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by Rahmad Samosir

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Rahmad Samosir[1], Sutan LMH Simanjuntak[2], and Budiarto[1]

[1]Departement of Mechanical Engineering, Faculty of Engineering, Christian University of Indonesia, Jakarta
[2]Departement of Mechanical Engineering, Faculty of Engineering, Universitas HKBP Nommensen, Medan, Indonesia

rachmadsamosir@yahoo.com, budidamaz@gmail.com

Abstract. The synthesis and testing of the physical properties and microstructure liquid fuels (C_5-C_{18}) of poly propylene plastic waste pyrolysis results with temperature variation has been done. One way of processing biodegradable plastic waste by pyrolysis. The process is carried out at various temperatures of 105 ° C, 205 ° C, 325 ° C, and within 48 minutes, and the resulting steam is condensed through the condenser crossflow. The results showed that the liquid fuel close to the characteristics of gasoline, premium gasoline fraction composition (C_5-C_{18}) 85.11%. Physical testing of liquid fuels with ICEL 2700 that density is 0.8204 g / cm^3 and an octane rating with ASTM D 2699 is 61.3. The results of FTIR spectrum of pyrolysed polypropylene have shown C = C functional group at 1648 cm^{-1}. GCMS analysis confirmed the availability of chain length of hydrocarbon between C_7 - C_{27} which is mixture of kerosene and diesel fractions.

1. Introduction

Indonesia is an archipelago in Southeast Asia consisting of 17,000 islands (6,000 inhabited) and is located on the equator. Land area: 699 548 mile^2 (1,811,831 km^2); total area: 741 096 mile^2 (1,919,440 km^2). Population: 2015: 252 370 792 persons (growth rate: 1,38% per year). National waste generation: 175,000 tons/day (64 million tons/year). The average production of waste: 0.7 kg /person/day. Low Calorie Value: 2000 - 3000 Kcal/Kg. General Composition of Municipal Solid Waste in Indonesia: Organic 55%; Plastics 25%; Paper 15%; Metals, glass 5%[1]. Plastic waste is one of the main problems facing today which can adversely affect humans and the environment because it is non-biodegradable. One method of processing plastic waste that is done today is to convert plastic waste into hydrocarbon fuels. This is because the plastic raw materials derived from petroleum derivatives that can be returned into the hydro-carbon as the basic fuel. Plastic waste conversion can be done with the process of cracking, the termination of the reaction the C - C of the carbon chain length and weight of large molecules into shorter carbon chain with a molecular weight.

In addition to generating energy, the burning of fossil energy sources as well as releasing gases, including CO_2, SO_2, NO_X, emissions that cause air pollution. So it is necessary to research on alternative fuels are expected to be used widely for environment-friendly society.
Pyrolysis is a process of thermal decomposition of organic material at elevated temperatures in the absence of oxygen. Plastic is a synthetic organic material or semi-synthetic organic material derived from petroleum and natural gas. Of plastic products, produced polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), low

density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), polyurethane and polyphenol, produces plastic waste which roughly consists of 50-60% type of PE, 20-30% of PP, PS and 10-20%, 10% PVC (Sarker, 2012).

Therefore, this study aimed to obtain liquid fuel from plastic waste poly propylene with pyrolysis methods and testing the physical properties and microstructure using FTIR and GC-MS, as well as the appropriate octane rating standard.

2. Research Method

Procedure

Polypropylene plastic waste shredded, weighed 3.0 kg, and put in a reactor and heated to a temperature of 400 ° C, and the resulting steam is condensed through the condenser crossflow. Fuel oil produced liquid, conducted tests among others, test density, octane value test, test the quantity and quality of fuel liquid materials with GCMS and test liquid with liquid fuels functional groups by FTIR. Tests carried out at the Forensic Laboratory, Police, Customs laboratory BPIP Jakarta, and LEMIGAS in Jakarta.

Figure 1. Schematic of synthesis fuel oil from poly propylene waste plastic with pyrolysis methods.

