Ecotrends: Journal of Recent Environmental Issues
Vol 01 Issue 01 (2025), e-ISSN XXXXXX, DOI:XXXXXXXXXXXX

Original Research article

Conversion of Plastic Waste to Oil by Pyrolysis Method as Alternative Fuel

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Article history: **Received** July 04, 2024 | **Revised** August 07, 2024 | **Accepted** February 04, 2025

ABSTRACT

This research title is conversion of plastic waste to oil by pyrolysis method as alternative fuel. The aim of this research are to give solutions to the government in overcoming the plastic waste problem in Indonesia, especially to Bank Sampah Mekar Sari in Mojosongo, Jebres, Surakarta and as an alternative fuel to petroleum fuel. The method ware used in this study is the pyrolysis method with LPJ gas as a source of heat energy. To convert 3 kg of plastic waste into oil by the pyrolysis method it takes 150 minutes (2.5 hours). The plastic waste was taken from the plastic waste collection place at Citra Plastik in Surakarta. Oil products ware determined the density and the compound content by Gas Chromatography-Mass Spectrometry (GC-MS). heat energy requirements and efficiency of the pyrolysis method in the conversion of plastic waste to oil respectively were 614.8 kJ/minute and 83.3%. according to the value GCMS spectra, 92.8% of the compounds contained in the oil was entered the retention time range in pertalite.

Keyword: Pyrolysis; plastic waste; oil; and alternative fuel

1. INTRODUCTION

The use of plastic is so massive that it is used in this modern era. Its waterproof, strong, and elastic properties make it the preferred material for the wider community in everyday life. Based on data from the Ministry of Environment and Forestry (KLHK), the amount of plastic waste are 17.1% of total waste per year, which is 5 million tons. A large amount of plastic waste is certainly worrying due to the nature of plastic that is not easily decomposed, so it can pollute the environment. Usually, people solve the problem of plastic waste by burning it, resulting in hydrogen sulfide (H_2S) gas which is toxic to humans and the environment. Another treatment method is recycling waste. However, this method is less effective, because the recycled waste will only turn into new products. If this new product loses its function, it will become plastic waste again. Therefore, another more effective method is needed to deal with plastic waste, namely the pyrolysis method (Endang et al., 2016).

Pyrolysis is a method of thermochemical decomposition of substances such as plastic waste at high temperatures in an inert deoxygenated environment (Verma et al., 2019). Plastics consisting of long-chain polymers can decompose into short-chain compounds due

to heating. This plastic decomposition can produce a liquid product that can be used as fuel. In addition to being useful for waste processing, the fuel produced can be an alternative fuel, especially because petroleum resources are dwindling and the price is getting more expensive (Thahir & Alwathan, 2014).

Pyrolysis oil from polypropylene plastic waste is obtained from the pyrolysis process at a temperature of 400^{o}C. The density value of PP plastic pyrolysis results is close to the density value of kerosene and diesel. The viscosity value of the PP pyrolysis oil is close to the gasoline viscosity value (Endang et al., 2016). Research by (Ahmad et al., 2015) stated that the highest total conversion of PP waste was achieved at a temperature of 300 °C at 98.66. This study aims to determine the ability of processing plastic waste into fuel oil.

2. MATERIALS AND METHOD

2.1. Materials

The main materials used in this study were plastic waste (the type is Polypropylene), pyrolysis reactor, condensor, stove, LPG gas, product container, water, and ice. analytic neraca, and Gas Chromatography Mass Spektrometry (GC-MS).

2.2. Pyrolysis of Plastic Waste

Preparation of raw materials for the type polypropylene plastic waste. The pyrolysis method used refers to previous research by Endang et al 2016 (Endang et al., 2016). The preparations include cleaning, drying, and enumerating plastic waste. 3 kilograms of polypropylene plastic waste was added to the pyrolysis reactor (Figure 1), then the reactor was heated with a heat source from LPJ gas. the plastic waste pyrolysis process was carried for 150 minutes. The pyrolysis oil was analyzed for its density and compound content. analysis of oil density was done by pycnometre. Analysis of the compounds content of oil resulting from pyrolysis was done by Gas Chromatography-Mass Spectrometry.

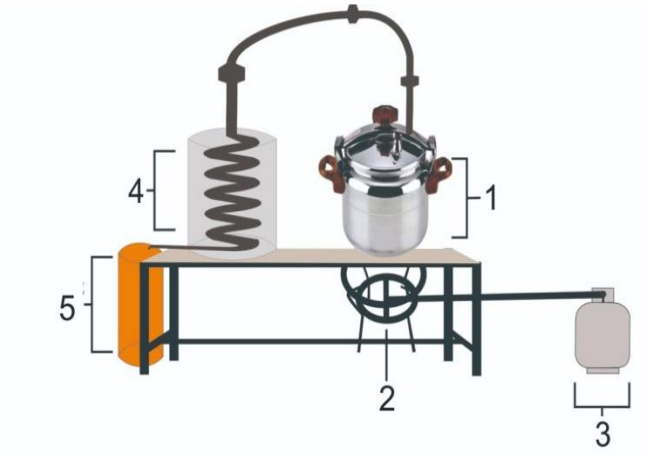

Figure 1. Schema of pyrolysis process

The parts of pyrolysis process:

