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Utilization of Bread Wrapper Plastic Waste as Alternative Energy of Gasoline Fuel

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Abstract

The issue on the demand for oil fuel nowadays continues to increase, while the availability of crude oil as a source of oil fuel is becoming limited. The reserves of crude oil in Indonesia is predicted to only suffice to fulfill the oil fuel demand for no more than another 25 years. Due to the decreasing crude oil reserve, scientists are soon looking for alternative energy resources as a solution for crude oil substitute. Bread plastic wrapper is one of the wastes polluting the environment which has not been found a solution to overcome it. The dumping of plastic waste can decrease the fertility of soil and within the soil, bread wrapper plastic waste cannot be degrade fast. The burning of plastic waste can result in poisonous gas or other dangerous substances for human health and the environment. The solution offered in order to overcome the problem of plastic waste is to manage bread wrapper plastic waste into alternative energy oil fuel. The method of pyrolysis is a way to convert plastic waste into liquid fuel that conducted in high temperature. Pyrolysis of bread wrapper plastic waste results in flammable solution and has a similar character with crude oil. Distillation method liquid fuel fractination results in oil fuel fraction, among others, gasoline fraction. Identification using GC-MS instrument shows that gasoline fraction of plastic oil fuel is composed of short chain hydrocarbon compound groups of alkane, alkene, cycloalkane and ketone. Calorific value of gasoline fraction 1 from bread wrapper plastic waste oil fuel is 12.070 cal/g, which is higher if it is compared to the calorific value of gasoline fuel at 11.528 cal/g.

Keywords: Plastic Waste, environment, pyrolysis, fractination, GC-MS, hydrocarbon, gasoline

INTRODUCTION

Along with the increase in world's population, the use of plastic goods is increasing. According to article 15 Constitution Number 18, Year 2008, the priority of the implementation of *Extended Producer Responsibility (EPR)* is treatment of product and plastic packaging which in fact is quite high in number at approximately 12-14% of the total waste. As an illustration for the city of Jakarta whose waste total is 6500 tons per day, which means that the amount of plastic is 780-910 tons per day. Big cities in Indonesia experience many urban problems, such as flood, traffic congestion and garbage. Garbage is one of the problems which is quite alarming for cities whose majority of population have consumptive life style thus the waste produced is quite high (Damanhuri, 2013). The management of urban waste in developing countries such as Indonesia is only done by piling and burning garbage directly in open air at final landfills.

Inorganic waste such as plastic bags, plastic bottles, plastic tubes, plastic pipes, and styrofoam are wastes that are not easily degradable but can be recycled. Plastic wastes found at present are only discarded, burned, or recycled. The process has not solved all of the problems of plastic waste since it is difficult to degrade in nature and when it is burned, it will result in dangerous compounds which are carsinogenic such as polychloro dibenzodioxins and polychloro dibenzo furan. Recycling of plastic waste is the only way which can reduce the amount of plastic waste found, but in reality, only a little which can be recycled and the recycled material result has low quality thus the recycling method is seen to be inefficient in solving the problem of plastic waste (Ernawati, 2011).

Plastic is an artificial inorganic material made up of chemical ingredients which are quite dangerous to the environment. Waste from plastic is quite difficult to degrade naturally. In daily life, the use of plastic material can be found in almost all of life's activities (Wahyono dan Sudarmo, 2012). According to Kadir (2012), plastic which is on the market at present is synthetic polymer made from crude oil and it is difficult to degrade in nature. Plastic is a long chain polymer of atoms which bind each other. Plastic is one type of macro molecule formed by the process of polymerization. Plastic is a polymer compound in which its main compositions are carbon and hydrogen. In order to make plastic, one of the most common ingredients used is naphta, which is a material produced from distillation of crude oil or natural gas (Surono, 2013). Plastic waste is classified into undegradable waste, since this type of waste requires relatively very long period to be able to be degraded by nature (Andarian dan Purwo, 2009).

The product of plastic goods besides being highly needed by the people also has a bad impact on the environment. For example, burning of PVC plastic can produce smoke containing chlorine. Plastic waste is highly potential in polluting the environment because plastic is a material that is difficult to be degraded so when it is piled in landfills, it will create many problems (Sahwan, et al, 2005). The burning of plastic waste is less effective and has risks because by burning plastic waste pollutant from exhaust gas emissions; CO_2, CO, NO_x dan SO_x, will result which can cause health problems (Sumarni dan Purwanti, 2008).

