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| RESEARCH ARTICLE

The Characterization of Used Cooking Oil as a Raw Material to Produce Biofuel Using CoMo/Bottom Ash with Catalytic Cracking Process

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| ABSTRACT

The research conducted in the study of converting used cooking oil into biofuel is done using the catalytic cracking technology process. Used cooking oil, a byproduct of household cooking oil waste, has the potential to be turned into energy. However, its utilization is not yet optimal, and it often just becomes household waste. Therefore, in this study, used cooking oil is used to produce biofuel. The CoMo/Bottom ash catalyst is used to accelerate the biofuel production process. The characteristics of the used cooking oil were analyzed using the Gas Chromatography-Mass Spectrometry (GC-MS) method, which revealed that the oil contained 2.50% linoleic acid, 0.54% myristic acid, and 22.11% palmitic acid, which are some of the main ingredients for making biofuel. The physical properties of the used cooking oil were found to be a viscosity of 3.81 mPa.s, a density of 0.93 g/ml, a refractive index of 1.43, and a flash point of 241°C. Meanwhile, the characteristics of the coal bottom ash used as a catalyst were analyzed using the X-Ray Fluorescence or X-ray diffraction method. It was found to contain 48.61% silicon dioxide (SiO_2), 13.97% aluminum oxide (Al_2O_3), 4.40% iron (III) oxide (Fe_2O_3), 2.92% calcium oxide (CaO), 0.82% magnesium oxide (MgO), and 0.48% potassium oxide (K_2O). The characteristics of the used cooking oil and the coal bottom ash that were analyzed show that used cooking oil can be used as raw material for biofuel production, while coal bottom ash can be used as a catalyst.

| KEYWORDS

Characteristics of Used Cooking Oil, CoMo Catalyst, Bottom Ash, GC-MS

| ARTICLE INFORMATION

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1. Introduction

Indonesia has a large potential for new renewable energy sources, one of which is biomass. One type of biomass that can be used as a source of energy is waste (Ministry of Energy, 2022). There are many types of waste, such as industrial waste and household waste. In this discussion, the waste that will be discussed is household waste, where these wastes can be utilized for renewable energy. Energy is one of the important components in daily life, where all activities of life require energy. Oil fuel can be used as the most commonly used energy (Alam et al., 2021).

From the problems that occur globally, biofuel is one of the answers and alternatives in fuel that can be produced from vegetable oil (I. Andrianti et al., 2019). One of the vegetable oils that can be used as raw material for biofuel is used cooking oil. Used cooking oil is one of the vegetable oils that are often used repeatedly until its color changes and the quality of the oil decreases (N. Erna et al., 2017). Used cooking oil has a triglyceride structure that also contains long hydrocarbons that can be utilized as a type of vegetable fuel (biofuel) (Febriana et al., 2020) and has properties such as flash point (240–300) ^{o}C, mass density 0.898 kg/L, and viscosity (7 – 30) Pa. s (Hasan et al., 2022). The highest content of fatty acid in used cooking oil is oleic acid ($C_{18}H_{34}O_2$) at 32.19% and palmitic acid ($C_{16}H_{32}O_2$) at 14.94% (Reza Falepi, 2019). To break down the long chain molecules into lower hydrocarbon fractions such as gasoline (C5-C11), a process called cracking is needed.

Cracking is the process of breaking down long hydrocarbon chain molecules into shorter or simpler hydrocarbon molecules. This process aims to obtain more useful compounds. Compounds such as propane, ethane, methane, butane, gasoline, kerosene, and diesel are produced in cracking.

Given a large amount of waste, especially household cooking oil waste, which can be utilized as an alternative renewable energy source, the author is interested in researching the characteristics of used cooking oil as a liquid fuel (biofuel) in the catalytic cracking process.

2. Literature Review

Research on catalytic cracking has been conducted before, including one study (Ritonga et al., 2013) that made biofuels from Palm Fatty Acid Distillate (PFAD) through catalytic cracking using CoMo/Zeolite catalysts with variations of 0%, 0.5%, 1%, 1.5% metal loadings, and temperatures of 360 ℃, 380 ℃, 400 ℃, and 420 ℃. The optimum yield was obtained at 400 ℃ and a CoMo metal loading of 1%, which was 88%; furthermore, (Asyraf Hazzamy et al., 2013) on Making Biofuels from Used Cooking Oil through Catalytic Cracking with Fly Ash Catalysts. In this study, the researcher used a combination of CoMo/Bottom Ash catalysts. The use of cobalt (Co) metal as a catalyst plays a role in increasing the activity, stability, and selectivity of a catalyst. Meanwhile, the use of molybdenum metal is used as an active component in the catalytic cracking process, which can increase the activity and selectivity of a reaction. Considering the stability of the surface area and constant pore volume for the repeated use of catalysts in a reactor, the CoMo catalyst is more active and selective than the NiMo catalyst in hydrodesulfurization reactions. Meanwhile, coal bottom ash has larger particle sizes and is heavier than fly ash. Bottom ash contains a lot of silica, so it can be used as a catalyst. In this discussion, the characteristics of used cooking oil as a fuel combined with CoMo/Bottom Ash catalysts are important in converting biofuel energy. The specifications of the CoMo catalysts are presented in Table 1 as follows:

