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Polypropylene Pyrolysis (PP) Uses Ni and NiMo Catalysts Supported on Mesoporous Silica

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Abstract. Research has been conducted to find out the amount of liquid fractions resulting from polypropylene plastic pyrolysis (PP) and the selectivity of Mesoporous Silica (MS), Ni/SM, and NiMo/SM against the fraction of gasoline and diesel pyrolysis results of polypropylene plastic (PP). The method in this study is pyrolysis method (heating in the absence of oxygen) and analysis of liquid fraction of pyrolysis result using GCMS (Gas Chromatrography Mass Spectrometry). In this study, the largest number of liquid fractions produced on pyrolysis with Ni-MS catalyst was 71.68 wt.%. GCMS analysis showed all selective catalysts for gasoline for mesoporous silica (MS), Ni/MS, and NiMo/MS by 73.75%, 57.21%, and 80.08%.

1. Introduction

Plastic waste is an unfinished global problem. In Indonesia, imports of polyethylene and polypropylene products continue to increase in line with the growing use of plastic commodities. In 2005-2009, PP production rate experienced an average growth of about 3.2% per year of 525,915 per year. Recycling is a solution to overcome the problem of plastic waste. The applicable recycling method is mechanical or chemical recycling [1,2]. Mechanical recycling has limitations when it reaches a simple fraction of plastic. So it will still leave plastic that can not be recycled. Pyrolysis method is a simple method that can be a solution. Recycling methods such as pyrolysis can significantly increase the recycling rate. This can happen because it can utilize a mixture of plastic waste unlike mechanical recycling [1,3].

The pyrolysis process involves the delivery of large molecules such as polymers (plastics) into short chains. Pyrolysis can be done up to 700 °C but high temperatures can produce more gas fractions than liquid fractions. Pyrolysis can be done at lower temperatures using the appropriate catalysts [4–7]. Generally mesoporous silica is used as a catalyst because it has a large surface area and has high thermal stability. Ni-MS and NiMo-MS catalysts attached to silica mesoporous have a specific surface area of 550 m^2/g [5]. In previous research, used lubricants were carried out using Ni-MS and NiMo-MS catalysts. The results obtained selective catalysts against gasoline and diesel.

The conversion of plastic waste into fuel is expected to reduce the environmental pollution [8]. Based on the description above, this study aims to find out the distribution of pyrolysis product phase and to know the distribution of liquid products.

2. Method

Plastic waste is collected from a trash can in Palopo City, South Sulawesi, Indonesia, and consists of food and drink containers, made of polypropylene (PP). The obtained waste is washed with water and soap and dried in a windy way. The plastic is cut into 2-3 cm in size and rinsed using aquadest then dried in the oven at a temperature of 60 °C for 12 hours. The catalyst used is the catalyst that has been prepared in the research [5].

Pyrolysis process is performed at atmospheric pressure with a temperature of 450 °C with the catalyst comparison to the bait is 1:10. Catalysts and baits are inserted into the reactor to be inserted into the heating furnace. Liquid fractions obtained from pyrolysis process are analyzed by GC-MS to find out the type of compound and conversion of liquid products. The selectivity of catalysts to the fraction of gasoline and diesel is determined based on the results of GC-MS and the weight of liquid products.

3. Result and Discussion

3.1. Catalytic Activity

Based on Table 1 it appears that the products produced in the form of liquid, gas and coke phases. In this study also conducted pyrolysis without catalyst with the aim to see the performance of the catalyst used. The majority of thermal cracking produce gas fraction products. This is due to thermal storytelling through radical formation mechanisms triggered by relatively high temperatures without catalysts producing short-chain hydro-carbon compounds (C1 – C4)[5].

Table 1. Distribution of Pyrolysis Products

Catalyst	Products Conversion (%-b/b)			Number of Acid Site (mmol/gram)
	Gas (%)	Liquid (%)	coke (%)	
No Catalyst	6.63	52.98	40.39	-
MS	39.9	59.1	1	5.1
Ni-MS	28.382	71.618	0	7.1
NiMo-MS	18.876	68	13.124	6.7

The use of catalysts will increase the reaction rate of PP to liquid products. This is due to catalytic cracking through the mechanism of carbocation formation with a minimum number of C atoms C7. From this process produced hydro carbon liquid fraction products are more dominant. Table 1 also shows a tendency that the development of Ni and Mo on silica increases the conversion of its products. Silica packing without metals produces the lowest liquid fraction. This is because silica has less active sites and only has a weak Lewis acid site [9].

Most liquid products are produced on pyrolysis using Ni-MS catalysts. Liquid products produced as much as 71,618% without producing coke. The amount of conversion of the resulting liquid fraction is directly proportional to the acidity of the catalyst. This is possible because the amount and size of the reactants can enter into a large pore. Catalyst acidity provides an active site that can interact with reactants and is supported by the size of the pore diameter [5,10].

