Effect of Catalysts on the Quality of Biodiesel from Waste Cooking Oil by Induction Heating

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Abstract. The target of increasing the use of renewable fuels is directly proportional to the increasing demand for biodiesel. High demand for biodiesel must be balanced with sufficient availability from producers. One of the factors that influence biodiesel conversion rate is the use of catalysts. The use of sodium teoxide (CH_3ONa) catalyst in the manufacture of biodiesel can be applied in the process of biodiesel production using induction heating technology. This technology will accelerate the heating process needed in the transesterification reaction. Based on research that has been done, the use of a catalyst concentration of 1% will produce a yield of 86.95% with product quality in accordance with SNI such as density 0.858 gr/cm^3, viscosity 5.727 cSt, flash point 190^{o}C, and acid number 0.439 mg-KOH/gr

Keyword: biodiesel, induction, catalyst, yield, waste cooking oil, quality

1. Introduction

The use of biodiesel as a mixture of diesel fuel (B30) is targeted to increase in 2020. Consumption of biodiesel itself in 2018 has reached 3.8 million kiloliters and it is predicted that in 2025 there will be an increase in biodiesel consumption to 6.9 million kiloliters. The high demand in the following year must be balanced with the provision of high quality biodiesel fuel stock so that biodiesel production with high conversion results is needed in a relatively short time. One of the factors that influence the process of biodiesel production is the use of catalysts. The catalyst functions to reduce the activation energy so that the transesterification reaction can take place in a short time. A large amount of catalyst used in the biodiesel production process will determine the conversion rate of triglycerides to biodiesel.

Research on the manufacture of biodiesel with various catalysts has been carried out before. Bai et al. conducted research into making biodiesel with waste cooking oil using KOH catalyst [1,7,9]. This research yields a 80-90% yield with the use of 0.75% catalyst within 0.33-2 hours. The use of NaOH catalysts in biodiesel production has also been carried out in 2016 [2]. NaOH catalyst gives a yield of

94.3% with the use of a 0.5% concentration of used cooking oil. According to Atadashi, et al., the use of CH_3ONa or CH_3OK catalysts is best because of their ability to dissociate into CH_3O^- and Na+ [1]. Researchers have also previously conducted research in the making of biodiesel from waste cooking oil by electrostatic methods [3,4]. Therefore, through this study, researchers conducted an experiment in the production of biodiesel from waste cooking oil with a CH_3ONa catalyst using induction heating technology.

Induction heaters generate heat from metals that are induced by magnetic fields due to eddy currents in a circular direction surrounding the magnetic field [5,10]. The use of this technology will result in a rapid heating process because it heats the material directly thereby reducing heat wasted into the environment and significantly reducing the heating time with the high power density and without any thermal inertia [6,8]. Theoretically, induction heaters consist of 3 components, namely high-frequency electrical power supplies, inductive coils, and workpieces made from a ferromagnetic material. Coils that are electrified with high frequency will produce a magnetic field. The magnetic field that penetrates the vessel will create an eddy current or eddy current, which generates heat in the vessel. Additional heat in the vessel is also caused by hysteresis meshes from ferromagnetic material which has low permeability. The heat in the vessel will travel to the mixture inside the vessel. The heat will not be generated outside of the generated magnetic field [11].

2. Materials and Methods

Used cooking oil has a 4.32% FFA. The catalyst is sodium hydroxide, which is made into a methoxide solution with varying concentrations of the weight of the oil used. The ratio used is 1:7 with temperature and reaction time of 60°C and 15 minutes. The main component of the tool used is located in the transesterification reactor that uses the principle of induction for heat supply in the reaction. A coil with a total of four turns at the bottom of the reactor will be electrified with a high-frequency electric current and will produce a magnetic field. This magnetic field then induces the metal contained in the reactor so that heat will be generated from the metal material. The heat will then be transferred by conduction to the mixture of materials inside the reactor. The mixture will be homogenized with a stirrer inside the reactor. The biodiesel products obtained were then analyzed for quality such as density, viscosity, flash point, and acid number to compare with the existing quality standards in Indonesia. The instrumentation used in this study is shown in Figure 1.

