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EFFECT OF THE AMOUNT OF COMO/BOTTOM ASH CATALYST IN THE CATALYTIC CRACKING PROCESS OF USED COOKING OIL ON BIOFUEL PRODUCT CHARACTERISTICS

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Abstract. This study aims to analyze the effect of variation in the amount of CoMo/bottom ash catalyst in the catalytic cracking process of used cooking oil on the characteristics of the biofuel products produced. Used cooking oil was chosen as an alternative raw material to replace petroleum due to its abundant availability and its potential to reduce environmental pollution. The method used was catalytic cracking with variations in the composition of CoMo catalyst and bottom ash, namely CoMo/bottom ash 25:75 and CoMo/bottom ash 75:25. The process was conducted at 150°C for 1-2 hours using a specially designed reactor. The results showed that catalyst composition had a significant effect on biofuel yield and quality. At 25:75 composition, the biofuel yield reached 5.04% or 135 ml, while at 75:25 composition, the yield was only 3.73% or 100 ml. Product quality analysis based on SNI 7182:2023 includes density, viscosity, and flash point. The biofuel density for the 25:75 and 75:25 compositions were 0.9010 gr/ml and 0.9637 gr/ml, respectively, with the best value in the 25:75 composition which is close to the SNI 7182:2023 standard. The viscosity of both compositions met the standard, namely 2.361 mm^2/s for the 25:75 variation and 2.365 mm^2/s for the 75:25 variation. However, the flash point of biofuel 73°C for 25:75 and 75.8°C for 75:25 did not meet the SNI 7182:2023 standard. In conclusion, the CoMo/bottom ash 25:75 catalyst composition produces biofuel with better density and viscosity, although the flash point still needs to be improved. Suggestions for further research are optimization of bottom ash activation process and exploration of other catalyst composition variations to increase yield and quality of biofuel.

Keywords*:* catalytic cracking, used cooking oil, CoMo/bottom ash catalyst, biofuel, product characteristics

Abstrak. *Penelitian ini bertujuan untuk menganalisis pengaruh variasi jumlah katalis CoMo/bottom ash pada proses catalytic cracking minyak jelantah terhadap karakteristik produk biofuel yang* *dihasilkan. Minyak jelantah dipilih sebagai bahan baku alternatif pengganti minyak bumi karena ketersediaannya yang melimpah dan potensinya untuk mengurangi pencemaran lingkungan. Metode yang digunakan adalah catalytic cracking dengan variasi komposisi katalis CoMo dan bottom ash, yaitu CoMo/bottom ash 25:75 dan CoMo/bottom ash 75:25. Proses dilakukan pada suhu 150°C selama 1-2 jam menggunakan reaktor yang didesain khusus. Hasil penelitian menunjukkan bahwa komposisi katalis berpengaruh signifikan terhadap yield dan kualitas biofuel. Pada komposisi 25:75, yield biofuel mencapai 5,04% atau 135 ml, sedangkan pada komposisi 75:25, yield hanya 3,73% atau 100 ml. Analisis kualitas produk berdasarkan SNI 7182:2023 meliputi densitas, viskositas, dan titik nyala. Densitas biofuel untuk komposisi 25:75 dan 75:25 masing-masing adalah 0,9010 gr/ml dan 0,9637 gr/ml, dengan nilai terbaik pada komposisi 25:75 yang mendekati standar SNI 7182:2023. Viskositas kedua komposisi memenuhi standar, yaitu 2,361 mm²/s untuk variasi 25:75 dan 2,365 mm²/s untuk variasi 75:25. Namun, titik nyala biofuel 73°C untuk 25:75 dan 75,8°C untuk 75:25 tidak memenuhi standar SNI 7182:2023. Kesimpulannya, komposisi katalis CoMo/bottom ash 25:75 menghasilkan biofuel dengan densitas dan viskositas yang lebih baik, meskipun titik nyala masih perlu ditingkatkan. Saran untuk penelitian selanjutnya adalah optimasi proses aktivasi bottom ash dan eksplorasi variasi komposisi katalis lainnya untuk meningkatkan yield dan kualitas biofuel.*

Kata kunci: *Catalytic cracking, minyak jelantah, katalis CoMo/Bottom Ash, biofuel, karakteristik produk*

1. Introduction

Energy is an important part of everyday life as almost all activities require energy. Fuel oil is still the most commonly used energy source. Currently, the fuel mostly comes from petroleum extracted from the ground, but the amount is decreasing. Therefore, other fuel sources are needed to replace petroleum. Other potential sources for alternative fuel production come from household, biomass and industrial waste, including used cooking oil (Moazeni et al., 2019).

