Waste processing technology for biodiesel fuel cooking oil using zeolite bayah catalyst

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Abstract. The waste of household cooking oil is thrown away so that it causes environmental problems. Therefore, this problem must be responded to immediately, for example by processing household waste cooking oil into environmentally friendly biodiesel as an alternative method to address this problem. This study aims to make biodiesel from household waste cooking oil to eliminate or reduce levels of free fatty acids (ALB) contained in used cooking oil catalyst, namely Zeolite Bayah catalyst, while the temperature and reaction time is a fixed variable for the esterification reaction. The methods of this study are activated zeolite as a catalyst and mixed it with waste cooking oil. The results of this study indicate that the processing of used cooking oil using Zeolite Bayah catalyst can reduce the free fatty acid content contained in used cooking oil, and the physical characteristics of biodiesel generally meet the SNI-04-7182-2012 standard. So that it can be seen that the Zeolite Bayah catalyst influenced the process of reducing free fatty acids in used cooking oil, it can be concluded that some of the parameters are already included in the national standard 04-7182-2012, and it can be seen that the Zeolite Bayah catalyst density parameters obtained the results of 871, the density of NaOH catalysts obtained 862, while from the national standard 04-7182-2012, it was set at 850-890. Both of these results have met the standard for the quality of making biodiesel.

1. Introduction
Technological developments and the world’s population are increasing, significantly affecting market demand for energy. Therefore, new and renewable alternative energy is needed, one of which is biodiesel fuel. Biodiesel is a fuel that is environmentally friendly, clean and does not contain sulfur so it can reduce environmental damage caused by acid rain [1]. However, one of the problems faced in using biodiesel is the price that is relatively more expensive than diesel fuel. Hence, we need a way to reduce the production costs of making biodiesel. One method that can be used is by replacing biodiesel-producing energy sources that can reduce production costs, for example from waste cooking oil. Waste cooking oil is not suitable for consumption and commercially has no selling value, therefore it is included in the waste category. Furthermore, cooking oil can damage the image of food that is processed and can also impair human health. If thrown into the environment is also a cause of environmental pollution. Making biodiesel by utilizing used waste oil is expected to reduce household or food industry waste and reduce biodiesel production costs so that it will ultimately reduce market prices.

The process of making biodiesel uses more homogeneous catalysts, such as KOH. But the use of this homogeneous catalyst raises new problems in the biodiesel produced, biodiesel still contains a catalyst so that it must be re-segregated. The use of KOH catalyst can also cause side reactions, such as the presence of saponification reactions thus affecting the process of making biodiesel [2]. In addition to
homogeneous catalysts, heterogeneous catalysts such as zeolite can also be used. The advantage of using zeolite is that the process of purifying biodiesel is easier, the separation of catalysts can be done only by filtering because zeolite has molecular filtering properties \[3\]. Therefore, the utilization of Banten zeolite as a homogeneous catalyst is expected to increase the purity of biodiesel. In previous studies, it was stated that catalytic activity of the solid acid Fe(HSO4)3 catalyst was evaluated for the production of biodiesel from waste cooking oil with high FFAs. The FAME yield reached 94.5% at the reaction time of 4 h, catalyst of 1%, molar ratio of methanol to TG of 15:1, and reaction temperature of 205 °C \[4\]. Zeolite-based catalyst was prepared from zeolite tuft by impregnation methods in potassium hydroxide solution \[5\]. Sunflower waste oil was used as a substrate for biodiesel production using the prepared zeolite-based catalysts. The 0.0004 M KOH/TZT catalyst provided the maximum biodiesel yield at 96.7% obtained in 2 h reaction time at reaction temperature of 50°C, methanol to oil molar ratio of 11.5:1, a stirring speed of 800 rpm and 335 mm particle size. This research aims to making biodiesel from waste cooking oil and evaluating zeolite as a catalyst.

2. Methods
This research conducted in March 2018 until August 2018 at the Environmental Chemistry Laboratory, Universitas Banten. The analysis was carried out at the Quality Control Laboratory of Lotte Chemical Indonesia.

