

## Study of The Effect of Zeolite Catalyst Use on Renewable Energy Products from HDPE Plastic Pyrolysis

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### Abstract

Nowadays, waste is a serious problem, especially plastic waste, which is quite alarming in the world. Plastic is waste that is difficult to degrade and takes hundreds of years to decompose. One of the promising technologies for recycling plastics is pyrolysis. This is the process of breaking long chains of polymers into hydrocarbons which are carried out at high temperatures. The purpose of this paper was to know the effect of using catalysts and non-catalysts on yield and calorific value. In this study, the pyrolysis process used a natural zeolite catalyst with a temperature of 500°C. 50 grams of HDPE Plastic feed was put into the reactor for 3 hours. The variations in the addition of Zeolite catalyst were 1.5, 2.5, 3.75 and 5%wt. The results goals that the highest yield was 44.36% and the heating value of 10230.295 cal/g for the addition of 5 grams of catalyst. The addition of a catalyst can increase the conversion of plastic to fuel

**Keywords:** *Catalyst, Plastic, HDPE, energy, pyrolysis*

### 1. 1. Preliminary Study Overview

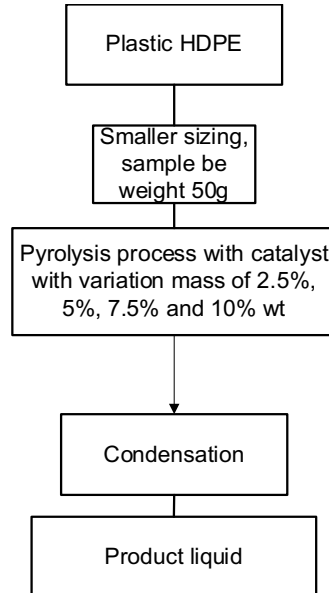
Plastics are a type of macromolecule formed by the polymerization process, which is the combination of several simple molecules (monomers) through a chemical process into large molecules called polymers [1]. This plastic waste is difficult to break down by bacteria and microorganisms. Therefore, recycling is one step that can be done so that it is not environmentally friendly. As an illustration, plastic bag waste if dumped into the ground takes about 1000 years for this waste to be degraded and degraded by microorganisms [2].

Pyrolysis appears to be an awesome technique for converting plastic waste into more useful materials such as Natural Gas or Oil Fuel even into high-value feedstocks for the industry. Pyrolysis is a substantial technique in which polymers are converted into liquid oil, charcoal and gases at high temperatures though thermal decomposition [3-5]. Catalysts can be very beneficial in this process during the cracking of long polymer chains. Some product of the catalytic pyrolysis of plastic such as diesel and gasoline [6]. A range of catalysts have been utilized, including Red Mud [7], FCC [8], ZSM-5 [7], HZSM-5 [9], Y Zeolite [10], Fe<sub>2</sub>O<sub>3</sub> [11], Al<sub>2</sub>O<sub>3</sub>, CA(OH)<sub>2</sub> [12], and natural zeolite [13], in catalytic pyrolysis to improve the quality of liquid oil. Zeolites and mesoporous are the most frequently used catalysts materials because of their porous structure. A number of acid porous solids, such as amorphous materials is used in some study case of polyolefin catalytic cracking like HDPE. The used catalysts have high conversion effect over the plastic waste at lower temperature and decrease the activation energy [14]. Many researchers investigate the catalytic degradation of polymer wastes in last year ago. Catalyst more benefit by added in many sample to modify the products.

From this research, it encourages us to research the pyrolysis catalytic method of HDPE type plastic waste with natural zeolite catalysts to determine its effect on yield and calorific value so that this research is feasible. It is hoped that this research can reduce the abundant plastic waste.

## 2. Research Method

Part of the second challenge about this study used in analyzing the effects of pyrolysis are problem identification, variables is used and arrange of instrument, experimental setup, and analysis and discussion in depth about implemented of catalysts.



**Figure 1. Flowchart of Experimental Oriented**

### 2.1. Experimental Setup

At this section, facts are found that an interest process about the pyrolysis conditions of HDPE-based plastic waste, both in terms of yield and calorific value aspects related to reactor performance using Zeolite catalysts. From the findings on the HDPE plastic problem, we made a comparison between the yield and calorific value produced from HDPE which has been managed by the reactor and produces liquid. With the variants between the existing and ideal conditions, a problem formulation will be made based on the research.