Pyrolysis is one of the methods which can be used to turn plastic waste into liquid fuel and can further be processed into oil fuel which is the same as gasoline fuel. The advantage of applying the pyrolysis method is among others having high conversion ratio and the product has high energy content also. Pyrolysis is defined as thermal degradation from solid fuel at limited air/oxygen condition in which this process will produce gas, tar and char (Blasi, 2008).

According to Wiratmaja (2010), in the production of alternative fuel, there are several things to be considered, namely ignition point or burning point that take place at a relatively low temperature, and the level of gasoline calorific value is quite high at around 10.160-11.000 kcal/kg. The availability of crude oil reserve in Indonesia at the moment is only sufficient to fulfil the demand for Indonesia's crude oil to up to the next 23 years. Emphasized by the implementation of government's focus to continue to increase the production, in order to reach target lifting of crude oil up to 1 million barrels in 2014 can cause the availability of crude oil to decrease fast in less than 23 years (Anonim, 2012).

Main points on energy have been stated in the National Energy policy which is aimed at saving crude oil and developing other alternative energy sources. Subroto (2013) explained that one of the alternative energies which are now developed is energy from organic materials, this is because the organic compound is classified as renewable energy. One of this is organic waste which is increasing from time to time in amount.

According to Surono (2013), plastic waste will have a negative impact on the environment as it cannot be degraded fast and can decrease soil fertility. The quicker of increasing of plastic waste, the more waste there is to handle, whether it is that produced from large industry or household industry. Plastic waste has become an environmental problem which up to the present cannot be overcome even though there are many solutions on the use of plastic waste but they have not been able to reduce the piling of plastic waste in nature (Anggono, 2009). Processing plastic waste especially bread wrapper plastic to be converted into oil fuel is quite interesting to be developed. If the plastic waste which is in abundant in amount can be processed into gasoline fuel, this becomes the perfect solution to the problem of plastic waste.

RESEARCH METHODOLOGY

Material

Waste used in this research is bread wrapper plastic taken from final landfill location at Sumompo village in the city of Manado.

Instrument

Instruments that used in this research are one set of pyrolysis instrument, one set of fractination distiller, condenser, Erlemeyer glass, separation funnel, measuring glass, analytic scale, clamp, stand, knife, straw, thermometer, Infra Red (IR), one set of Mass Spectroscopy Gas Chromatography instrument (GC-MS), and 1 set of *Bomb Calorimeter* instrument.

Research Procedure

Steps of bread wrapper plastic waste pyrolysis was adopted from procedure that conducted by Anom (1991) as follows:

1. Bread wrapper plastic waste used as study sample was collected from garbage dump, then it was washed to clean and it was dried completely.
2. 1 set of plastic waste pyrolysis instrument was arranged.
3. 250 g of bread wrapper plastic waste was measured, then the sample was put into 500 mL distillation flask.
4. Pyrolysis process of bread wrapper plastic waste started to be conducted by observing changes in pyrolysis temperature and physical changes that took place; plastic waste started to melt, thaw and evaporate. The steam was cooled off then solution was obtained and it was put in the Erlenmeyer.
5. Steam that could not be melted was extremely light gas and was left to evaporate.
6. The process of bread wrapper plastic waste pyrolysis was stopped when there were no more distillates trickling into the Erlenmeyer.
7. Distillate as a result of pyrolysis was put in the Erlenmeyer and the weight was measured.
8. Result of distillate I (solution) was a mixture of plastic oil fuel.
9. Then distillate I solution was given treatment of fractination distillation with the aim of separating liquid fuel component wanted, by observing the increase of boiling point as indicator.
10. The first distillate collected at a temperature of $\leq 200^{o}$C was fractions F1, and F1 is a liquid which is similar to gasoline fuel.
11. The weight of fraction F1 was then measured and then calculated in weight percentage as follows:

$$\frac{\textbf{F1 weight}}{\textbf{Sample weight}} \textbf{ x 100\%}$$

Identification of F1 Fraction using IR and GC-MS instrument

Fraction F1 that obtained was identified using IR and GC-MS instrument. Identification with IR was aimed at identifying function groups found in fraction F1. Identification using GC was aimed at identifying the number of compounds found in fraction F1, while identification using MS was intended to identify the relative molecule mass of compound components contained in fraction F1.

