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Making Biodiesel From a Mixture of Castor Oil and Used Cooking Oil In Terms of Stirring Time and Speed

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ABSTRACT

Biodiesel is an alternative fuel to replace diesel which has great potential as a diesel engine fuel. This research discusses the manufacture of biodiesel from a mixture of castor oil and used cooking oil using a KOH catalyst. The focus of the research is on the effect of time and stirring speed on the quality of the biodiesel produced. The research results showed that the highest yield was obtained at a stirring time of 60 minutes at a speed of 300 rpm, namely 32%. The best product that complies with SNI 7182:2015 standards is obtained with a stirring time of 20 minutes and a speed of 500 rpm, producing a viscosity of 5.0206 cSt, a flash point of 104°C, and a cetane number of 52.2. High stirring speeds help ensure the mixture of raw materials and catalyst is mixed evenly, resulting in biodiesel with good characteristics.

Keywords: *Biodiesel, Castor Oil, Used Cooking Oil.*

1. INTRODUCTION

The growing global energy demand, coupled with the environmental impacts of fossil fuel consumption, has led to an increased interest in alternative fuels. Biodiesel, a renewable energy source derived from vegetable oils or animal fats, presents a viable solution to reducing greenhouse gas emissions and dependency on fossil fuels. Biodiesel can be produced through a chemical process called transesterification, where oils react with alcohol in the presence of a catalyst to form esters (biodiesel) and glycerol [1].

One of the significant advantages of biodiesel is its ability to be used in diesel engines without major modifications. Additionally, biodiesel produces lower emissions of carbon monoxide, particulate matter, and unburned hydrocarbons compared to petroleum diesel [2]. This makes biodiesel an environmentally friendly alternative that also contributes to sustainable energy practices.

Castor oil and waste cooking oil are two potential feedstocks for biodiesel production. Castor oil, derived from the seeds of Ricinus communis, has been recognized for its high yield and sustainability as a biodiesel source. It is non-edible, ensuring that its use does not compete with food supply chains [3]. Waste cooking oil, on the other hand, offers an economically feasible and environmentally beneficial use for a material that would otherwise be disposed of as waste [4].

The selection of a suitable catalyst is crucial for the transesterification process. Potassium hydroxide (KOH) is commonly used due to its effectiveness in yielding high-quality biodiesel with low free fatty acid content [5]. The process parameters, such as reaction time and stirring speed, significantly influence the efficiency of biodiesel production.

Given the potential benefits of biodiesel and the need for optimizing its production, this study investigates the production of biodiesel from a mixture of castor oil and waste cooking oil using KOH as a catalyst. The research focuses on the effects of time and stirring speed on the yield and quality of the biodiesel produced. The outcomes of this study are expected to contribute valuable insights into the optimal conditions for biodiesel production, thereby enhancing its viability as a sustainable energy source.

2. MATERIAL AND METHODS

This research was conducted at the Energy Engineering Laboratory and analyzed at the Chemical Engineering Laboratory of Politeknik Negeri Sriwijaya. The resulting samples are 9 samples. From these samples, each yield is obtained, the 3 highest yields will be analyzed for biodiesel characteristics based on SNI 7182: 2015. This study involved the following variables: 1) Independent Variables : Stirring time and speed, which were varied to assess their impact on biodiesel yield and characteristics. 2) Fixed Variables : The type and amount of catalyst (KOH), the ratio of reactants (castor oil, used cooking oil and methanol), and the reaction temperature.

The research procedure was carried out in several stages as follows: Preparation of Raw Materials, castor oil and used cooking oil were mixed with a certain proportion (depending on variables). After preparation, the raw material sample of the oil mixture is checked for FFA first. If FFA >2% then the esterification process is carried out first, then the transesterification process is carried out. If FFA <2%, the transesterification process is carried out directly [6].

Percent FFA content using the equation [7] :

$$\%FFA = \frac{V\ titrasi \times N\ NaOH \times Mr\ NaOH}{m\ sampel \times 1000} \times 100\% \quad (1)$$

Transesterification Reaction, the mixture was reacted with KOH as a catalyst. The reaction was carried out under different conditions of stirring time (e.g. 20, 40, 60 minutes) and stirring speed (e.g. 300, 400, 500 rpm).

Post-reaction treatment, after the reaction, the biodiesel is separated and purified through washing and separation. The data collected are the biodiesel yield. Percent yield content using the equation [8] :

$$\%\ Yield = \frac{Vol.Outlet}{Vol.Inlet} \times 100\% \quad (2)$$

Testing of the resulting characteristics (viscosity, density, flash point and cetane number). These are measured using standardized instruments and methods.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Stirring Time and Speed on % Yield

In the biodiesel production research, the raw material used was a mixture of castor oil and used cooking oil. The fixed variables used are raw material composition and temperature, while the independent variables used are time and stirring speed.