#### 2.1.1. Variable identification

The research variables are the variations used in the pyrolysis process: Fixed Variable (a) HDPE plastic mass (50g), (b) Nitrogen Pressure: 1 kg / cm<sup>3</sup>; Independent variable addition of natural zeolite catalyst mass (1.5%, 2.5%, 3.75% and 5% wt).

#### 2.1.2. Experimental Setup

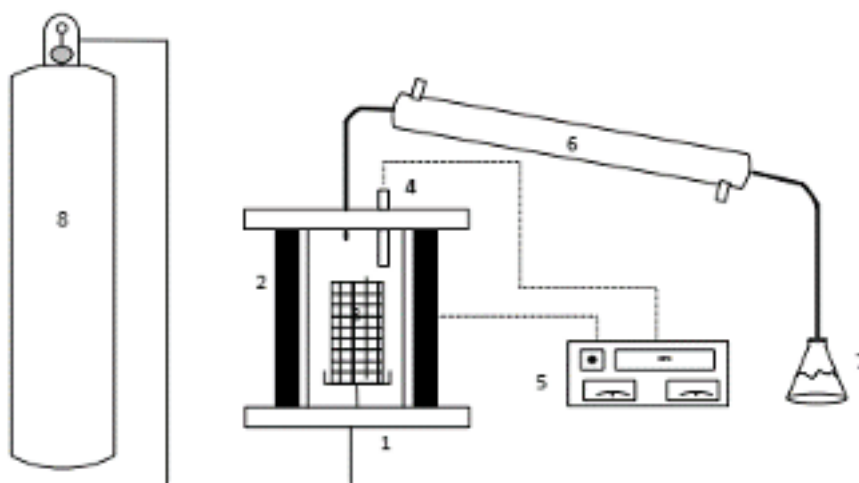
All of the catalytic degradation experiments of polyolefin mixed waste (RW) were applied in a stainless-steel semi-batch reactor with 500 mL volume equipped with a temperature measurement system. Some plastic from HDPE waste mixed with catalyst is fed into the reactor. The reaction system is shut down at P atm and then the heater is turned on. The pyrolysis was started from 18°C to a maximum of 550°C for about three hours.

The pyrolysis experiments were conducted base on dynamic process using a heating rate of 10°C / min and a different time set by the temperature program. Temperature handled using a PID temperature controller (Unitronics V570). The vaporized product from the reactor is accumulate through a stainless pipe in that it reaches the base of the reactor then is released into the condenser system to condense the condensation of the product. The condensing vapor from the reactor is cooling down by the condenser were connected to the reactor. The dynamics of the pyrolysis process are controlled by time measuring the volume of oil collected. The liquid product received is accumulated into a condenser and then

discussed. Most of the condensable product is accumulate in the first condenser. Based on the operating conditions, sometimes condensate is observed in the second condenser. The viscous liquid product appears above 410°C.

**Tabel 1. Pyrolysis reactor specifications**

Parameter	Value
Heating tank (height)	370 mm
Heating tank (diameter)	300 mm
Catalytic chamber (height)	250 mm
Catalytic chamber (diameter)	175 mm
Reactor (total capacity)	25 L
Catalytic chamber (total capacity)	1.5 L
Condenser (length)	870 mm
Condenser (diameter)	145 mm
Temperature (maximum)	500° C



**Figure 2. Flowchart of Experimental Oriented**

Image name (1) Reactor pyrolysis, (2) Electrival heater, (3) Sample placed, (4) Thermocouple, (5) Controlling instrument, (6) Condenser, (7) Liquid placed, (8) Nitrogen tube



**Figure 3. Flowchart of Experimental Oriented**

### 3. Result and Discussion

Pyrolysis of High-Density Polyethylene (HDPE) plastic is conducted in a semi-batch reactor made of stainless steel at a certain temperature using a counter flow condenser cooler. Pyrolysis was carried out with a residence time of 3 hours. The raw material used is a plastic bottle cap, after heating in the reactor at a certain temperature (according to variables) it will be decomposed into a gas which can condense into a liquid. The pyrolysis process starts at a temperature of 500-650°C suppose to know the effect of temperature on the liquid yield, heating value and the fraction formed.

