

## Synthesis of Hydrocarbon Through Pyrolysis of Used Lubricant with CaO

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### ABSTRACT

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The processing of used lubricants by pyrolysis with CaO was carried out. Pyrolysis was carried out at 375°C using a glass reactor. The effect of pyrolysis time and the addition of CaO on the pyrolysis of used lubricants was investigated. A SimDis (Simulated Distillation) analyzer is used to analyze the hydrocarbons of the pyrolysis products, while AAS is used to analyze the metal content. The results show that the addition of CaO to lubricating oil has an effect on increasing the yield, reducing the density, reducing the specific gravity, reducing the viscosity, reducing the metal content, reducing the acid number and increasing the recovery of the diesel/petrol content in hydrocarbons. The longer time during the pyrolysis process affects higher yield, higher density, higher specific gravity, higher viscosity, lower metal content and lower acid number. The results of the hydrocarbons obtained are 3 components, namely gasoline, aviation fuel and diesel. The dominant products of pyrolysis of used lubricants without CaO are diesel-type hydrocarbons (44.4%) and gasoline-type hydrocarbons with CaO (45.9%). The best results were obtained for waste oil samples with the addition of CaO, giving a yield of 72%, a density of 858.8 kg/m<sup>3</sup>, a specific gravity of 0.86, a viscosity of 17.01 cStokes, a Pb metal content of 0.522 mg/L and a Cu metal content of 0.292 mg/L. L, acid number 1.08 mg KOH/g, Simdis 44.38% diesel.

**Keywords:** pyrolysis, lubricant, hydrocarbon, calcium oxide

## 1. INTRODUCTION

Lubricant is a type of sticky liquid that acts as a lubricant, protector, and cleaner, preventing conflict between the metal in the machine and the base [1]. Lubricants are usually obtained by handling petroleum, which is supported by a step-by-step distillation process of its boiling point [2]. Used lubricating oils contain heavy metals (e.g. Cr, Cd, As, and Pb) and harmful chemical compounds such as polynuclear aromatic hydrocarbons, benzene, chlorinated solvents, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs)[3].

Even today, the use of used lubricants by the local population is not optimal, especially for use as fuel. D3 waste is a very dangerous waste because it is destructive, flammable, hazardous, susceptible, hazardous, cause illness, and aggravation, is mutagenic and radioactive [4].

The use of lubricants as fuel requires earlier handling so that good quality fuel can be obtained, especially in terms of ease of ignition and

combustion temperature. The aim of this research is to utilize used lubricants into diesel fuel.

## 2. MATERIALS AND METHODS

### 2.1 Materials and Experimental procedure

The materials used in this study were waste lubricating oil, CaO, KOH and ethanol. The pyrolysis was carried out in a glass reactor with a volume of 500 ml equipped with a water cooler and a product container. The experimental procedure was carried out by adding 50 mL of used lubricant to the reactor and then adding CaO 2%-b to the reactor. Then heat the mixture to 370°C and hold it at this temperature for 30, 45 and 55 minutes. The product gas is condensed and tamped in a container. The yield of the hydrocarbon products formed is then calculated and analyzed

## 2.2 Methods of Analysis

### 2.2.1 Analysis of yield hydrocarbon

Biohydrocarbon yield is calculated by dividing the total product weight by the lubricant feed used. Calculations are described more clearly in the equation (1).

$$\text{Yield} = \frac{\text{Product (g)}}{\text{Used lubricant (g)}} \times 100\% \dots\dots\dots(1)$$

### 2.2.2 hidrokarbon Analysis

The hydrocarbon analysis was carried out using the SimDis (Simulated Distillation) analyzer. A SimDis report provides valuable information about the boiling point distribution of crude oils and petroleum raw materials. This information is critical for refinery engineers to determine the most efficient way to operate and control the distillation process. Therefore, a good, robust and reliable SimDis analyzer is an essential tool for the optimal (and economical) operation of a refinery plant.

### 2.2.3 Analysis of Density, viscosity, and specific gravity

Hydrocarbon products were analyzed for density, viscosity and specific gravity using a picnometer and viscometer respectively.

### 2.2.4 Analysis of acid value

The acid number indicates the same free fat content in the sample. This analysis was performed using the standard test D8045

## 3. RESULTS AND DISCUSSION

### 3.1. Effect of adding CaO on pyrolysis products

According to previous study [5], CaO serves to break chemical chains so that non-flammable substances are separated. Combustibles form new chemical chains, making them better when used as fuel by reducing the sulfur content in the fuel. In addition, the addition of CaO also serves to reduce the sulfur content. Pyrolysis of used lubricants with and without CaO was carried out at 370 °C for 55 minutes.