3.2. Liquid Fraction Distribution

Based on GCMS test obtained compounds contained in liquid fractions of pyrolysis results. To facilitate the identification of compound fractions that appear, the results of chromatograms are divided based on the retention of time and concentration of each fraction of the compound calculated based on the percentage of area of the chromatogram results. Classification of gasoline and diesel fractions is based on the retention time of gasoline and diesel on chromatograms. Classification of liquid fractions of PP pyrolysis products with catalyst variations can be seen in the Table 2

Table 2. Distribution of liquid fractions in catalyst variations

Catalyst	Fraction	Time Retention (s)	Peak	% Area	Carbon
No Catalyst	Gasoline	0-20	-	-	C_5-C_{12}
	Solar	20-50	-	-	C_{13}-C_{20}
	Heavy Oil	50<	1	100	C_{21}<
Mesoporous Silica (MS)	Gasoline	0-20	1-16	73,75	C_5-C_{12}
	Solar	20-50	17-44	22,43	C_{13}-C_{20}
	Heavy Oil	50<	45-47	3.82	C_{21}<
Ni/MS	Gasoline	0-20	1-16	57,21	C_5-C_{12}
	Solar	20-50	17-65	33,78	C_{13}-C_{20}
	Heavy Oil	50<	66-76	9,01	C_{21}<
NiMo/MS	Gasoline	0-20	1	80,08	C_5-C_{12}
	Solar	20-50	-	-	C_{13}-C_{20}
	Heavy Oil	50<	2	19,92	C_{21}<

GC-MS analysis was conducted to determine the selectivity of liquid fraction of PP (polypropylene) plastic pyrolysis results qualitatively and quantitatively. Classification of gasoline and diesel fractions is based on the retention time of gasoline and diesel on chromatograms. Based on table 2 gasoline fractions appear at a retention time of 0-20 minutes (C5-C12), the diesel fraction appears at a retention time of 20-50 minutes (C13-C20), and for 50 minutes and above in classified into heavy oil fractions (C21<). By reading, the higher and wider the peak of the compound in the chromatogram indicates that the percentage of compounds in the area has a large value. The liquid fraction of pyrolysis results is very similar to commercial gasoline [5,11].

4. Conclusion

The result showed that the highest liquid product was achieved by Ni-MS catalyst (71.68 wt.%) and GCMS analysis showed all selective catalysts for gasoline for mesoporous silica (MS), Ni/MS, and NiMo/MS by 73%, 57.21%, and 80.08%.

5. References

[1] Qureshi M S, Oasmaa A, Pihkola H, Deviatkin I, Tenhunen A, Mannila J, Minkkinen H, Pohjakallio M and Laine-Ylijoki J 2020 Pyrolysis of plastic waste: Opportunities and challenges *J. Anal. Appl. Pyrolysis* **152** 104

[2] Das P and Tiwari P 2018 The effect of slow pyrolysis on the conversion of packaging waste plastics (PE and PP) into fuel *Waste Manag.* **79** 615

[3] Zhang Y, Ji G, Chen C, Wang Y, Wang W and Li A 2020 Liquid oils produced from pyrolysis of plastic wastes with heat carrier in rotary kiln *Fuel Process. Technol.* **206** 106-455

[4] Abidin S W A, Nurmalasari N, Sumiati S and Ramadani A 2020 Plastic Pyrolisis of Low Density Polyethylene (LDPE) Using Bleaching Earth (BE) Catalyst Become Liquid Fuel *Al-Kim.* **8**

[5] Trisunaryanti W, Falah I I, Nurmalasari and Sutarno 2016 Mesoporous Silica Impregnated by Ni and NiMo as Catalysts for Hydrocracking of Waste Lubricant *Int. J. ChemTech Res.* **9** 8

[6] Xue Y, Kelkar A and Bai X 2016 Catalytic co-pyrolysis of biomass and polyethylene in a tandem micropyrolyzer *Fuel* **166** 227

[7] Chai Y, Gao N, Wang M and Wu C 2020 H2 production from co-pyrolysis/gasification of waste plastics and biomass under novel catalyst Ni-CaO-C *Chem. Eng. J.* **382** 122

[8] Anon 2014 Fuel Production from LDPE Plastic Waste over Natural Zeolite Supported Ni, Ni-Mo, Co and Co-Mo Metals *Procedia Environ. Sci.* **20** 215

[9] Trisunaryanti W, Triyono and Fatmawati D A 2020 Synthesis of Co-NH2/mesoporous silica bifunctional catalyst using Sidoarjo mud and bovine bone gelatin template for conversion of used cooking oil into biofuel. *Rasāyan J. Chem.* **13** 723

[10] Trisunaryanti W 2018 *Dari Sampah Plastik Menjadi Bensin Solar* (UGM PRESS)

[11] Nurmalasari N, Purwanti E and Suaedi S 2019 Conversion of Polypropylene Into Liquid Fuel Using Bleaching Earth as A Catalyst *Int. Conf. Nat. Soc. Sci. ICONSS Proceeding Ser.* 74