We can see that the highest percentage yield per sample obtained is 32%, 30%, and 29%, respectively. This shows that the difference in yield percentage from each sample is not too far. It can be observed that the stirring speed has no significant impact on the percentage yield. Instead, the stirring time plays a pivotal role, as the transesterification process necessitates an adequate duration for the chemical reaction to occur effectively.

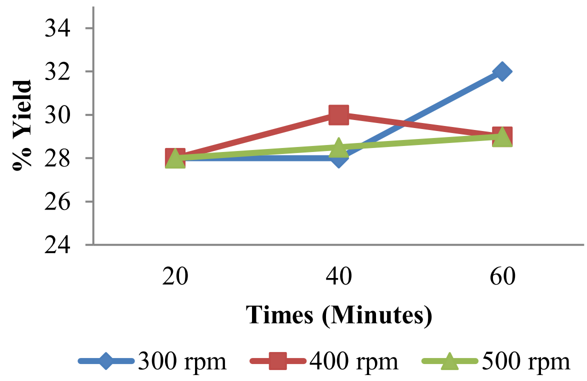

Figure 1. Effect of stirring time and speed on biodiesel yield

Although the difference is slight, we can conclude that the longer the stirring time and the lower the stirring speed, the higher the yield percentage. Conversely, the faster the stirring time and the higher the stirring speed, the lower the yield percentage. A sufficient duration of stirring facilitates the thorough integration of the particles within the mixture, thereby enabling a more comprehensive transesterification reaction to occur [9].

3.2 Effect of Stirring Time and Speed on Density

Based on the sample with the highest % yield, the characteristics of the biodiesel will be analyzed. After the series of research was carried out, characterization was carried out to determine whether the biodiesel produced was in accordance with SNI. The SNI standard of biodiesel density according to SNI 7182:2015 is 0.85-0.89 g/ml.

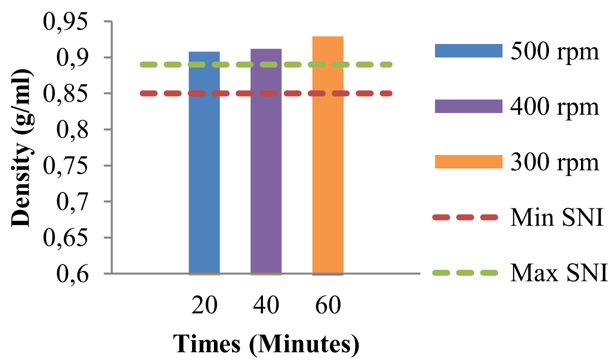

Figure 2. Effect of stirring time and speed on density

From the figure it can be seen that the sample produces a density value that exceeds SNI and from the figure above it is also found that the sample that is close to the SNI value is a sample that has a low stirring time of 20 minutes and a high stirring speed of 500 rpm. This is because during the transesterification process, the fatty acid chains in the raw material oil will be split into shorter methyl ester chains so that the density will decrease along with the decrease in molecular weight [10].

3.3 Effect of Stirring Time and Speed on Viscosity

The standard SNI 7182: 2015 biodiesel viscosity is 2.3 - 6.0 cSt. From the figure we can see that the viscosity values of the samples have met SNI. The respective viscosity values are 6.0143, 5.4911, and 5.0206 cSt. This shows that the longer the stirring time and the slower the stirring speed, the higher the viscosity. Conversely, if the stirring time is shorter and the stirring speed is faster, the viscosity value will be lower and closer to the SNI. This is in accordance with the limits set by SNI 7182:2015 for biodiesel, which requires the kinematic viscosity to be in the range of 2.3 - 6.0 cSt at 40°C.

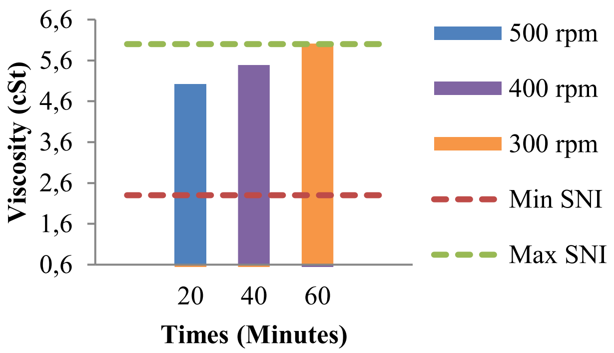

Figure 3. Effect of stirring time and speed on viscosity

High viscosity is the main disadvantage of vegetable oils because it is much greater than the viscosity of diesel fuel, making it difficult to pump fuel from the tank to the engine combustion chamber. The viscosity and density of biodiesel greatly affect the injection characteristics, the greater the viscosity and density of the fuel, the smaller the spray angle and the longer the fuel spray distance [11].