Table 1. CoMo Catalyst Specifications

Exterior		Blue grey sphere
Size	(mm)	⌀3.0~5.0
CoO%	(m/m)	1.8±0.3
MoO3%	(m/m)	9.5±0.5
Specific surface area	(m2/g)	≥260
Pore volume	(ml/g)	≥0.35
Bulk density	(kg/L)	0.80±0.05
Crushing strength	(N/granula)	≥120
Temperature	(oC)	260~380
Pressure	(MPa)	~0.2
Space velocity		200~1500h-1

Figure 1. CoMo Catalysts

Table 1. shows the specifications of the CoMo catalysts. The CoMo catalysts are made of cobalt metal and molybdenum metal. Cobalt metal is one of the transition metals that can be used as an acid catalyst. Meanwhile, molybdenum metal is a metal that is relatively inert or reacts slightly with acid and alkaline solutions (D. Siswidihardjo, 2006); where the data specifications are obtained directly from Jianxi Xintao Technology Co.LTD and already meet the catalysts standards so that can be used.

3. Methodology

Research Procedures in the implementation of research was carried out in several stages as follows:

3.1 Raw Material Preparation

Used cooking oil was obtained from the production of Pempek Wia Plaju and then filtered. Bottom ash coal was obtained from PT. Bukit Energi Services as 4kg and CoMo catalyst from Jianxi Xintao Technology Co.LTD as 1kg. In this research, preparation was carried out; firstly, the preparation of used cooking oil and then used cooking oil was analyzed for its characteristics in order to determine the components contained in the used cooking oil compound. Secondly, catalysts were prepared; in this case, catalysts are made with a composite of CoMo and bottom ash coal so that a composition ratio is carried out here, namely the composition of 100:0, 75:25, 50:50, 25:75, and 0:100. Then finally, the characteristics of coal ash catalysts, with the aim of seeing the components contained in coal ash, so analysis is carried out using the X-Ray Fluorescence (XRF) method.

3.2 Characteristics Analysis of Raw Material

Used Cooking oil is initially tested using Gas Chromatography Mass Spectrometry. Subsequently, flash point, viscosity, density and bias index analysis were performed on the raw material of waste oil. Bottom ash coal is initially tested with X-Ray Fluorescence (XRF) to find out what compounds are contained in the bottom ash coal.

4. Results and Discussion

4.1 Testing Analysis of Used Cooking Oil Raw Material

The characteristics of used cooking oil raw material in the catalytic cracking process can be seen in Table 2 and Figure 2.

Table 2. Testing Analysis of Used Cooking Oil Raw Material

No	Parameter	Result
1	Flash Point (°C)	241
2	Density (gr/ml)	0,93
3	Viscosity (mPa.s)	3,81
4	Refractive Index	1,43

Figure 2. Used Cooking Oil Sample

Table 2. presents the findings of the study on the properties of used cooking oil. The results indicated that the oil had a flash point of 241 °C, a density of 0.93 gr/ml, a viscosity of 3.81 mPa/s, and a Refractive index of 1.43. Other studies on the density of cooking oil by (Reza, 2019), (Endang et al., 2015), (Andrianus et al., 2013), and (Rusdianasari et al., 2019) yielded values of 0.9071 gr/ml, 0.8896 gr/ml, 0.8957 gr/ml, and 0.9191 gr/ml, respectively. These findings suggested that used cooking oil could potentially serve as a suitable raw material for producing biofuel through the process of catalytic cracking.

4.2 XRF Analysis of Coal Bottom Ash

The XRF analysis testing of coal bottom ash can be seen in the table below.

Table 3. Testing of Coal Bottom Ash

No	Parameter	Result (%)
1	Silicon Dioxside (SiO_2)	48.61
2	Aluminium Oxide (Al_2O_3)	13.97
3	Iron (III) Oxide (Fe_2O_3)	4.40
4	Calcium Oxide (CaO)	2.92
5	Magnesium Oxide (MgO)	0.82
6	Potassium Oxide (K_2O)	0.48

Figure 3. Bottom Ash of Coal Used

Table 3. Showed the results of testing between the parameters SiO_2, Al2O3, Fe_2O_3, CaO, MgO, and K_2O and the results obtained using the X-Ray Fluorescence or X-ray diffraction method, which was the main method for identifying catalyst components. The results were a composition of silicon dioxide (SiO_2) at 48.61%, Aluminum Oxide (Al_2O_3) at 13.97%, Iron (III) Oxide (Fe_2O_3) at 4.40%, Calcium Oxide (CaO) at 2.91%, Magnesium Oxide (MgO) of 0.82% and Potassium Oxide (K_2O) of 0.48%. From the results of the test, it was found that the SiO_2 parameter had higher test results. For bottom ash, it must be rich in silica, calcium, aluminium and high iron content; this became the consideration for use as a catalyst. The higher the value of silicon dioxide (SiO_2), the better it was for use as a catalyst (R.N Hayni et al., 2020).