However, this waste is often disposed of carelessly, which risks polluting the environment, especially soil and water, and endangering health if reused without going through a safe process. In fact, used cooking oil has the potential to be reused into valuable products, such as biofuels. Used cooking oil is a more promising feedstock for producing alternative fuels compared to fresh vegetable oil. Depending on the origin of the used cooking oil, biodiesel production from used cooking oil generally uses transesterification, hydrocracking or catalytic cracking processes (Keera et al., 2018; Goh et al., 2019; Kim et al., 2019; Kouzu et al., 2020).

One method that is considered effective in converting used cooking oil is catalytic cracking, which is a thermochemical process that decomposes large molecules into short-chain hydrocarbons similar to liquid fuels (Nazarudin et al., 2022). The success of the process is largely determined by the type and amount of catalyst used. Transition metal-based catalysts such as Cobalt-Molybdenum (CoMo) are proven to have high effectiveness in the cracking process. In addition, bottom ash can also be a more environmentally friendly and more economical solution if utilized as a catalyst mixture in the catalytic cracking process. Therefore, it is important to further investigate how the variation in the amount of CoMo/bottom ash catalyst affects the process efficiency and product quality of used cooking oil catalytic cracking.

In the catalytic cracking process, the addition of catalysts serves to accelerate the decomposition reaction and shorten the hydrocarbon chain, so that the results are more easily condensed into oil from catalytic cracking. This research uses a combination of CoMo catalysts with bottom ash from activated coal. Cobalt (Co) metal plays a role in increasing the activity, stability, and selectivity of the catalyst. Meanwhile, molybdenum (Mo) functions as an active component that supports the increase in activity and selectivity of catalytic cracking reactions (Suharbiansyah, 2015). In terms of surface area stability and pore volume that remains when used repeatedly in the reactor, CoMo catalysts are proven to be more active and selective than NiMo catalysts in the hydrodesulfurization process (Irvaisal et al., 2010). Coal bottom ash has a larger particle size and weight than fly ash, and contains high amounts of silica, making it a potential catalyst base material (Hayni et al., 2020).

Many previous studies on catalytic cracking have been conducted, including the production of biofuel from Palm Fatty Acid Distillate (PFAD) through a catalytic cracking process with a CoMo/Zeolite catalyst with varying carrier metal content of 0%, 0.5%, 1%, 1.5%, and temperatures of 360°C, 380°C, 400°C, and 420°C (Irvaisal Ritonga et al., 2010). Furthermore, research on the Production of Biofuel from Used Cooking Oil Through a Catalytic Cracking Process with Fly Ash as a Catalyst (M. Asyraf Hazzamy et al., 2013).

In this study, the authors conducted the study using used cooking oil as the raw material and processed it using the catalytic cracking method. The research innovation lies in the catalyst used in the catalytic cracking process.

2. Material and Methods

2.1 Material

In this study, 5 liters of used cooking oil, 100 grams of CoMo catalyst, and 100 grams of bottom ash catalyst were used as raw materials.

Table 1. Testing Analysis of Used Cooking Oil Raw Material

Parameter	Hasil
Flash Point (°C)	241
Density (gr/ml)	0,93
Viscosity (mPa/s)	3,81
Refractive Index	1,43

Source: (Oktadina, P. A. N et al., 2023)

Table 1. shows that the test results for used cooking oil yielded a flash point of 241°C, a density of 0.93 g/ml, a viscosity of 3.81 mPa/s, and a refractive index of 1.43. This analysis was conducted to determine the initial results for further research to determine the differences between the initial and post-test data.

2.2 Procedure

The implementation of this activity begins with the material preparation stage, then in this study, the research variable is the variation of the composition of the CoMo catalyst mixture with Bottom Ash, namely in the ratio of 25 grams of CoMo and 75 grams of Bottom Ash. Another variation is 75 grams of CoMo and 25 grams of Bottom Ash. This catalytic cracking process takes place at a temperature of 150 oC for 1-2 hours.

In this study, the quality of biofuel products resulting from the catalytic cracking process is based on SNI 7182: 2023 standards, which include density, viscosity and flash point. The results of density analysis are calculated using formula (1) and the results of viscosity analysis are calculated using formula (2) as below.

Density is the measurement of mass per unit volume with a certain standard unit of measurement, such as kg/m3. This density calculation is calculated using equation 1.

$$\rho = \frac{m}{v} \tag{1}$$

Where:
X: density (g/cm^3 or kg/m^3)
m: sample mass (g or kg)
v: sample volume (cm^3 or m^3)

Viscosity is an assessment of the immunity of a fluid copied either by demand or stress. More clearly, viscosity is a level of fluid density that can explain the size of a touch in the fluid. Then, if the greater the viscosity in the fluid, it will be more difficult to move and it will also be more difficult for objects to move in the fluid. This viscosity calculation is calculated using equation 2.

$$v = \frac{\mu}{\rho} \tag{2}$$

Where:
v: kinematic viscosity (mm^2/s or cSt)
µ: dynamic viscosity (mPa-s or cP)
ρ: density (g/cm^3)

Flash point is the lowest temperature point at which a fuel can ignite under certain conditions at a pressure of one atmosphere. The determination of flash point is also related to safety in fuel handling storage and is tested using the Pensky Marten Closed tester.

