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Time Optimization on Biodiesel Conversion from Waste Cooking Oil

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Abstract. The need of energy is increasing in present, due to the world population growth and increasing industrial sector. Many peoples concerned about climate change and energy sustainability. For that reason, in recent years, the renewable energy is getting more intention. One of the prospecting renewable energy is biodiesel. There are many sources for biodiesel production, such as; jatropha curcas oil, sunflower seed oil, waste cooking oil, etc. In this research the waste cooking oil (WCO) is used for producing biodiesel through transesterification process by varying the reaction time. This research aims to find the optimum biodiesel conversion based on the reaction time process. The result show that the maximum yield is 62.8% when the reaction time is 80 min. The density value is around 0.88 g/ml and the viscosity is around 3.6 mm²/s, both of those value are meet with the standard of biodiesel.

Keywords: Biodiesel, Density, Viscosity, Renewable Energy, Waste Cooking Oil

1. Introduction

The energy requirement is increasing in line with the increasing of fuel for transportation activities, industrial activities, household activities and other activities that need electricity's. This condition triggered an increase in fuel prices in many countries [1-4]. The alternative energy needs to overcome the scarcity of fuel. One of the energy diversities is a renewable energy such as biodiesel or biofuel. Biodiesel is used as an alternative fuel to substitute diesel / diesel oil [5]. This type of energy could be derived from vegetable oils such as jatropha oil, palm oil, and coconut oil. However, the use of coconut oil and palm oil as biodiesel may disrupt the edible oil stocks [6]. So that, the alternative source from waste oil, such as; Waste Cooking Oil (WCO), have good opportunity as raw materials.

The synthesis of biodiesel from WCO could be done through transesterification process. Transesterification is a reaction that produces an ester from the breakdown of triglyceride compounds and migration of alkyl groups between esters. Esters produced from this transesterification reaction usually called biodiesel. The transesterification reaction is explained in Figure 1.



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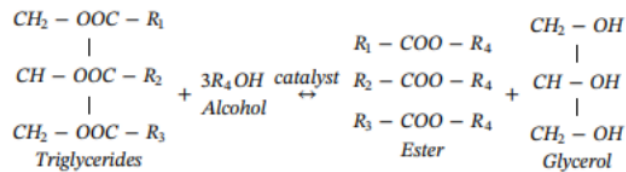


Figure 1 Transesterification reaction (Adapted from [7])

Commonly, the WCO is wasted and its need properly treatment before sending it to environment [5]. For that reason, this research purpose is to increase the value of waste cooking oil by using it as material source for biodiesel and optimize the reaction time in transesterification process.

2. Methodology

2.1 Materials

The material used in this research is WCO, sodium hydroxide tablets (>90%), methanol (>96%), potassium hydroxide tablets (>80%), PP (PH 8.2-9.8), hydrochloric acid (37%), acetone (99%) etc. The WCO, which is derived from palm oil, was collected from a restaurant located in Surabaya, Indonesia.

2.2 Synthesis Process

Initially, the waste cooking oil was tested to determine the FFA contain. Deferent treatment applied to the WCO according to FFA contain. The process of transesterification was carried out by adding methanol to WCO with a certain reactant ratio and adding NaOH as catalyst into a stirred reactor. The reaction undergoes in batch conditions at a certain temperature and at various reaction times. The reaction time varies from 20 to 80 minutes at 20-minute intervals. The full procedure is listed in the Figure 2.

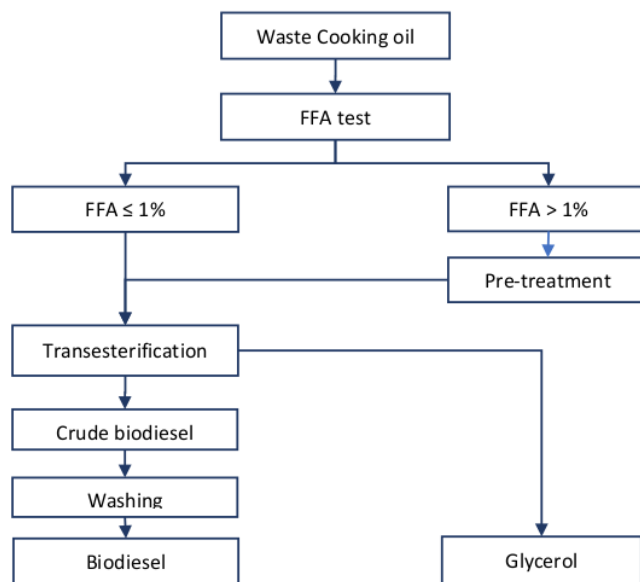


Figure 2. Research procedure

3. Result and Discussion

3.1 Waste Cooking Oil Characterization

The characterization of WCO were determined from the properties of physical state, viscosity, colour and Density, and its presented in table 1.