2.1. Tools and materials
The tools used in this study are glass tools commonly used in laboratories (glassware), pH meters, centrifuges, shaker, mortar, sieves 100-150 mesh, analytical balance sheets, stopwatches, thermometers, distillation flasks, GCMS, Materials used are concentrated HNO3 cooking oil, 2M HCl solution, 0.2M NaOH, pH 7 Buffer and pH 4, GCMS, falling ball viscosimeter, pycnometer, triple neck flask, stirrer, thermometer, and condenser. The material used is cooking oil waste, methanol and Bayah Banten natural zeolite, this zeolite was obtained from the Bayah Mountains of Banten.

2.2. Research procedure
Bayah Banten Zeolite Activation as a Catalyst. A total of 25 grams of natural zeolite was put into a glass beaker containing 125 ml of 6M HCl, Shaking for 30 minutes at a temperature of 50°C while stirring with a magnetic stirrer, then filtered with a size of 60 mesh and washed repeatedly until no Cl ions were detected AgNO3 solution, dried at 130°C for 3 hours \[5\].

2.3. Making biodiesel
The 1% catalyst (KOH / H-Zeolite) is mixed with methanol (100 mL) and heated at 6 °C. Used cooking oil (400 mL) is also heated at a temperature of 60 °C in a three-neck pumpkin which is equipped with a thermometer and stirrer. After the temperature of the two reactants was reached (60 °C) the catalyst solution and methanol were put into a three neck flask, the stirrer was run at a rotational speed [5].
3. Results and discussions

3.1. Processing cooking oil waste to biodiesel with zeolite catalyst

Figure 1. Biodiesel with zeolite catalyst.

The manufacture of biodiesel with zeolite catalyst obtained a density of 0.871 g/mL, viscosity of 36.6 Cps, moisture content of 0.04%, flash point 136 °C, pour point 18 °C, acid number 0.42 mg KOH/g, setana number 55, composition of constituent compounds (sulfur 0.02 mg / kg, phosphorus 2.4 mg / kg, combustion time 2.7 seconds, combustion 15%. It can be concluded that biodiesel with zeolite catalyst has met the biodiesel standard.

3.2. Processing waste cooking oil to biodiesel with catalyst NaOH

NaOH catalyst is a base catalyst which is used as a zeolite comparison catalyst in making biodiesel. Making biodiesel using NaOH catalyst obtained results that national biodiesel standard because in this esterification process NaOH can react to free fatty acid content using alcohol (methanol) with NaOH catalyst.
The analysis of the examination of the manufacture of biodiesel from used cooking oil using NaOH catalyst was obtained as follow:

Table 1. Results of biodiesel with NaOH catalysts.

| Analysis              | Unit       | Results | Methods      |
|-----------------------|------------|---------|--------------|
| Density               | g/ml       | 0.862   | Vicnometer   |
| Viscosity             | Cps        | 29.7    | DV-E Viscometer |
| Water Content         | %          | 0.05    | Calvisher    |
| Flash Point           | °C         | 120     | -            |
| Pour Point            | °C         | 18      | -            |
| Acid Number           | mg KOH/g   | 0.49    | Titration    |
| Cetane Number         | min 51     | 55      |              |
| Sulfur                | mg/Kg      | 0.11    |              |
| Phosphorus            | mg/Kg      | 1.7     |              |
| Burning Time          | <50 second | 43      |              |
| Residue               | %          | 5%      | 1.8          |
| Combustion Residue    | %          | 40%     | 9.6          |
Biodiesel samples obtained were analyzed (density, viscosity, moisture content, point, point of spill, acid number, cetane number (sulfur, phosphorus), residual burn time, and residual combustion). The biodiesel produced will be compared with the biodiesel standard. Based on the table above obtained the following results, density and viscosity parameters at 40°C at 0.862 g/mL and 29.7, 0.05% moisture content, 120°C point, 18°C point, acid number is 0.49 mg KOH/g, cetane number 55, sulfur 0.11 mg/kg, phosphorus 1.7 mg/kg, burn time 43 seconds, residue 1.8%, residual combustion 9.6%. From these results it can be concluded that the results of some of these parameters are close to the National Standard of Biodiesel in general because the amount obtained is approaching the Value Standard that is in the National Standard of Biodiesel

3.3. Zeolite catalyst biodiesel
Based on the results of the study, it can be concluded that the manufacture of biodiesel meets the average of the National biodiesel standard (SNI 04-7182-2012), because the results of the analysis that has been obtained can accelerate the esterification process. Reduce the free fatty acid content in used waste cooking oil.