3. Results and Discussion

In this study, the catalytic cracking process was carried out using a set of catalytic cracking tools designed and made by researchers, with the main raw material, namely used cooking oil as much as 2500 ml in 1 time the process of making biofuel. The catalytic cracking process lasts for 1-2 hours with a heating temperature of 150 oC. The results showed that in the variable variation of CoMo 25 grams and Bottom Ash 75 grams of biofuel products obtained as much as 135 ml or 5.04%. In the variable variation of CoMo 75 grams and Bottom Ash 25 grams, the biofuel product obtained was 100 ml or 3.73%.

Table 2. Biofuel Product Yield Data

CoMo/Bottom Ash Catalyst Composite	Volume (ml)	Density (gr/ml)	Viscocity (mm^2/s)	Flash point (°C)
75:25	100	0,9637	2,365	75,8
25:75	135	0,9010	2,361	73

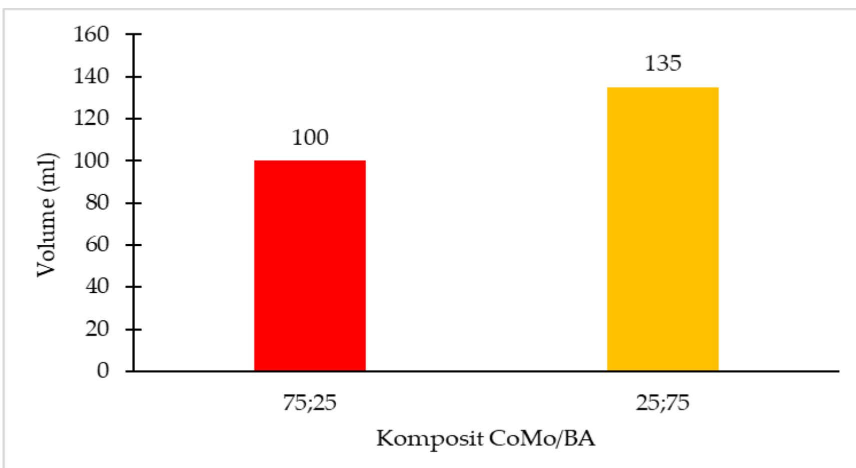

Figure 1. Biofuel Product Volume Chart

Zhang et al (2021) conducted catalytic cracking of used cooking oil with a yield of 55-78% using CoMo/Al2O3 catalyst. Then Silva et al. (2020) also conducted the same research but used a CoMo/Zeolite catalyst with a yield of 68%. And Rodríguez et al. (2023) also conducted the same research but with a different catalyst, namely CoMo/TiO2 with a product yield of 50-75%.

Based on the research that has been done, this study only obtained a biofuel product of 3.73% for the CoMo/bottom ash 75:25 composite variation and for the 25:75 variation obtained a result of 5.04%. This means that the amount of product produced in this study is very small due to the use of bottom ash as a catalyst mixture which before use must be activated first, but the use of bottom ash can be a solution for waste reduction.

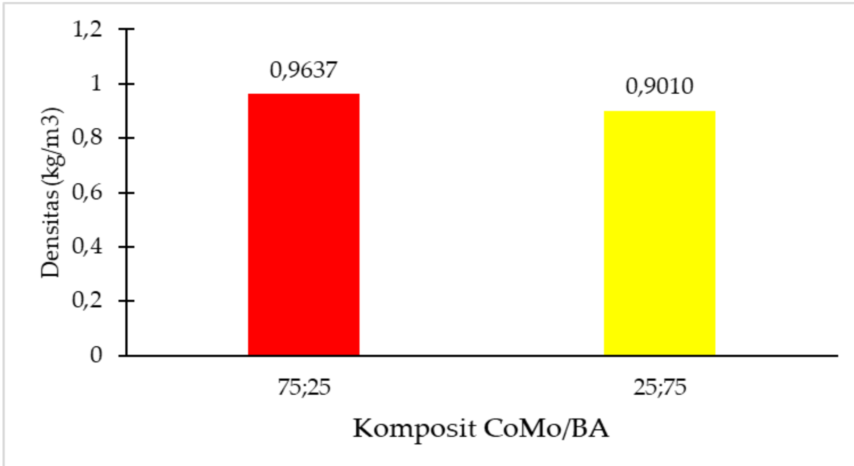

Figure 2. Biofuel Density Chart

In the graph above, it can be seen that the density of biofuel products from both variations meets SNI 7182: 2023 standards, where in the variation of CoMo 75 grams and Bottom Ash 25 grams the density analysis results are 0.9637gr/ml. In the variation of CoMo 25 grams and Bottom Ash 75 grams, the density analysis results are 0.9010 gr / ml. When referring to the SNI 7182: 2023 standard for the best density characteristics, namely the CoMo variation of 25 grams and bottom ash 75 grams, because the density analysis value is 0.9010 gr/ml, which means it is closer to the SNI standard of 0.86-0.90 gr/ml.