3. Results and Discussion

a. Analysis of pyrolysis process

Pyrolysis process has been made of waste plastics polypropylene (PP) data obtained time, and temperature as shown in Table 1. Plastic waste polypropylene has a melting point of 132^0C, the melting point at a temperature of 134^0C, and began to melt about 136^0C. There is a difference in the melting point, in which the pure polypropylene material has a melting point of about 130 ^{0}C. This is because there are other additional material on polypropylene plastic waste. Results pyrolysis 205^0C was observed in the temperature range of about 325^0C, the time it takes 25 minutes

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Table 1. Data for time and temperature pyrolysis of polypropylene

Time (min.)	Temperature (℃)	Information
0	35	The process has not yet begun
5	60	Exit gas
15	105	Exit gas and oil
20	135	Exit gas and oil
25	150	Exit gas and oil
30	180	Exit gas and oil
35	205	Exit oil
40	225	Exit oil
45	250	Exit oil
50	275	Exit oil
55	300	Oil began to slow down
64	325	Not exit oil

b. Analysis of Density

Density testing and analysis method / instrument ICEL 2700.M16. The result can be seen in Table 2. Fuels produced density testing is done to find out how heavy type of fuel that will be compared with a standard density of fuel oil. The density values obtained are as follows.

Table 2. Value of density with variation of process temperature

No.	Sampel	Value of Density
1.	A (105^{0}C)	0,8203 gr/cm ^{3}
2.	B(205^{0}C)	0,8204 gr/cm ^{3}
3.	C(325^{0}C)	0,8204 gr/cm ^{3}

The density of the test results, the density of the resulting fuel is still in the vulnerable in the premium fuels from 0.715 to 0.78 g / ml (Pertamina, 2007), diesel from 0.82 to 0.88 g / ml (MEMR, 1979) and kerosene 0.835 g / ml (MEMR, 1979). This is because the product produced depends on the temperature used. The higher the temperature used then the resulting product will become lighter.Where the higher temperature, which is the light hydrocarbons produced will be more and more.

c. Analysis of GC-M Spectrometry

On testing and analysis GC-MS (Gas Chromatography-Mass Spectroscopy) method / instrument ICEL 2900 M0. The result can be seen in figure 2 and table 3. The GC-MS analysis of thepyrolytic oil sample from polypropylene waste plastic (Figure 2) is summarized in Table3. From GCMS analysis in versus of retention time following types of hydrocarbon compounds are appeared. Depends on different retention time different compounds are appeared, such as at retention time (min) 3.56 obtained compound Heptane (C_7H_{14}), at retention time 4.64 compound is 1-Heptene, 4-methyl- (C_8H_{16}),at retention time 5.46 and 5.72

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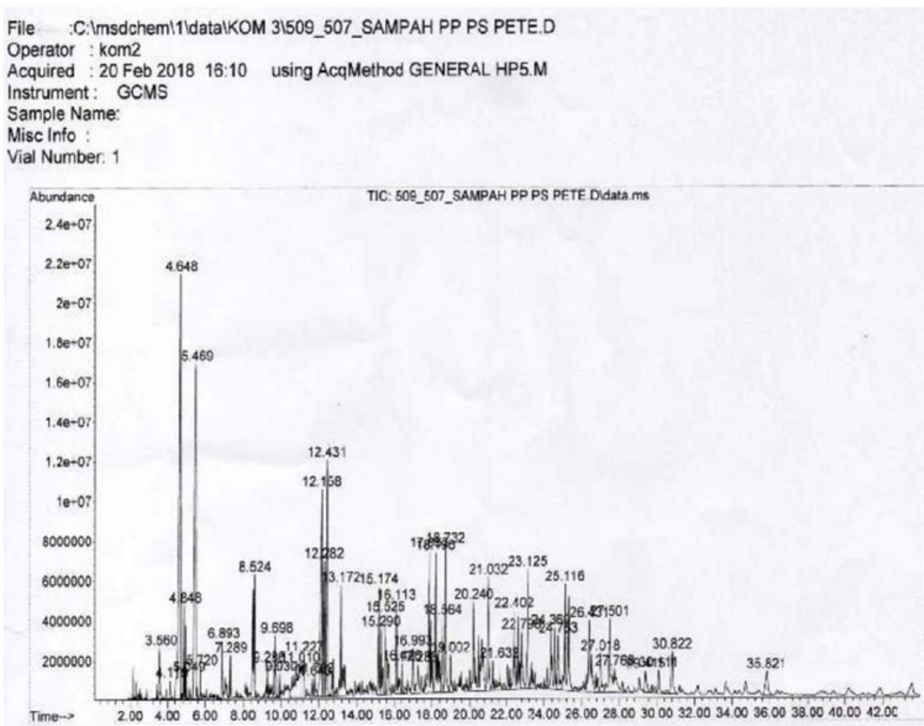
found compound are Octane (C_8H_{18}) and Cyclohexane, 1,3,5-trimethyl-(C_9H_{18}). Retention time versus compound determination focused on higher the retention time represents the bulky or bigger the compound size. Suppose in the middle of the analysis chart appearing that at retention time 8.54, 9.29, and 9.69 the compounds are α-MethylStyrene, Benzene, 1-propenyl- and 2-Undecanethiol, 2-methyl- respectively. In the analysis high number of retention time are found such as 21.03, 22.40, 22.79, 23.13 and 27.01 their compounds are Nonadecane($C_{19}H_{40}$),1-Eicosane($C_{20}H_{40}$), Eicosene ($C_{20}H_{42}$) and Heneicosene ($C_{21}H_{44}$), and Heptacosane ($C_{27}H_{56}$). The compound obtained from the pyrolysis of polypropylene has a hydrocarbon chain between the C_7 – C_{27} (Table 4) that indicated that this compound is a compound mixture of kerosene and diesel fractions. Kerosene fraction has a carbon chain length C_8-C_{19} carbon chain length whereas for diesel is C_7 - C_{27}.