Figure 1 shows that the yield of pyrolysis products with the addition of CaO (71.7%) is higher than without CaO (64.5%). It is possible that CaO played a role in absorbing impurities in used lubricants, resulting in more volatile hydrocarbon and non-hydrocarbon products. In addition, the obtained pyrolysis products were analyzed using SimDis.

Figure 2a shows that the pyrolysis product of used lubricants consists of 2 parts, namely hydrocarbons and non-hydrocarbons. According to [6], it contains heavy metals (e.g. Cr, Cd, As and Pb) and harmful chemical compounds such as polynuclear aromatic hydrocarbons, benzene, chlorinated solvents, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). According to the literature, the non-hydrocarbon residual components are heavy metals. This fact is supported by the results of the AAS analysis, which showed the detection of several metals. Pyrolysis products with CaO produce higher hydrocarbons than without CaO. This can be explained by the fact that impurities and non-hydrocarbon compounds were adsorbed on CaO. Figure 2b shows the progression of hydrocarbon content based on the number of carbon atoms. The figure shows that the pyrolysis of used lubricants with CaO produces a predominantly gasoline-equivalent hydrocarbon fraction (45.9%). This phenomenon indicates that the use of CaO increases the cracking reaction of long-chain hydrocarbons. This makes sense because according to Arpa, O (2009) this CaO plays a role in breaking the hydrocarbon chain. On the other hand, the pyrolysis of used lubricants without CaO produces a predominantly diesel-equivalent hydrocarbon product. Simdis analysis results indicate that when the desired product is mainly gasoline, pyrolysis uses CaO, while for diesel fuel, pyrolysis occurs without CaO. The effect of adding CaO on the pyrolysis of used lubricants can also be shown in the metal content of the pieolysis products shown in Figure 3.

The metal contents observed in the pyrolysis product of used lubricants are Cu and Pb metals. Figure 3 shows that pyrolysis of used lubricants reduced Cu metal content more (Fig. 3 a) than Cu metal content (Fig. 3 a). Meanwhile, the addition of CaO to pyrolysis reduced the content of the two metals relatively insignificantly by about 2 points. Referring to Fig. 2, where pyrolysis with CaO produces higher hydrocarbon products, this suggests that CaO absorbs relatively more non-metallic impurities.