In addition, higher viscosity can lead to sub-optimal fuel distribution and increased emissions. Therefore, viscosity control is critical to ensure optimal engine performance and environmental sustainability [12].

3.4 Effect of Stirring Time and Speed on Flash Point

Flash point is the lowest temperature at which fuel vapor can ignite but does not continue to burn while the burn point is the lowest temperature at which fuel vapor can ignite and continue to burn sustainably. The SNI standard for flash point of biodiesel according to SNI 7182:2015 is at least 100°C.

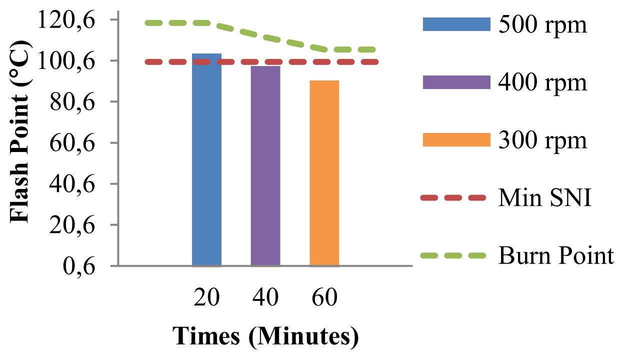

Figure 4. Effect of stirring time and speed on flash point

We can see that only one sample reached the SNI for flash point. The sample that reached the SNI on the flash point was the sample with a stirring time of 20 minutes and a stirring speed of 500 rpm, which produced a flash point of 104°C. From figure it can be concluded that a very high stirring speed has an influence on the flash point that reaches the SNI value. With a stirring speed of 500 rpm and a stirring time of 20 minutes, this sample reaches a flash point value that meets the SNI, compared to other samples that have a longer stirring time but a lower stirring speed. Another reason for not achieving the SNI flash point is that the biodiesel is not fully washed or purified and may still contain methanol from the transesterification process, because not being fully washed or purified and then separated will make biodiesel that still carries water with at least it can also make the flash point lower.

The high stirring speed helps to ensure that the feedstock and catalyst mixture are evenly mixed. This homogeneity of the mixture is important to ensure the transesterification reaction proceeds optimally, resulting in biodiesel with more consistent physical and chemical characteristics, including a standard flash point. This means the reaction can reach equilibrium faster, producing better quality biodiesel in less time.

3.5 Effect of Stirring Time and Speed on Cetane Number

Cetane number is one of the most important fuel properties that measures the auto-ignition characteristics of fuels in powered diesel engines. A higher cetane number indicates a fuel that ignites more easily and burns cleaner in a diesel engine. The SNI standard is at least 51.

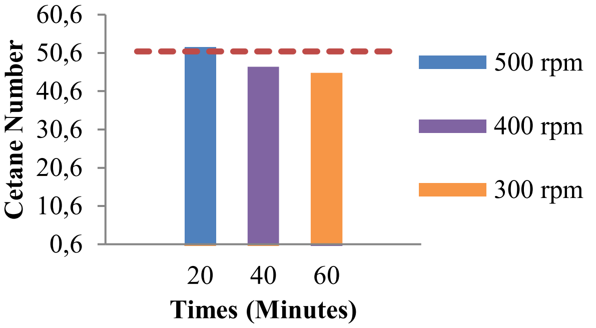

Figure 5. Effect of stirring time and speed on cetane number

From the figure it can be concluded that the factor that greatly influences the cetane number that reaches SNI is the stirring speed of 500 rpm. In this condition, with a stirring time of only 20 minutes, the cetane number obtained is 52.2. This shows that the faster the stirring speed and the shorter the stirring time, the higher the cetane number. Conversely, the longer the stirring time and the slower the stirring speed, the lower the cetane number. A high cetane number can improve engine performance by producing short ignition times and lower pressures. This is due to faster detonation and lower detonation, resulting in lower pressure [13].

4. CONCLUSIONS

The highest biodiesel yield was obtained, reaching 32%, 30%, and 29%, respectively. The highest yield was achieved in the sample with a stirring time of 60 minutes and a stirring speed of 300 rpm. The best product, as determined by an analyzed of its characteristics in accordance with the SNI 7182: 2015, is sample 3, with a stirring time of 20 minutes and a stirring speed of 500 rpm. This sample attained a viscosity of 5.0206 cSt, a flash point of 104°C, and a cetane number of 52.2.

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