Retention time(min.)

Figure 2. GC-MS plot of poly propylene waste pyrolytic oil.

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Table 3. GC-MS chromatogram of poly propylene waste plastic into fuel compound list

Number of peak	Retention Time (min.)	Compound Name	Compound Formula	Molecular Weight
1	3.56	1-Heptene	C7H14	98
2	4.64	1-Heptene, 4-methyl-	C8H16	112
3	4.84	Toluene	C7H8	92
4	5.46	Octane	C8H18	114
5	5.72	Cyclohexane, 1,3,5-rimethyl-	C9H18	126
6	6.89	Ethylbenzene	C8H10	106
7	7.28	Benzene, (1-methylethyl)-	C9H12	120
8	8.54	α-Methyl Styrene	C9H10	118
9	9.29	Benzene, 1-propenyl-	C9H10	118
10	9.69	2-Undecanethiol, 2-methyl-	C12H26S	202
11	10.10	CycloOctane, 1,4-dimethyl-tran	C10H20	140
12	11.11	Benzene, (3-methyl-3-butenyl)-	C11H14	146
13	12.15	Dodecane	C12H26	170
14	12.43	Decane, 2,3,5,8-tetramethyl-	C14H30	198
15	13.17	1-Tridecene	C13H26	182
16	15.62	Benzeneacetic acid, 4-pentadecyl ester	C23H38O2	346
17	16.11	Pentadecene	C15H32	212
18	16.47	Trichloroacetic acid, hexadecyl ester	C18H33Cl3O2	386
19	17.81	Hexadecane	C16H34	226
20	18.56	3-Heptadecene, (Z)-	C17H34	238
21	18.73	Heptadecane	C17H36	240
22	19.00	1-Hexadecanol, 2-methyl-	C17H36O	256
23	20.24	9-Nonadecene	C19H38	266
24	21.03	Nonadecane	C19H40	268
25	22.40	1-Eicosene	C20H40	280
26	22.79	Eicosane	C20H42	282
27	23.13	Heneicosane	C21H44	296
28	27.01	Heptacosane	C27H56	380

d. Analysis of FTIR Spektrofotometer result

Testing and analysis of FTIR method / instrument ICEL M01 results spectrum as shown in figure 3 and table 4. The results of FTIR analysis of the pyrolysis of polypropylene is shown in Figure 6 and Table 2. From the FTIR results obtained functional group = C-H stretching, wherein the alkene compound group = C-H stretching located between 3100-3000 cm^{-1}. These functional groups are supported by the emergence of functional groups of C = C stretching located between 1690-1450 cm^{-1}. Furthermore, the functional groups of C-H stretching of CH_3, C-H stretching of the CH_2 and non-conjugated functional groups of hydrocarbons. In addition, the group also obtained CH_2 scissoring, C-H bending of CH_3 and function of -HC = CH- (trans). Functional groups of = C-H bending of alkenes located between 1000-548 cm^{-1}.