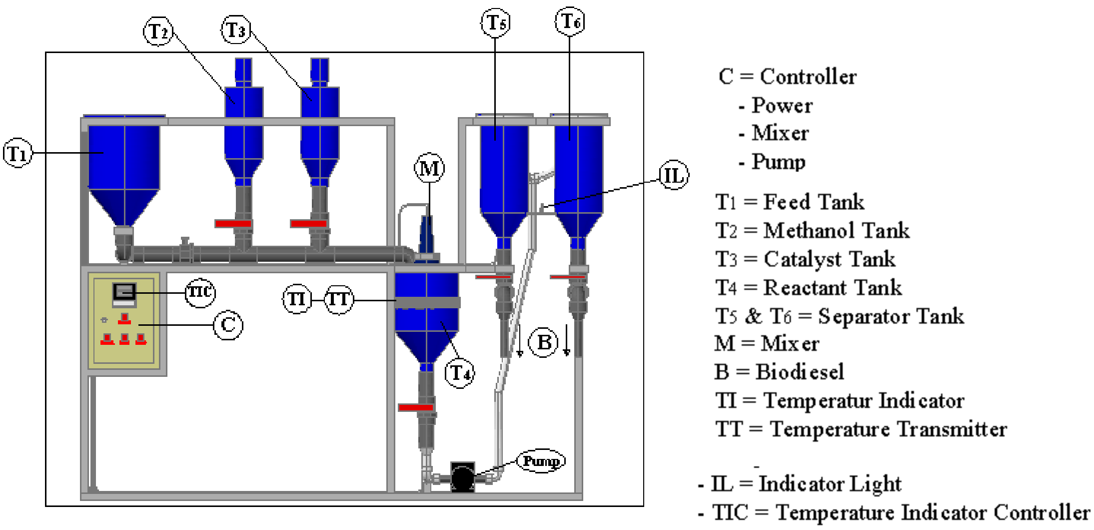

Figure 1. Biodiesel Production using Induction Heater Instrumentation

3. Result and Discussion

The concentration of catalyst varied in this study was 0.6%, 0.8%, 1.0%, 1.2%, and 1.4% by weight of the oil used. The relationship between the use of catalyst concentrations for used cooking oil raw materials to the yield of biodiesel produced is shown in Figure 2.

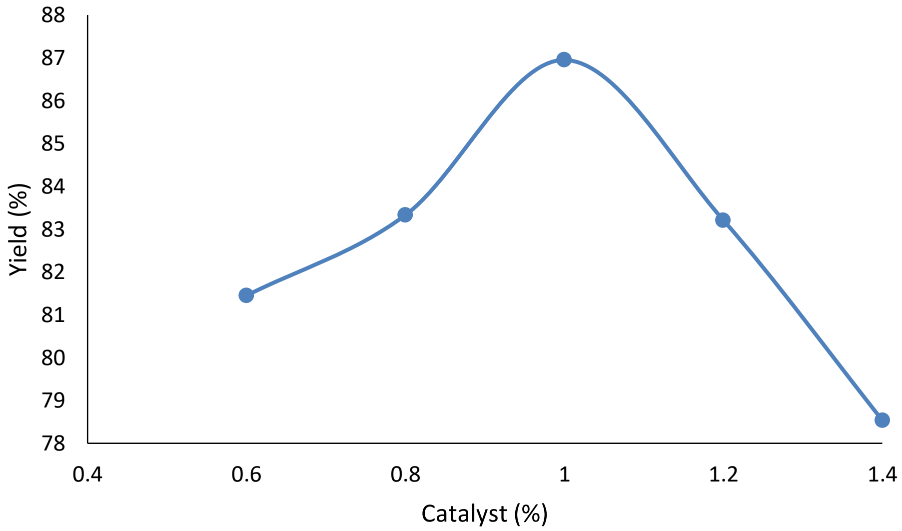

Figure 2. Relationship of Catalyst Concentration to Biodiesel Yield

Based on Figure 2, it was found that an increase in the concentration of catalyst used would increase the yield of biodiesel products. The highest yield was obtained at the use of a 1% concentration of 86.95%. The higher the concentration of catalyst in solution, the smaller the activation energy of a reaction [12]. The use of high catalyst concentrations increases the rate of transesterification reaction between triglyceride molecules with methanol and reduces the activation energy needed to achieve the transesterification reaction so that the conversion of oil to biodiesel is increased. On the other hand, the addition of catalysts by 1.2% resulted in a decrease in yield. The use of excess catalyst concentrations can increase saponification reactions and reduce yield production.

Density is one of the parameters determining the quality of biodiesel products. Density is related to the carbon chain of the alkyl ester. The relationship between the catalyst concentration and the density of the biodiesel product produced is shown in Figure 3.