Table 2. Analysis biodiesel results with zeolite catalyst.

| Analysis          | Specification | Results  | Method         |
|-------------------|---------------|----------|----------------|
| density           | g/ml          | 0.871    | Vicnometer     |
| viscosity         | Cps           | 36.6     | DV-E Viscometer|
| water content     | %             | 0.04     | Calvisher      |
| Flash Point       | °C            | 136      | -              |
| Pour point        | °C            | 18       | -              |
| Acid number       | mg KOH/g      | 0.42     | Titration      |
| Cetane Number     | min 51        | 55       | Spectrometer   |
|                   |               |          | UV 1601PC      |
| Sulfur            | mg/Kg         | 0.02     |                |
| Phosphorus        | mg/Kg         | 2.4      |                |
| Burning Time      | <50 seconds   | 40       |                |
| Residue           | %             | 5%       |                |
| Combustion residue| %             | 40%      |                |
|                   |               | 15       |                |
Based on the table, the results of biodiesel extraction with Zeolite catalyst were obtained, namely: density and viscosity at 40 °C at 0.871 g/ml and 36.6 Cps, moisture content 0.04%, flash point 136%, pour point 18 °C, acid number 0.42 mg / KOH/g, cetane number 55, sulfur (0.02 mg/kg, phosphorus 24 mg/kg), residue 2.7% and burning 15%.

Based on the results of the study, it can be concluded that the manufacture of biodiesel met the average of the National biodiesel standard (SNI 04-7182-2012), because the results of the analysis that has been obtained, namely the base catalyst (NaOH) can accelerate the esterification process, reduce the free fatty acid content in used cooking oil.

Based on the research that has been done, if it is presented in graphical form the graph will be obtained as follows:

![Graph of biodiesel results with catalyst NaOH and zeolite.](image)

**Figure 3.** Graph of biodiesel results with catalyst NaOH and zeolite.

4. **Conclusions**
   Based on these data, it can be seen that the results obtained from the production of biodiesel NaOH catalysts and zeolite catalysts have relatively different results. Where the results obtained from biodiesel with zeolite are likely to be faster and the results obtained are more maximal. Due to the function of zeolite itself which is to accelerate the esterification and transesterification process. The results obtained in the reaction are closer to the main purpose of biodiesel in general, where the characteristics of biodiesel itself can eliminate or reduce the content of fatty acids in used cooking oil, namely by using a zeolite catalyst. Esterification reaction conditions at the time of the study eliminated faster the content of fatty acids in used cooking oil, so that the fatty acid content of the oil turned into methyl ester, then methyl ester can break down alkaline groups from ester compounds using KOH (Potassium Hydroxide).

   Experimental variables that influence the yield of biodiesel during the esterification process are the weight of zeolite catalyst and mole ratio of oil: methanol, while temperatures of 60-70°C and reaction time of 60 minutes are fixed variables.

   Based on the table above obtained the following results, namely density and viscosity parameters at 40°C at 0.862 g/ml and 29.7, 0.05% moisture content, 120°C point, 18°C point, 0 acid number, 49 mg KOH/g, cetane number 55, sulfur 0.11 mg/kg, phosphorus 1.7 mg/kg, burn time 43 seconds, residue 1.8%, residual combustion 9.6%. From these results it can be concluded that the results of some of these parameters are close to the National Standard of Biodiesel in general because the amount obtained is approaching the Value Standard that is in the National Standard of Biodiesel.
References

[1] Sara S 2017 Production of biodiesel using HZSM-5 zeolites modified with citric acid and SO4$^{2-}$/La2O3  *J Catalysis Today* **279** pp 267-273

[2] Tony T 2016 Biodiesel production from refined sunflower vegetable oil over KOH/ZSM5 catalysts  *J Renewable Energy* **90** pp 301-3016

[3] Fitriyah F 2016 Interkalasi Xilenol Orange pada Zeolit Alam Lampung Sebagai Elektroda Zeolit Termodifikasi  *J Educhemia* **2** pp 162-175

[4] Fatah H A 2013 Production of biodiesel from mixed waste vegetable oils using Ferric hydrogen sulphate as an effective reusable heterogeneous solid acid catalyst  *J catalysis* **456** pp 182-187

[5] Noor Al-Jammal, Zayed Al Hamamre and Mohammad Alnaief 2016 Manufacturing of zeolite based catalyst from zeolite tuft for biodiesel production from waste sunflower oil  *J Renewable Energy* **93** pp 449-459