physical properies of each mixture was analyzed in terms of density, viscosity, and flash point. Density of the mixtures was analyzed using densitometer KEM Kyoto Electronic DA-100. Data was read in unit of gram permililiter. Viscosity was measured using Kohler Viscometer CFR 350 as shown below.

**Fig. 3.** Koehler Viscometer

Data was read and calculated to meet the unit of centistoke. Finally, flash point was analyzed using Koehler Closed Cup Flash Point Tester K-16270 as shown as follow.

**Fig. 4.** Flashpoint Tester

## 3 Result and Discussion

After carefully collecting all required data on measuring instruments, further calculation is cariied out to determine physical properties of the mixtures. They are presented on this following table.

**Table 1.** Data of Physical Properties

| Mixture | Density (kg/liter) | Viscosity ($mm^2$/detik) atau cSt | Flashpoint (°C) |
|---|---|---|---|
| B0 | 0.821 | 3.51 | 62 |
| B10 | 0.823 | 3.65 | 69 |
| B20 | 0.835 | 3.81 | 77 |
| B30 | 0.836 | 4.06 | 84 |
| B40 | 0.847 | 4.17 | 92 |
| B50 | 0.847 | 4.38 | 101 |
| B100 | 0.878 | 5.24 | 138 |

The table reveals a valuable information that mixing and blending biodiesel and petrodiesel is merely a physical reaction. For example, at B10 its density is 0.823. This value is very close to value of 10% multiplied by 0.878 plus 90% multiplied by 0.821. Similar result is found on viscosity and flashpoint. In order to make these values much clearer, the table is converted into a graph as follows.

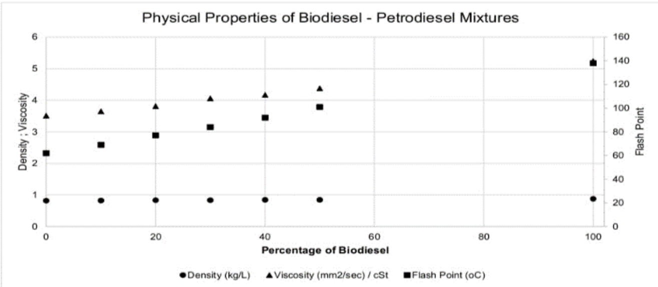


**Fig. 5.** Graph of Physical Properties of Mixtures

On the graph, all three physical properties are represented with dots and they form straight lines. This means that no chemical reaction occurs during mixing and blending those two fuels. Therefore, to determine optimum mixture that contain maximum of biodiesel with physical properties meet requirements for fuel of an ordinary diesel engine, it should be compared to either SNI or ASTM.

According to ASTM D975 for diesel engine fuel or petrodiesel, density around 0,84 kgm-3, flashpoint minimum 52 oC, and kinematic viscosity 1.3 to 4.1 mm2/s. It can be cocluded that the optimum mixture is B40.

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