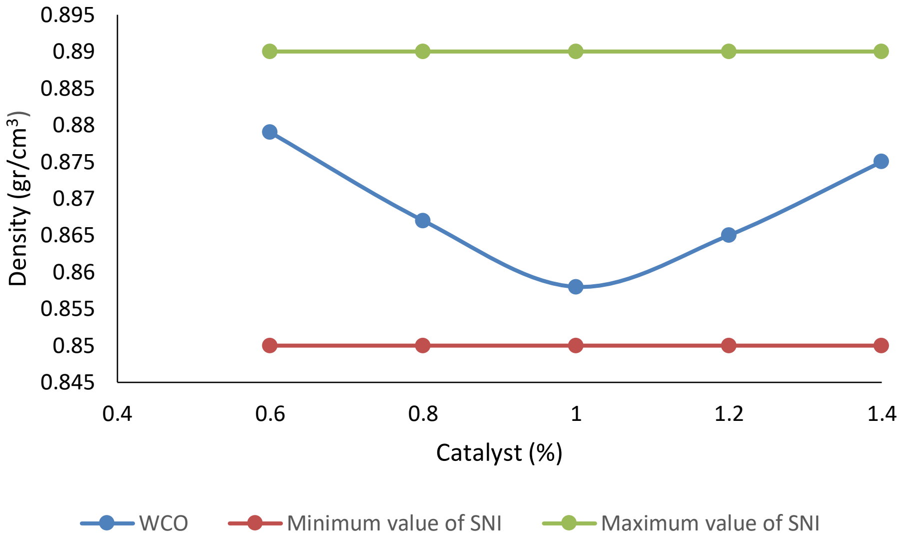

Figure 3. Relationship of Catalyst Concentration to Density

The viscosity that is too high will increase the friction losses that occur in the pipe, aggravate the pump work, and complicate the filtering process so that it increases the likelihood of dirt being deposited and the fuel removal process [13]. The relationship between the use of catalyst concentration and the viscosity of the product produced is shown in Figure 4.

Figure 4 shows the effect of the catalyst concentration used on the viscosity of the product produced. The highest viscosity is in the product with the use of catalyst 1.4%, which is 5.754 cSt while the lowest viscosity is in the product with the use of catalyst 1%, which is 5.727 cSt. The use of optimum catalyst concentration will increase triglyceride conversion and reduce unreacted triglyceride content. This causes a decrease in the value of the resulting product viscosity. The use of an excessive amount of catalyst will cause an increase in the formation of an emulsion that leads to the formation of a gel.

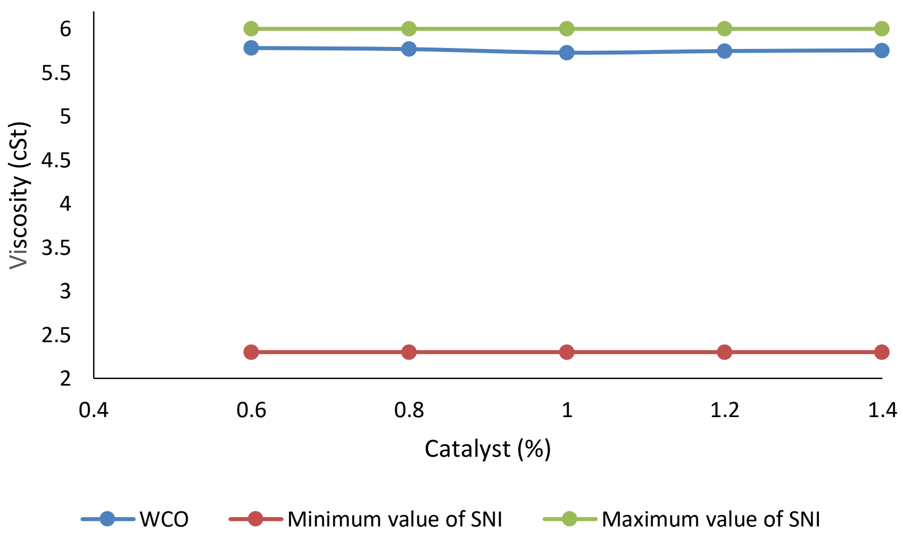

Figure 4. Relationship of Catalyst Concentration to Viscosity

A high flash point guarantees safer treatment and storage [14]. The relationship between the use of catalyst concentration and the flashpoint of the product produced is shown in Figure 5.