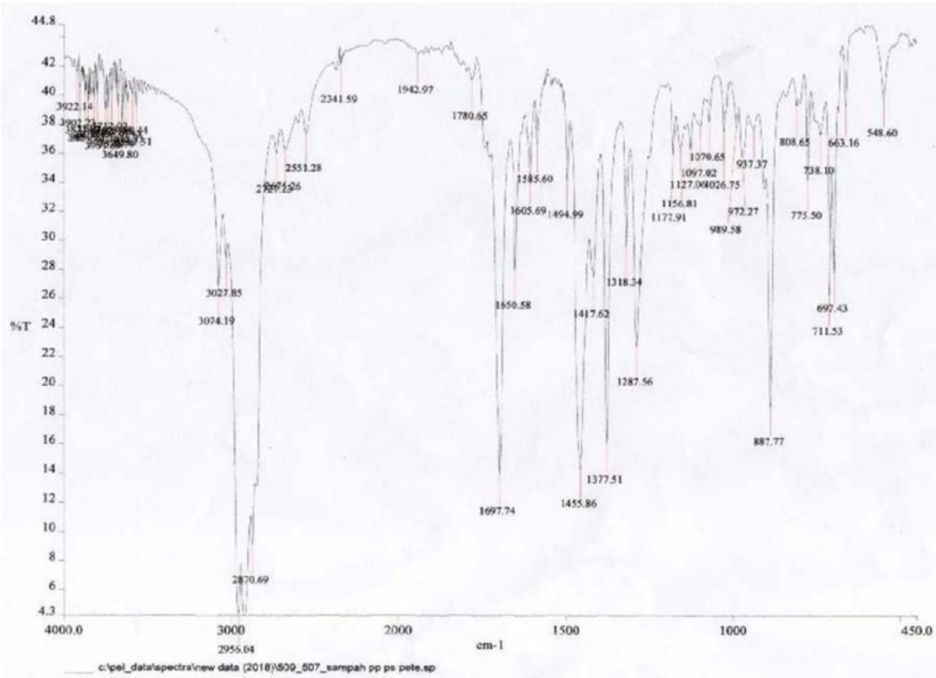

Figure 3. FTIR spectrum of PP plastic waste to liquid fuel

Table 4. Data of FTIR of PP plastic waste to liquid fuel result

Wave number (cm^{-1})	Type of vibration	Nature of functional group
2956	C-H $_{\text{stretching}}$	Alkane
1377	C-H $_{\text{scissoring and bending}}$	Alkane
2868	C-H $_{\text{stretching}}$	Alkane
1650	C=H $_{\text{stretching}}$	Alkane
1455	C=H $_{\text{stretching}}$	Alkane
972	C-H $_{\text{bending}}$	Alkane
887	C-H $_{\text{out of plane bending}}$	Alkane
738	C-H $_{\text{bending}}$	Alkane, Phenyl ring substitution
1070,1097,1127	C-O $_{\text{stretching}}$	Alcohol, Ethers, Carboxylic acids, Esters
1697,1780	C=O $_{\text{stretching}}$	Aldehydes, Ketone

4. Conclusion

Pyrolysis of polypropylene has been done for processing into liquid fuel.

1. The results of FTIR analysis showed a functional group C = C of hydrocarbons.The group also obtained CH_2 scissoring, C-H bending of CH_3 and function of -HC = CH- (trans). Functional groups of = C-H bending of alkenes.

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2. The compound obtained from the pyrolysis of polypropylene has a hydrocarbon chain between the C_7 – C_{27} that indicated that this compound is a compound mixture of kerosene and diesel fractions. Kerosene fraction has a carbon chain length C_8-C_{19} carbon chain length whereas for diesel is C_7 - C_{27}.
3. The processing of polypropylene plastic waste at temperatures of around 350^0C produce liquid fuel with density 0.8204 g / cm^3.

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