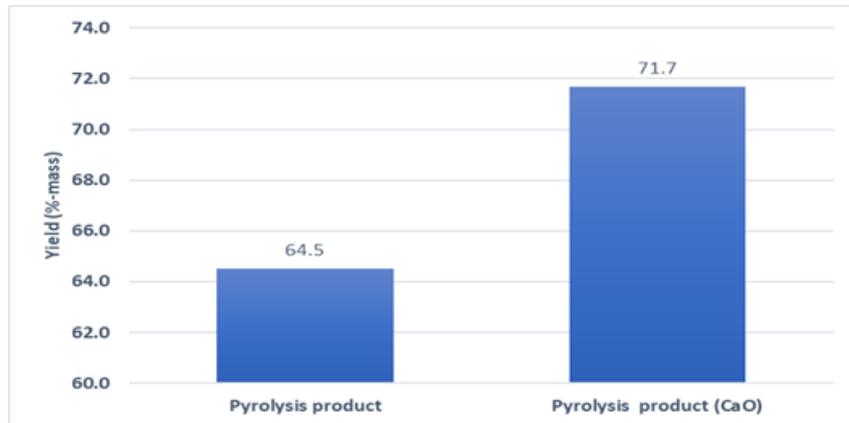


Figure 1. Yield of pyrolysis product with and without CaO

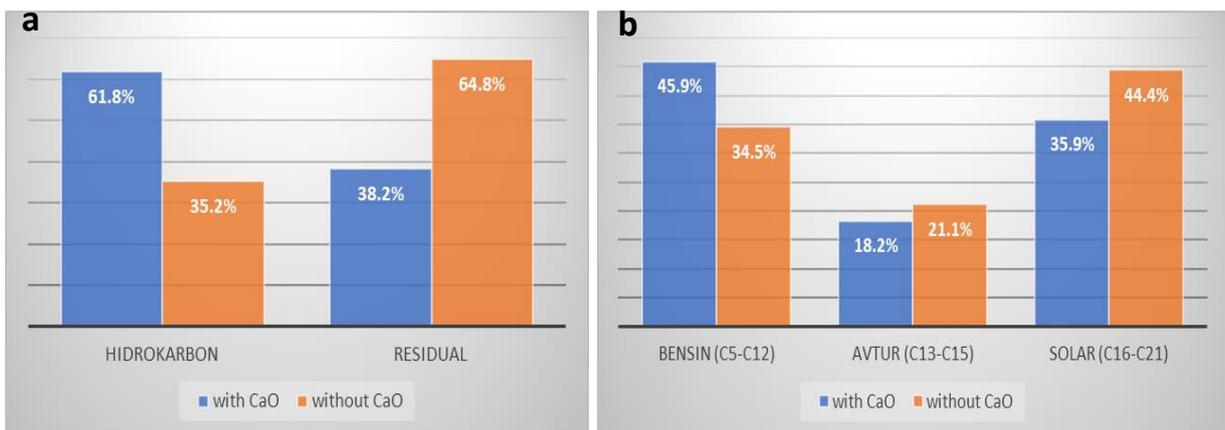


Figure 2. SimDis analysis result; a) component composition; b) hydrocarbon composition