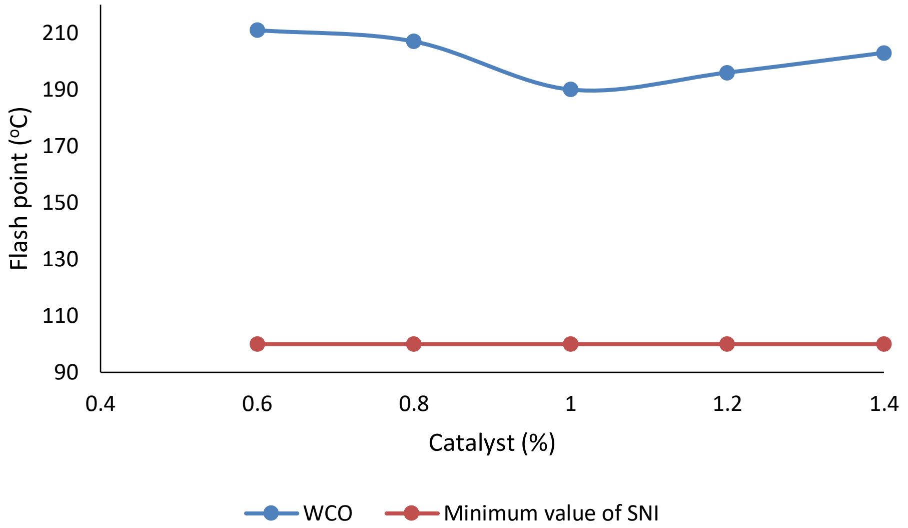

Figure 5. Relationship of Catalyst Concentration to Flashpoint

Based on Figure 5, it is found that the highest flash point is in the product with a catalyst concentration of 1% which is 190°C while the lowest flashpoint is in the product with a catalyst concentration of 0.6% which is 211°C. High catalyst concentrations will increase the production of biodiesel yield due to the increasing conversion process. However, the use of which exceeds the optimum amount, the catalyst will cause the conversion process to be less perfect so that the purity of the biodiesel product is lower. The low purity of biodiesel indicates the presence of components such as a number of catalysts remaining from the transesterification reaction, unconverted oil, and water contained in oil. This component will complicate the process of igniting biodiesel in the combustion engine and indicate the high flash point on the product.

High acid levels can shorten the life of the pump and filter use of fuel so that it will more easily lead to corrosion. High acid values indicate a decrease in the quality of methyl esters due to oxidation [15]. The relationship between the use of catalyst concentrations and the acid number of the product produced is shown in Figure 6.

Based on Figure 6, it is found that the acid number is influenced by the concentration of the catalyst used. The lowest acid number is in products with a catalyst concentration of 1%, 0.439 mg-KOH / gr while the highest acid number is in products with a catalyst concentration of 1.4%, which is 0.711 mg-KOH / gr. The optimum concentration of catalyst causes the free fatty acids that react with the catalyst to increase so that the number of acidic products becomes lower. The use of an excess catalyst will form fat-free soap so that it will complicate the purification process.

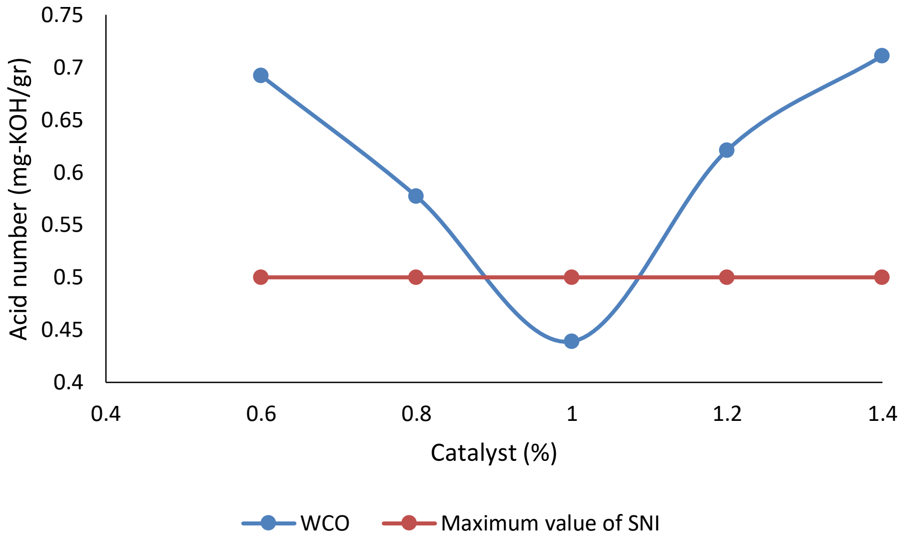

Figure 6. Relationship of Catalyst Concentration to Acid Figures

4. Conclusions

The use of induction heating technology as a heat transfer media in the process of making biodiesel provides advantages in terms of using the reaction time required. The process of making biodiesel, which is done by induction technology uses only 15 minutes of reaction time each time running. The variation of catalyst concentrations carried out aims to determine the use of optimum concentrations to obtain high conversion results and following applicable quality standards in Indonesia. The use of catalyst concentrations of 1% by weight of oil will produce a relatively high yield of 86.95% with product quality in accordance with SNI such as density 0.858 gr / cm3, viscosity 5.727 cSt, flash point 190^{o}C, and acid number 0.439 mg-KOH/gr.

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