The effect of adding a catalyst on the liquid yield of pyrolysis products

Figure 4 shows that the liquid yield from pyrolysis increases with the increase in the amount of catalyst that is inserted. The highest yield value of HDPE plastic was obtained at 44.3% with the addition of 5 grams of catalyst.

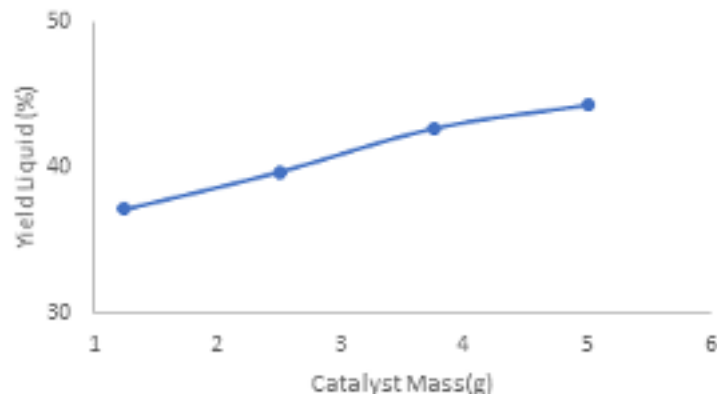


Figure 4. Influences addition of catalysts vs yield liquid products pyrolysis product HDPE

Reformed catalysts show a double effect. Whilst acidic sites accelerate the isomerization reaction, metallic sites accelerate the hydrogenation and dehydrogenation reaction [18]. Furthermore, the technique of these reformed catalysts will improve the overall catalytic pyrolysis efficiency and increase the product quality. However, some research and trouble shooting for improvement still remain in the catalytic pyrolysis of plastic waste.

#### The effect of adding a catalyst on the liquid calorific value of pyrolysis products

From figure 5, the results of the liquid calorific value of pyrolysis products are obtained in several variations of the addition of catalysts and the highest value for HDPE plastic is 10230.295 cal / g. The calorific value of HDPE plastic is 10136.11 cal / g which is close to the kerosine calorific value of about 10270 cal / g [16]. The results of the heating value show a deflation in line with the increasing in pyrolysis temperature. This is due to the amount of water content in the product liquid which is formed from oxygen that enters from the leakage of the pyrolysis reactor so that the calorific value of the liquid product decreases.

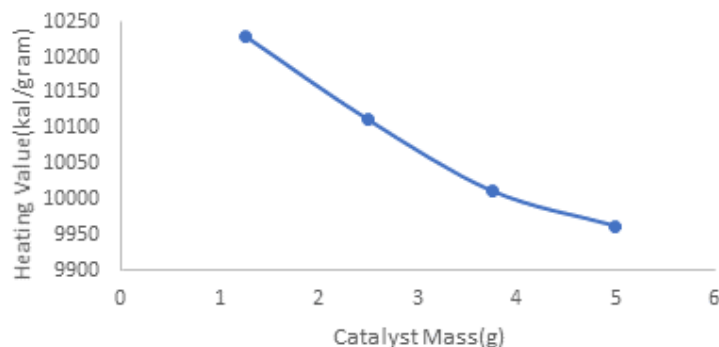


Figure 5. Influences addition of catalysts vs heating value liquid products pyrolysis

The more water content, the more energy is needed to evaporate the water and the lower the heat generated from the combustion [17]. Figure 5 shows that the calorific value of the liquid from pyrolysis decreases with the addition of more catalysts. This is because there is still water content in the product liquid so that the water can affect the resulting calorific value.

#### 4. Conclusion

Based on the experimental discussion in section four, it is true that the waste plastic is able to get the high yield 44.36% of liquid product by using reactor. The employed Zeolite as a catalyst successfully converts waste plastic into liquid fuel. Higher yield or liquid products was reach for the temperature above 500°C. 50 grams of HDPE Plastic feed was put into the reactor for 3 hours. The variations in the addition of Zeolite catalyst were 1.5, 2.5, 3.75 and 5%wt. The results showed that the highest yield was 44.36% and the heating value of 10230.295 Cal/g for the addition of 5 grams of catalyst. The addition of a catalyst can increase the conversion of plastic to fuel.

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