The determination of Heat Level of Fraction F1 using *Bomb Calorimeter* Instrument

The test of calorific value used *Bomb Calorimeter* instrument. It is an instrument used to measure the amount of heat that released during complete burning in excessive O_2, a fuel compound. One of the parameters per unit mass.

RESULTS AND DISCUSSION

Pyrolysis

Pyrolysis of bread wrapper plastic waste took place at more or less 3,5 to 4 hours. The process of pyrolysis started from heating of plastic waste until it finished, which means that the process of pyrolysis was stopped since there was no distillate dripping from the pyrolysis instrument. The weight of bread wrapper plastic waste used for study sample was 250 g. The observation of pyrolysis process of bread wrapper plastic waste is as follows:

1. Pyrolysis of bread wrapper plastic waste, heating started from temperature of 110-125^{o}C, observed was the physical change of plastic waste slowly from solid into melted form. Besides that it was also observed there was an indication of air bubbles and white smoke which were significant inside the pyrolysis flask.
2. Pyrolysis of plastic waste at heating of approximately 140-160^{o}C, observed was that plastic sample was starting to melt and then it was boiling and it evaporated. At this stage the white smoke in the pyrolysis flask had gone.
3. Plastic waste pyrolysis at heating of approximately 160 - 200^{o}C, it was observed that there was an indication of dew drops sticking on the condenser wall. Several minutes later it was observed that the indication of liquid which started to drip, and the solution was collected in the Erlenmeyer glass.
4. Heating of approximately 200 - 275^{o}C, the process of pyrolylis started to be normal, this is indicated by the dripping speed of the plastic solution which started to be stable.
5. Pyrolysis process ended until there was no longer distillate dripping and the time used was less then four hours.

The result of pyrolysis of 250 g of bread wrapper plastic waste resulted in distillate weight of (I) 180,20 g. Distillate (I) was given treatment of fractination which was aimed at separating fuel fraction in the mixture. Fractination distillation was based on increase in boiling point of oil fuel: gasoline boiling point < 200^{o}C (Koesoemadinata, 1980). Result of distillate pyrolysis (I) and gasoline fraction distillate (F1) is shown in Figure 1.

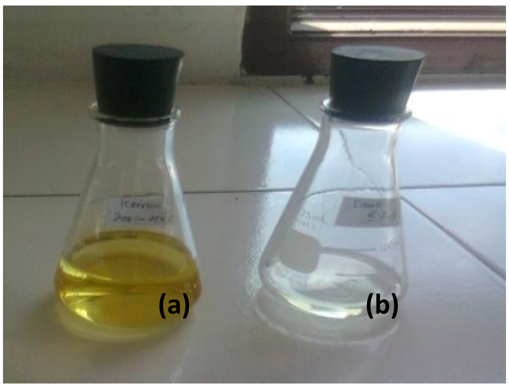

Figure 1. (a) distillate I, (b) gasoline fraction distillate (F1)

From 180,20 g bread wrapper plastic oil (distillate I), after fractination resulted in more or less 80,50 g gasoline fraction F1. 11. Percentage of fraction weight of gasoline F1 obtained was 80,50/250 x 100% = 32,20%. Bread wrapper plastic oil fuel of gasoline fraction F1 was clear in color. The difference of bread wrapper plastic oil fuel was not the same with gasoline fuel found on the market. The difference in color could be caused by the composition of chemical components of gasoline fuel F1 which are different to the gasoline fuel found on the market.

Calorific value of bread wrapper plastic oil fuel of gasoline fraction F1 was 12.070 cal/g. The calorific value of plastic oil fuel is quite high, if it is compared to value standard of gasoline fuel calorie: 11.528 cal/g (Koesoemadinata, 1980). The indication of a difference in calorie value from the standard oil fuel on the market to calorific value of plastic oil fuel can be caused by the difference in chemical compounds making up the fuel. Besides that, the process of production of oil fuel found on the market is processed directly through graded distillation, while plastic oil fuel is processed through pyrolysis process and fractiorized distillation. According to Agrariksa et. al (2013), the consumption of fuel is closely related to the level of calorie of fuel, that the higher the fuel calorific value, the lower the material consumption level. Study result showed that consumption calorific value of plastic oil fuel is higher than calorific value of fuel found on the market, which means it is able to produce higher power from the genuine fuel, so a lower fuel consumption level from the consumption level of the premium fuel itself is obtained. This can be implied also that plastic oil fuel is able to give thermal efficiency in combustion reaction, thus the performance of engine is economical in terms of fuel.