1. Reactor pyrolysis
2. Gas stove
3. Liquefied petroleum gas (LPJ)
4. Condenser
5. Product container

3. RESULTS AND DISCUSSION

3.1. Comparison of Oil Product and Residual

The plastic waste pyrolysis process produces oil (Figure 3) in the product container and residue (Figure 4) in the pyrolysis reactor, with values of 2.45 kg and 0.43 respectively. as shown in Figure 2

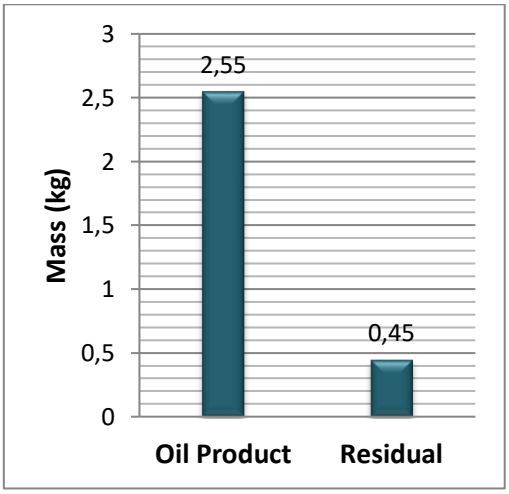

Figure 2. Graph Comparison of Oil Product and Residual

Figure 3. Oil Product

Figure 4. Residue

3.2. Efficiency of Pyrolysis method

Efficiency of Pyrolysis method is a comparison of the performance of pyrolysis in producing oil to the plastic waste used, efficiency of pyrolysis method was determined using Equation 1 (LA ODE MOHAMMAD FIRMAN et al., 2019)

$$\eta = \frac{Feed\ weight - Residual\ feed\ weight}{Feed\ weight} \quad \text{.....1}$$

$$\eta = \frac{3\ kg - 0{,}45\ kg}{3\ kg} \text{ x } 100\% = 85\ \%$$

Based on Equation 1 the pyrolysis efficiency to convert plastic waste to oil was obtained 83.3%

3.3. Heat Energy of Pyrolysis Plastic Waste

The amount of energy needed during the pyrolysis process to conversi of 3 kg polypropylene (PP) plastic to oil with an LHY LPG value of 46,110 j/g, the mass of LPJ gas was used 2 kg (2000 g), and the time of pyrolysis process was 150 minutes was calculated based on equation 2(La, Ode).

$$\text{Stove energy} = \frac{Mass\ x\ LHV\ LPG}{Time} \quad \text{..... 2}$$

$$\text{Stove energy} = \frac{2000\ x\ 46.110 j/g}{150} = 614.8\ \text{kJ/minute}$$

Based on Equation 2 the energy requirement to convert 3 kg of plactic waste to oil was obtained 614.8 kJ/minute.

3.4. Gas Chromatography Mass Spektrometry Analysis

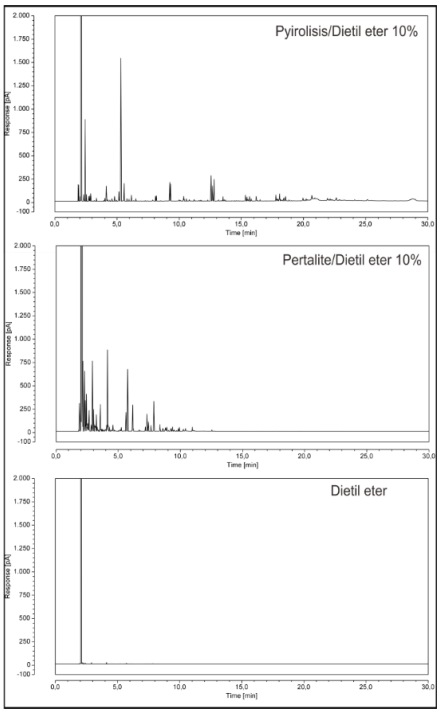

Figure 5. GCMS spectra profile pyrolysis/dietil eter 10%; pertalite/dietil eter 10%; and dietil eter

GCMS analysis was used to determine the compounds content of oil. According to Fiqure 4, the GCMS spectra of pyrolysis and pertalite showed the same GCMS patterns. This shows that the compounds contained in the oil such as pertalite compounds. according to the value GCMS spectra, 92.8% of the compounds contained in the oil was entered the retention time range in pertalite.

4. CONCLUSION

Conversion of plastic waste by pyrolysis method had been successful. the pyrolysis efficiency to convert plastic waste to oil was 83.3%. the heat energy requirement to convert 3 kg of plastic waste to oil was obtained 614.8 kJ/minute. 92.8% of the compounds contained in the oil was entered the retention time range in pertalite.

ACKNOWLEDGMENT

Thanks had given supporting in this research.

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