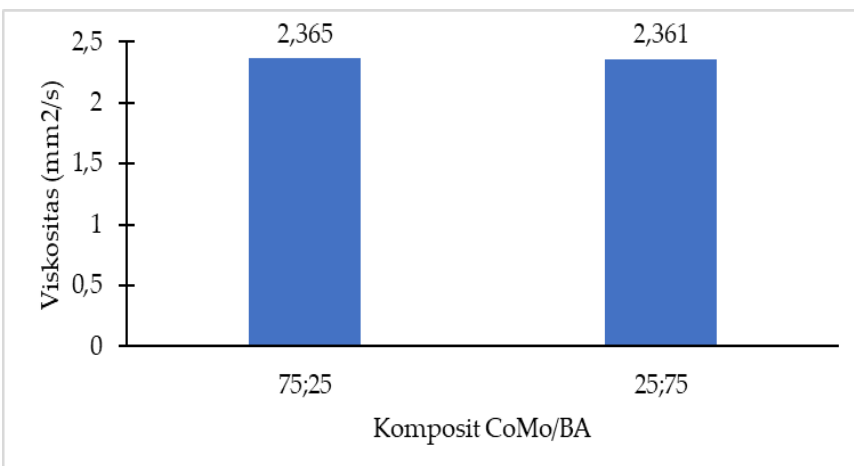

Figure 3. Biofuel Viscosity Chart

In the graph above, it can be seen that the viscosity of biofuel products from both variations meets the SNI 7182: 2023 standard, where in the variation of CoMo 75 grams and Bottom Ash 25 grams the results of the viscosity analysis are worth 2.365 mm2/s. Based on this research, it is found that both composite variations fall within the test parameters based on the SNI 7182: 2023 standard. In the variation of CoMo 25 grams and

Bottom Ash 75 grams, the results of the viscosity analysis are 2.361 mm2/s. Based on the results of this study, it is found that both composite variations are included in the test parameters based on SNI 7182: 2023 standards.

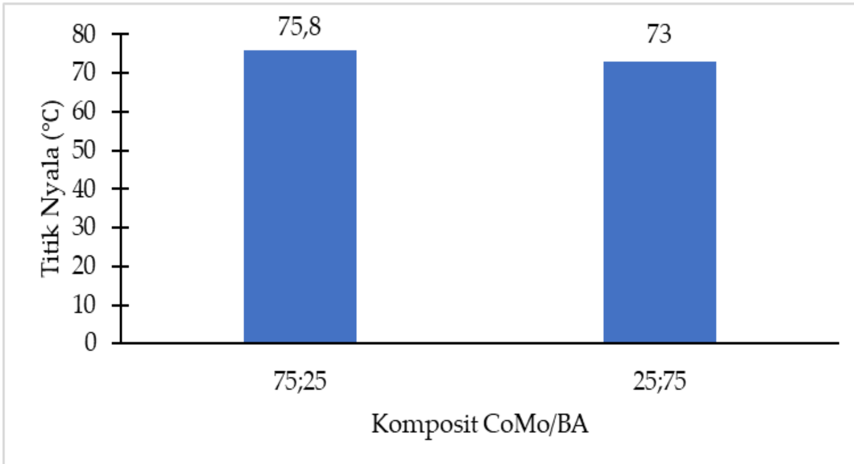

Figure 4. Graph of Flash Point of Biofuel

In the graph above, it can be seen that the flash point of biofuel products from both variations meets SNI 7182: 2023 standards, where in the variation of CoMo 75 grams and Bottom Ash 25 grams the results of the flash point analysis are 75.8 °C. In the variation of CoMo 25 grams and Bottom Ash 75 grams, the flash point analysis result is 73 °C. Based on the results of this study, it is found that the two products do not fall into the SNI 7182: 2023 standard category.

4. Conclusion

Based on the research that has been done, the composition of the catalyst will affect the number of products and characteristics of biofuel from used cooking oil through the catalytic cracking process at 150 °C with CoMo/Bottom Ash catalyst.

The results of the research made that for biofuel characteristics based on SNI 7182: 2023 standards state that in the flash point test parameters the two variations do not meet the standards, in the density test parameters the CoMo/Bottom Ash 75: 25 variation falls into the SNI 7182: 2023 standard category. And based on the viscosity test parameters, both biofuel products have entered the SNI 7182: 2023 standard.

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