Analysis of Gasoline Fraction Infra Red (IR) Spectrophotometry

From the data of infra red spectrum, bread wrapper waste oil fuel of gasoline fraction F1 show groups of OH at wavenumber (υ) of 3417,86 cm^{-1}. H-aromatic (Ar-H) group at wavenumber (υ) of 3078,39 cm^{-1}. CH_3 and CH_2 groups at wavenumber of 2924,09 cm^{-1} and 2870,08 cm^{-1}. The prediction of the indication of CH aromatic group is confirmed by the presence of absorption at wavenumber of 1643,36 cm^{-1} and 1458,18 cm^{-1}. C-O esther group appear at wavenumber of 1381,03 cm^{-1}. CH aromatic substituted group appear as strong absorption of wavenumber 887,26 cm^{-1} and 740,67 cm^{-1}

Analysis of Mass Spectroscopy Gas Chromatography (GC-MS) of Gasoline Fraction F1

Analysis result of GC-MS of bread wrapper plastic waste oil fuel of gasoline fraction F1 is shown in Figure 2.

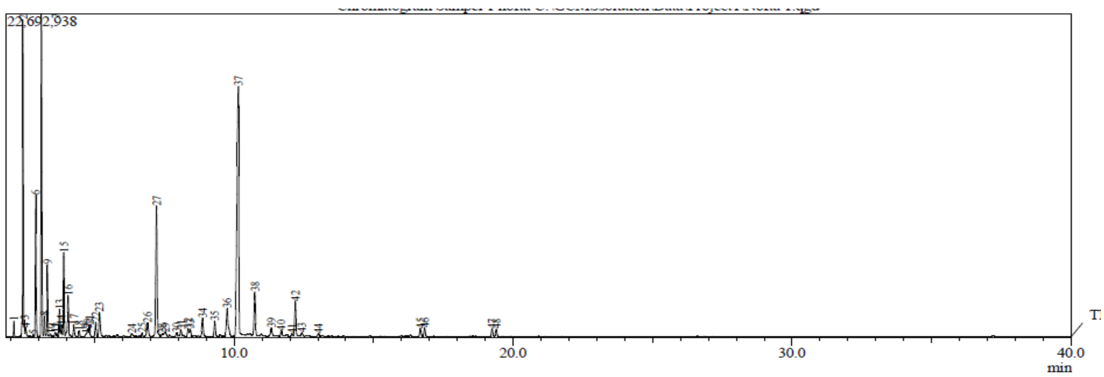

Figure 2. Chromatogram of GC of bread wrapper plastic waste oil fuel of gasoline fraction F1

Chromatogram of gas of bread wrapper plastic waste oil fuel of gasoline fraction F1 shows 48 peaks, this can be interpreted that bread wrapper plastic waste oil fuel of gasoline fraction comprises of 48 compounds. After being grouped, evidently bread wrapper plastic waste oil fuel of gasoline fraction (F1) contain of combination of hydrocarbon groups of alkane, alkene, cycloalkane, ketone and alcohol compounds.

Then, analysis of chromatogram GC on 3 compounds in mixture of bread wrapper plastic waste oil fuel of gasoline fraction namely peak compound 9, peak compound 27 and peak compound 40 was conducted. To identify molecule structure and fragmentation pattern of the three compound peaks MS spectrum analysis was conducted.

1. Peak Compound 9.

Based on data from mass spectrum (MS), peak compound 9 has a base peak similar to compound shown by *library* data of Wiley229.LIB at m/z = 41. Comparison of mass spectra of peak compound 9 and compounds of 2-methyl pentane-2 shown in Figure 3.