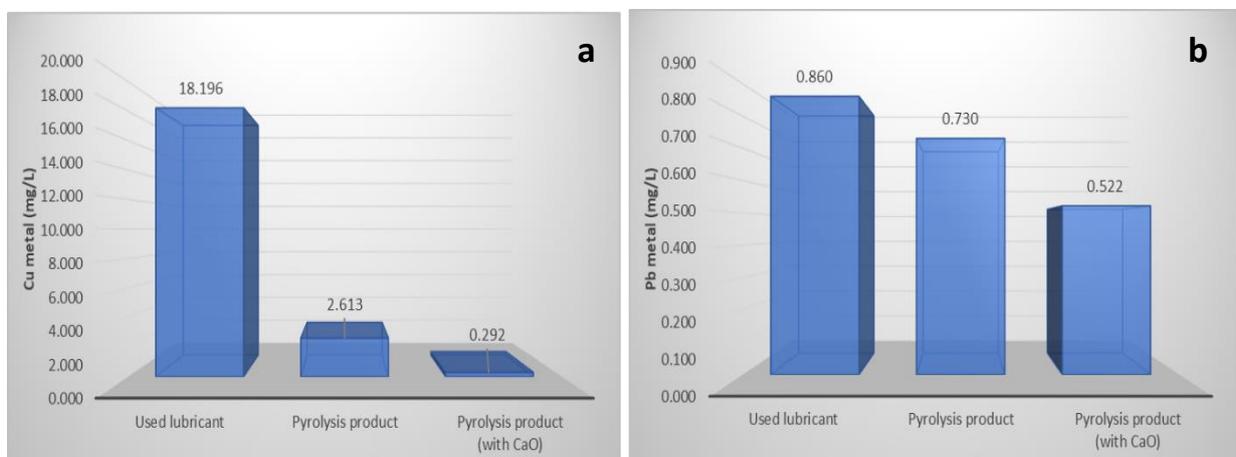


Figure 3. Metal content: a) Cu metal; b) Pb metal

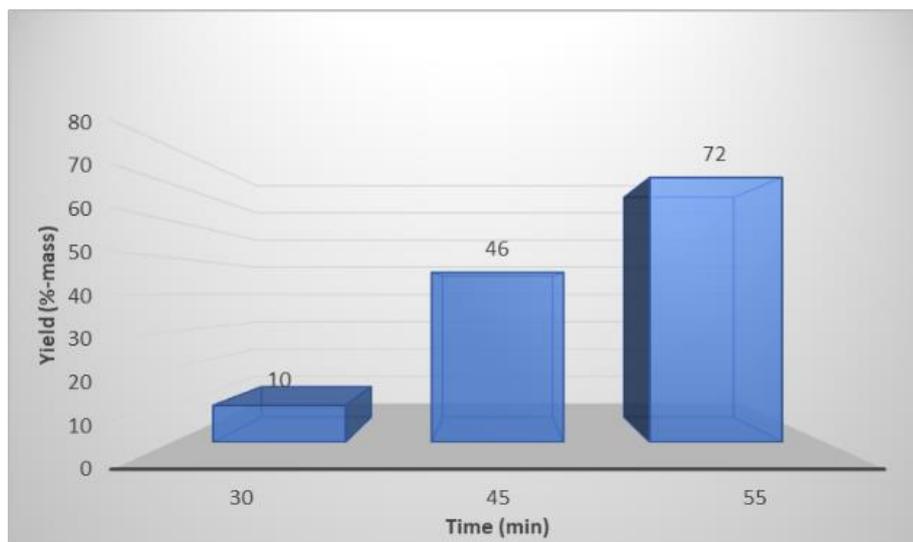


Figure 4. Effect of time on pyrolysis product

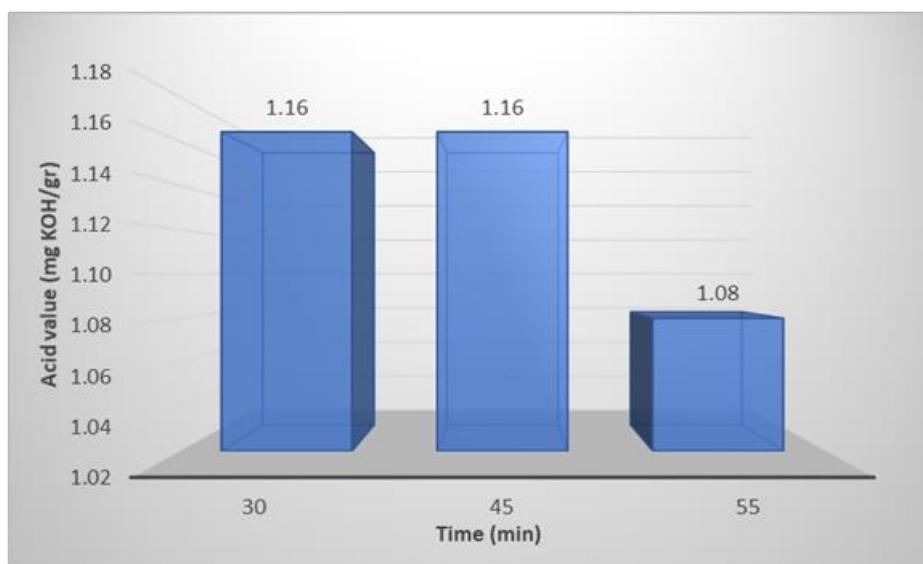


Figure 5. Effect of time on acid value

Table 1 Characteristics of pyrolysis product hydrocarbons

| Characteristic               | Oil sample | Pyrolysis Product | Pyrolysis Product CaO) |
|------------------------------|------------|-------------------|------------------------|
| Density (kg/m <sup>3</sup> ) | 909.3      | 836.1             | 858.8                  |
| Viscosity (cPoise)           | 87.22      | 16.28             | 17.01                  |
| Spesific gravity             | 0.91       | 0.84              | 0.86                   |

### 3.2. Effect of time on pyrolysis product

Investigation of the effect of pyrolysis time of used lubricants on the resulting product has been carried out by pyrolysis for 30, 45 and 55 minutes at 280°C. Obtaining pyrolysis products at various times is presented in Figure 4.

Figure 4 shows that the longer the pyrolysis time, the higher the product yield. The highest pyrolysis product yield was 72% with a pyrolysis time of 55 minutes. higher than previous studies of 60% (Arpa, 2010). This fact was due to the fact that in its research Arpa performed a one-hour pyrolysis of used lubricants in a stainless-steel reactor at 330 °C, while in this study a glass reactor was used. The influence of pyrolysis time on the acid number is shown in Figure 5.

Figure 5 shows that pyrolysis of waste oil over 30 to 45 years was unable to reduce the acid number in the pyrolysis product from 1.16 mg KOH/gram of sample. Furthermore, after 55 minutes of pyrolysis, the acid number decreased until it reached 1.08 mg KOH/gram of sample. The acid number indicates the number of free acid numbers in the pyrolysis product. The decrease in acid number that occurred during 55 min of pyrolysis suggested that a decarboxylation reaction of fatty acids to hydrocarbons occurred under these conditions. This is supported by the results of the SimDis analysis in Figure 2: The 55-minute pyrolysis of used lubricants with and without CaO creates a composition of gasoline and diesel.

The characterization of the hydrocarbons produced by pyrolysis includes density, viscosity and specific gravity. Table 1 shows that pyrolysis of used lubricants with and without CaO resulted in a decrease in density, viscosity and specific gravity values. The trend of fuel type in pyrolysis products cannot be determined. This is because the pyrolysis products were not separated at the boiling point of each fuel.

### 4. CONCLUSION

Hydrocarbon products have been successfully produced by pyrolysis of used lubricants. The highest yield of pyrolysis products (hydrocarbons) was achieved in pyrolysis with the addition of CaO at 71.1%. The dominant products of pyrolysis of used lubricants without CaO are diesel-type hydrocarbons (44.4%) and gasoline-type hydrocarbons with CaO (45.9%). The pyrolysis

treatment of used lubricants produces hydrocarbons that have a lower density, viscosity and specific gravity compared to used lubricants.

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### CONFLICT OF INTEREST

No conflict of interest was reported by the author(s).

### CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

**Endar Puspawiningtyas:** Conceptualization, Methodology, Investigation, Formal analysis, Writing-original draft, Supervision

**Endar Puspawiningtyas:** Data curation, Formal analysis, Investigation

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