Table 1. WCO characterization

Properties	Experimental Value
Physical state	Liquid
Color	Dark oily
Density (g/ml)	0.95
Viscosity (mm ² /s)	2.3
FFA content (wt% of oil)	0.93

3.2 Density and Viscosity Analysis

The viscosity and density properties of produced biodiesel were described in Table 2 and Table. Those table described the comparison with standard values as well. The result show that both are meet the criteria of biodiesel.

Table 2. Density analysis

Time (min)	Density (g/ml)	Biodiesel Standard [8]	Diesel Standard [9]
20	0.884		
40	0.884	0.88	0.85
60	0.875		
80	0.872		

Table 3. Viscosity analysis

Time (min)	Viscosity (mm ² /s)	Biodiesel Standard [8]	Diesel Standard [9]
20	3.76		
40	3.66	1.9 -6.0	1.3-4.1
60	3.33		
80	3.01		

3.3 The effect of Reaction Time on Conversion and Yield Products

One of the parameters that affect biodiesel products is reaction time. Reaction time has an effect on yield and conversion product [10]. However, Buasri et.al [11] has reported that reaction time exceeding the optimal value of the biodiesel production may result in reverse reaction. This is because the transesterification reaction is a reversible reaction.

The relationship between conversion and the reaction time show in Figure 3. It can be seen the reaction conversion achieved the highest level in the reaction time range of 40-60 min. Whereas, after 60 min the conversion tends to decrease. This could happen because of at 40-60 minutes is the optimal reaction time in the production of biodiesel from waste cooking oil (WCO). At the reaction time of 80 minutes the reaction conversion decreased. This is because the reaction time of 80 minutes has

exceeded the optimal reaction time, so the possibility of a reverse reaction occurs. This is accordance with research studied by Buasri et al. [11]. They concluded that the reaction can be reversible when the product concentration is high, preferably reverse reaction.

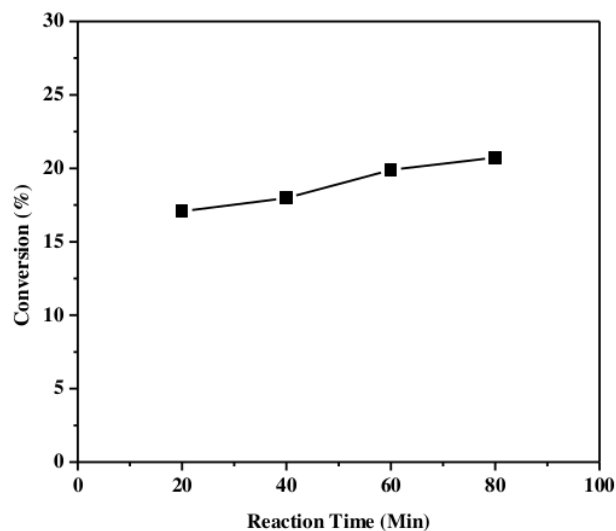


Figure 3. Conversion

In Figure 4, it can be seen that the longer time reaction effect on increasing the yield. The highest yield is 62,8% in 80 min. However, it shows that after 60 min the rate of yield production is lower than 40 to 60 min. This could be happened because of saponification reaction begins, after a reaction time of 60 minutes, and glycerol is formed.

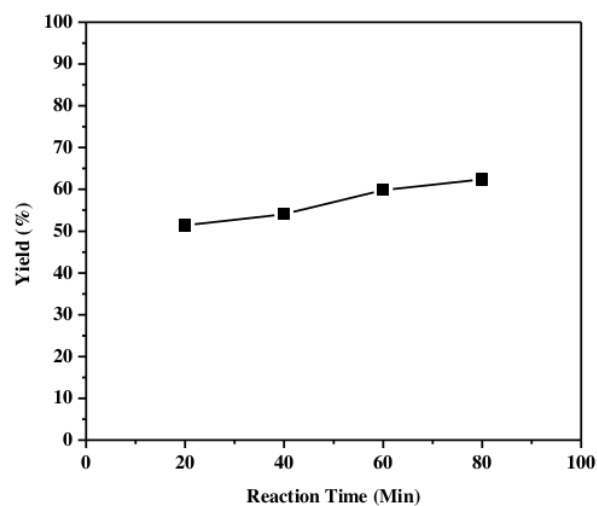


Figure 4. Biodiesel Yield

4. Conclusion

According to the fact that reaction time have strong influence on the yield of biodiesel production, so it concluded that the increasing reaction time will increase the conversion and yield. The most optimal operating conditions with the largest conversion of 22.5% are obtained at reaction time 80 min. Also, the best reaction time is 80 min with the yield reached 62.8%. Based on the ASTM (American Society for Testing Materials) standard, the value of density and viscosity resulted in this research are meet with their criteria.

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