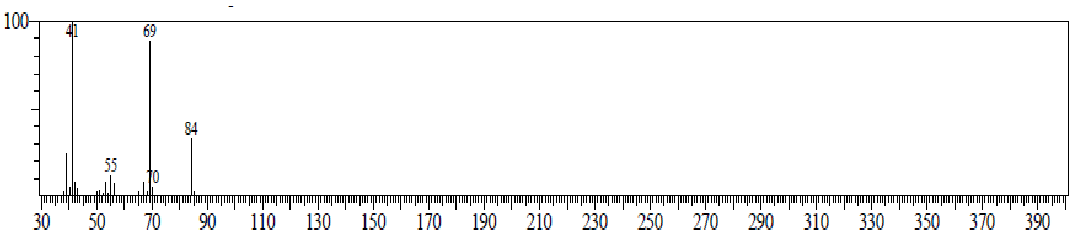

Figure 3. (a) Mass Spectrum (MS) from library data of Wiley229.LIB.

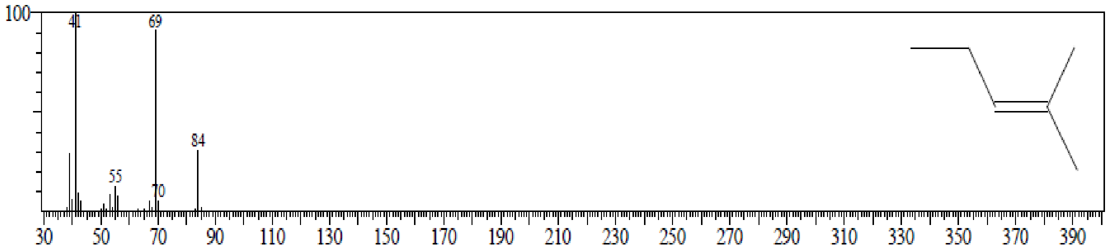

Figure 3. (b) Mass Spectrum (MS) peak compound 9 from gasoline fraction (F1)

Peak compound 9 has a base peak similar to compound shown by library data of Wiley229.LIB at m/z = 41. Both spectra show the same molecule ion peak at m/z = 84 which indicates the molecule weight of compound. The indication of electron release at molecule m/z = 84 results in molecule ion fragment (M^+) m/z = 72. Release of –CH_3 (15) at molecule m/z = 84 result in molecule ion fragment m/z = 69. Molecule m/z = 69, then there is a break of bond by releasing -CH_2 (14) resulting in molecule ion fragment m/z = 55. Molecule ion fragment m/z = 55 conducts one break of bond by releasing –CH_2 (14) resulting in molecule ion fragment m/z = 41, and at once is the base peak of peak compound 9.

The indication of similarity in base peak at m/z = 41 (100%) and similarity in molecule ion M^+ = 84, and the indication of similarity in compound fragment pattern thus it can be concluded that peak 9 is the same as 2-methyl pentane-2 compound with a molecule weight of 84 (C_6H_{12}). Release fragmentation pattern of ion or peak compound molecule 9 is shown in Figure 4.