4.3 Gas Chromatography Mass Spectrometry Analysis Results

The Gas Chromatography Mass Spectrometry test is a chemical compound analysis with a liquid sample that is injected into an injector and then vaporized. The vaporized sample is carried by the carrier gas to the column for the separation process (Adhani et al., 2020). The results of the Gas Chromatography Mass Spectrometry Analysis can be seen in Fig. 4 as follows:

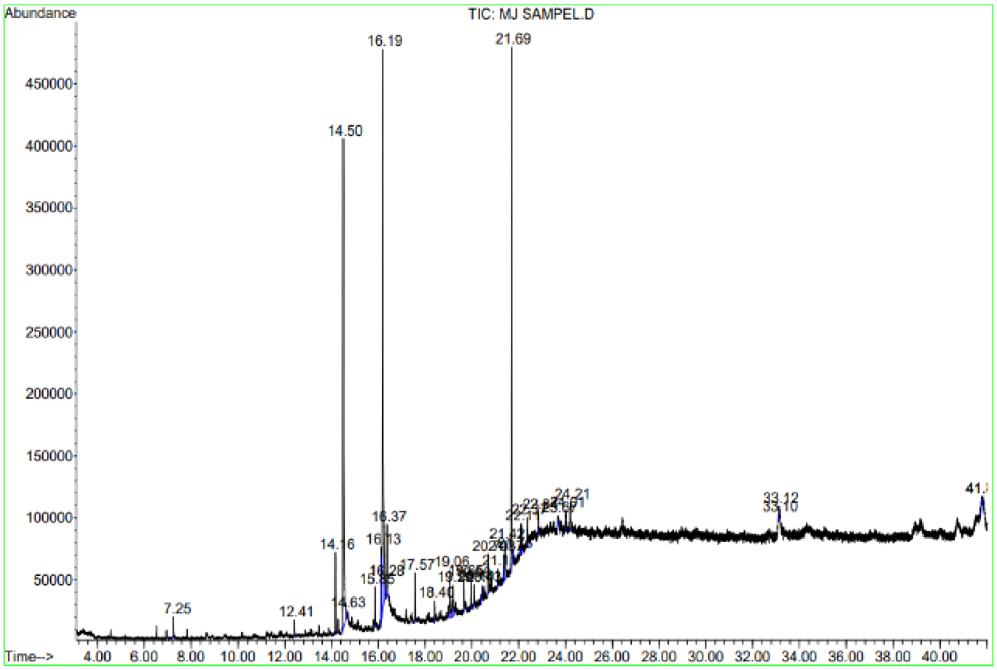

Figure 4. GCMS Used Cooking Oil

Fig. 4 shows the results of the peaks of the composition of used cooking oil chromatography. It could be seen that the number of components reached 34 components, which could be indicated by the formation of 34 peaks (Wulandari et al., 2022). From the GCMS analysis, the highest fatty acid composition was palmitic acid, which was 22.11%. The result showed that the high palmitic acid content was the basis for considering it as a raw material in the research of catalytic cracking of waste oil as a fuel because it had a long hydrocarbon chain.

5. Conclusion

Based on the conducted research, the characteristics of the obtained used cooking oil were found to have the potential to be converted into fuel, while the obtained bottom ash catalyst also showed potential for conversion into a catalyst. The characteristics of the raw material, in the form of used cooking oil, were examined through GC-MS analysis, revealing the presence of linoleic acid, myristic acid, elaidic acid, and palmitic acid, with an abundance of 22.11%, among others. Thus, it could be used as a raw material in the investigation of catalytic cracking of used cooking oil as a fuel because it had long hydrocarbon chains that allowed it to be utilized as a vegetable-based fuel (biofuel). The analysis of the characteristics of coal bottom ash indicated the presence of silicon dioxide (SiO_2) at a concentration of 48.61%, aluminium oxide (Al_2O_3) at 13.97%, iron (III) oxide (Fe_2O_3) at 4.40%, calcium oxide (CaO) at 2.91%, magnesium oxide (Mgo) at 0.82%, and potassium oxide (K_2O) at 0.48%. The analysis of the bottom ash further showed that the highest concentration was found in silicon dioxide (SiO_2) at 48.61%. To obtain optimal results, it was recommended to subject the raw material of used cooking oil to a pretreatment process before converting it into fuel. This pretreatment process aimed to reduce free fatty acid, impurities, and moisture content by using a filtration method.

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