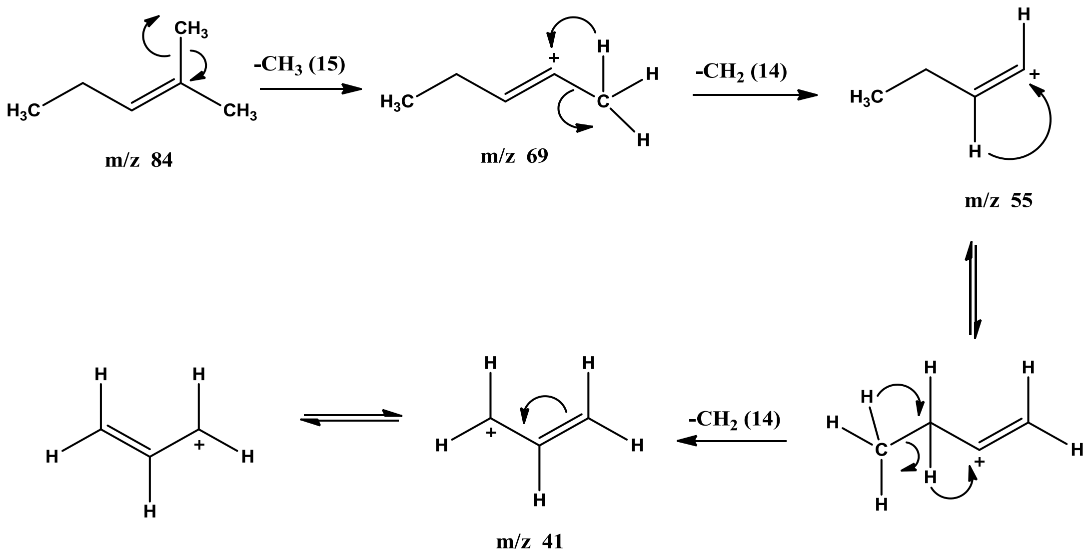

Figure 4. Prediction of fragmentation pattern of release of ion or molecule compound 9 or compound 2-methyl pentane-2

2. Peak Compound 27.
Based on the data from mass spectrum (MS) peak compound 27 has a similar base peak to the compound shown by library data data library of Wiley229.LIB at m/z = 43, shown in Figure 5.

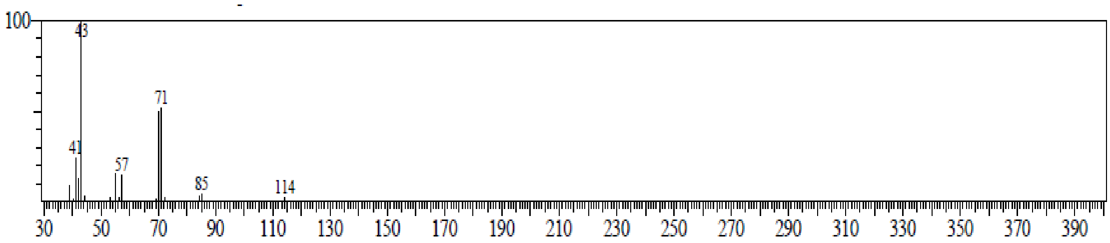

Figure 5. (a) Mass Spectrum (MS) from library data Wiley229.LIB.

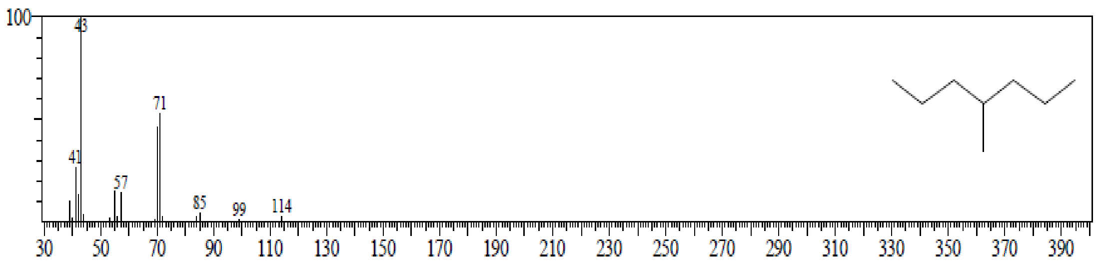

Figure 5. (b) Mass Spectrum (MS) of peak compound 27 from gasoline fraction (F1)

Both spectrum in Figures 5a and 5b show molecule ion at m/z = 114 which indicates molecule weight of compound. The indication of electron release in molecule m/z = 114 results in molecule ion fragment of (M^+) m/z = 114. Release of $-CH_3$ (15) at molecule m/z = 114 results in molecule ion fragment m/z = 99. Furthermore there is a break in bond by releasing $-CH_2$ (14) four times in a row resulting in molecule ion fragments m/z = 85, m/z = 71, m/z = 57, and m/z = 43. Molecule ion fragment m/z = 43 is the base peak of peak compound 27. Fragment release pattern of molecule ion of compound 27 is shown in Figure 6.

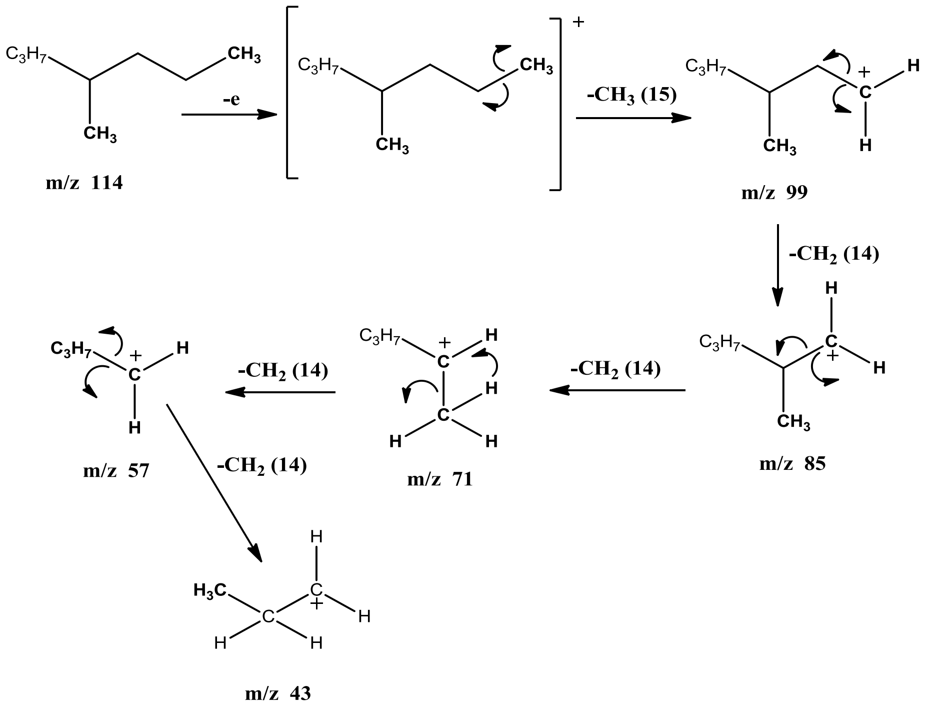

Figure 6. Prediction of release fragmentation pattern of ion or molecule of compound 27 or 4-methyl heptane compound.

Based on the presence of similarity of base peak at m/z = 43 (100%) and similarity of molecule ion M^+ = 114, also the presence of similarity of compound fragmentation pattern thus it can be concluded that peak compound 27 is a 4-methyl heptane compound with a molecule weight of 114 (C_8H_{18}).

3. Peak compound 40.

Based on data of mass spectrum (MS) peak compound 40 has a base peak similar to compound shown by library data data library of Wiley229.LIB at m/z = 109, shown in Figure 7.

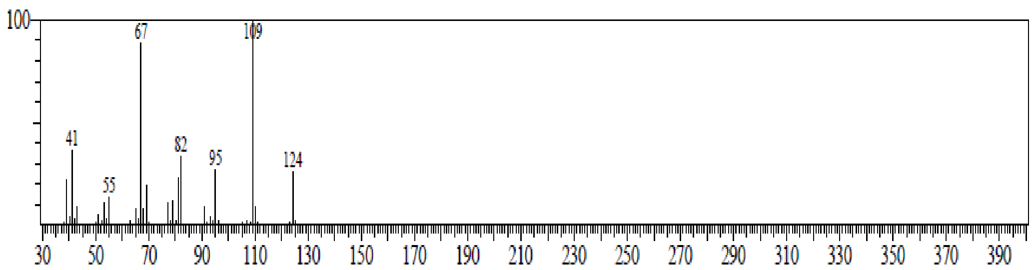

Figure 7. (a) Mass Spectrum (MS) from library data of Wiley229.LIB.

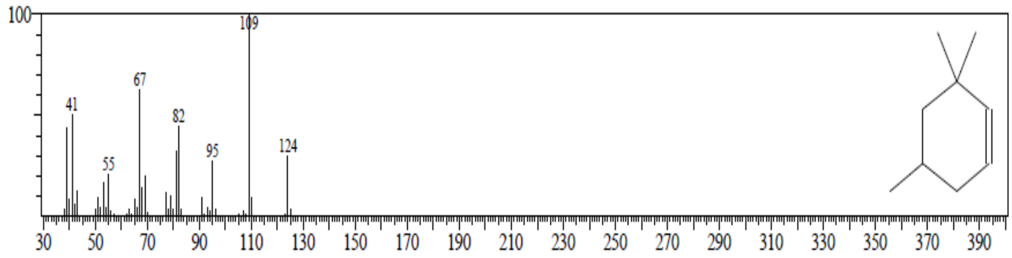

Figure 7. (b) Mass Spectrum(MS) of Peak Compound 40 From Gasoline Fraction (F1)

Both spectrum in Figure 7a and 7b show ion molecule at m/z = 124 which indicates molecule weight of compound. The presence of electron release in molecule m/z = 124 results in fragment of molecule ion (M^+) m/z = 124. Release of –CH_3 (15) in molecule m/z = 124 results in fragment of molecule ion m/z = 109. Furthermore, there is a break in bond by releasing of -CH_2 (14) resulting in fragment of molecule ion m/z = 95. Release of –CH (13) results in molecule ion fragment m/z = 82. Release of –CH_3 (15) results in molecule ion fragment m/z = 67. Release of -C (12) results in molecule ion fragment m/z = 55, and a break in bond by releasing -CH_2 (14) resulting in molecule ion fragment m/z = 41. Fragment pattern of molecule ion release of compound 40 is given in Figure 8.

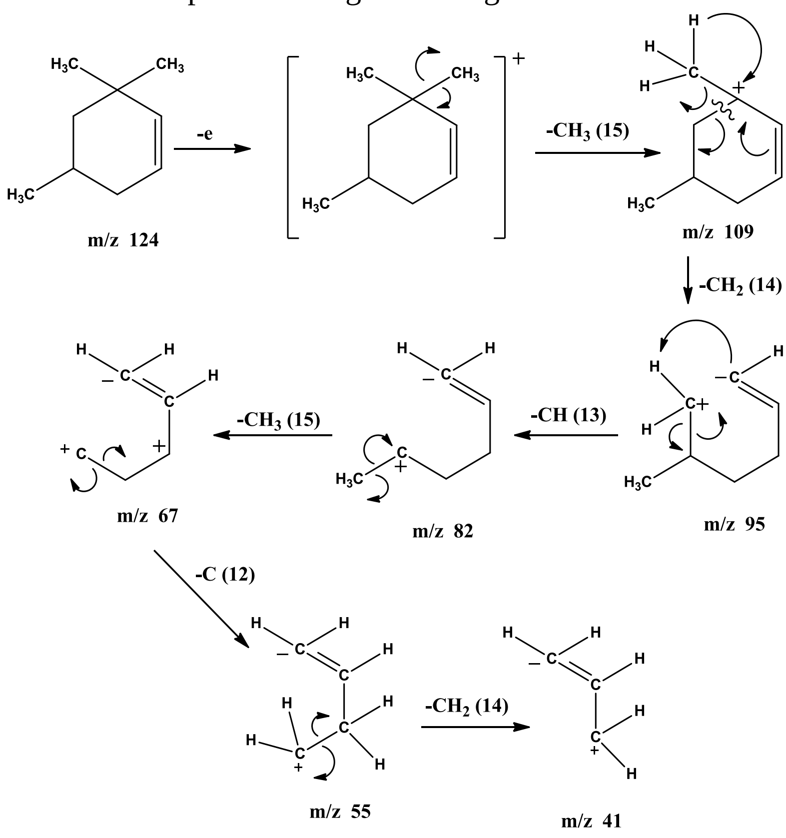

Figure 8. Prediction of Fragmentation Pattern of Released Ion or Molecule of Compound 40.

Based on the presence of similarity of base peak at m/z = 109 (100%) and similarity of molecule ion M^+ = 124, also the presence of similarity of compound fragmentation pattern thus it can be concluded that peak compound 40 is compound 3,3,5-trimethyl cyclohexane, with a molecule weight of 124 (C_9H_{16}).

CONCLUSION

Based on the discussion of study result, it can be concluded as follows:

1. Pyrolysis of 250 g bread wrapper plastic waste produces 80,50 g liquid fuel or 32,20% oil fuel which is similar to gasoline fuel that sold on the market.
2. Calorific value from oil fuel of gasoline fraction bread wrapper plastic waste is 12.070 cal/g which is higher compared to the standard calorific value of gasoline fuel which is on the market: 11.528 cal/g.
3. Identification using GC-MS shows that oil fuel gasoline fraction consists of 48 hydrocarbon compounds, contained of alkane group compound, alkene, cycloalkane, ketone and alcohol.
4. Plastic waste which has been a serious problem can evidently be converted into oil fuel as an alternative to gasoline substitute, something that can be beneficial to human and the environment.

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