

# Low Density Polyethylene (LDPE) Waste Plastic Transformation into Renewable Heavy Fuel Using Thermal Cracking

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**Abstract** Low density polyethylene (LDPE) waste plastic was transformed into heavy fuel by using fractional distillation column process with liquefaction process. For experimental purpose two types of temperature profiles were used one for LDPE waste plastic liquefaction temperature and another one for fractional distillation column temperature. In this experiment liquefaction temperature ranges 100-420 °C and fractional distillation temperature ranges 340-365 °C. LDPE waste plastic to heavy fuel production was performed without adding any kind of catalyst in presence of oxygen and without vacuum system. Different types of analytical equipment were used for produced fuel analysis purposed such as GC/MS, FT-IR and DSC. By using GC/MS analysis result indicates that LDPE waste plastic to produced heavy fuel hydrocarbon chain range C<sub>5</sub> to C<sub>28</sub> and light gas are also present and hydrocarbon range is C<sub>1</sub>-C<sub>4</sub>. FT-IR (Spectrum 100) analysis results indicate that produced fuel functional group has bands energy which is reflecting with calorific value. By using DSC analysis result showed produced fuel delta H value or enthalpy value. Produce fuel can be use for heavy equipment internal combustion engine or electricity generation or feed for feed stock refinery process.

**Keywords** Polyethylene, Waste Plastic, LDPE, Thermal, Renewable, Fuel, Hydrocarbon, GC/MS

## 1. Introduction

The decomposition of waste plastics into fuel represents a sustainable way for the recovery of the organic content of the polymeric waste and also preserves valuable petroleum resources in addition to protecting the environment[1]. Municipal waste plastic represents about 8 wt% of the municipal solid waste and it generally consists of mixture of different kind of plastics: 40.5 wt% HDPE (High Density Polyethylene) and LLDPE/LDPE (Linear /Low Density Polyethylene), 19.6 wt% PP (Polypropylene), 11.9 wt% EPS PS/ (Expandable Polystyrene / Polystyrene), 10.7 wt% PVC (Polyvinyl Chloride), 8.1 wt% PET (Polyethylene terephthalate), and about 5 wt% ABS (Acrylonitrile Butadiene Styrene) and 4.2 wt% other polymers[2]. This waste is difficult to be treated or recycled due to its complex nature and composition, structural deterioration of the polymeric components and the contamination with various organic, inorganic or biological residues. Pyrolysis is one of the best methods to recover the material and energy from polymer waste, as only about 10% of the

energy content of the waste plastic is used to convert the scrap into valuable hydrocarbon products[3]. The conversion of waste plastics into fuel represents a sustainable way for the recovery of the organic content of the polymeric waste and also preserves valuable petroleum resources in addition to protecting the environment[4]. The world's limited reserve of coal, crude oil and natural gas places a great pressure on mankind to preserve its existing non-renewable materials. Among the various recycling methods for the waste plastics, the feedstock recycling has been found to be a promising technique. There are a lot of research[4-15] in progress on the pyrolysis and utilization of pyrolysis products for various applications.

Thermal degradation of polymer mixtures is more complex than the degradation of single polymers. Interactions can appear at high temperatures during decomposition in the polymer bulk, between the components of the mixture and the low molecular weight products and free radicals that are formed by the scission of the polymeric chains. Due to these interactions, some polymers can affect the quality of pyrolysis products even they are in small amount in polymer mixture. This is of very high interest especially when the pyrolysis oils have to pass some quality standards for use as feedstock or fuels[16]. ABS with flame retardant PVC and PET are heteroatom containing polymers that create problems during thermal decomposition because bromine, chlorine and nitrogen can remain as organic

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compounds in pyrolysis oils or can produce acid or toxic gases such as HCl, HBr, and HCN, NH<sub>3</sub> or polyhalogenated dibenzodioxins and dibenzofurans [17, 18]. Therefore, the amount of these compounds has to be decreased as much as possible. Thermal degradation of ABS gives oils with high content of benzene derivatives (toluene, ethylbenzene, styrene, cumene, and  $\alpha$ -methylstyrene) but also containing significant amount of organic nitrogen as aliphatic and aromatic nitriles or nitrogen containing heterocyclic compounds. The amount and distribution of these compounds strongly depends on the thermal or catalytic conditions used for degradation [19, 20].

## 2. Materials and Method

The raw materials were collection from Stamford city Wal-Mart store. Collected raw material comes with other plastic also such as LDPE (Low Density Polyethylene), HDPE (High Density Polyethylene), PP (Polypropylene) and PS (Polystyrene). All plastics separated by manually from mixed plastics. LDPE waste plastic washed with soap and water by using sink because LDPE waste plastic was shopping or packaging bag and color was various types. Then washout LDPE waste plastic dried into room temperature by putting on the laboratory floor. After that LDPE waste plastic cut into small pieces manually by using scissors. Small pieces LDPE waste plastic shopping bags were manually transferred into reactor chamber. Stainless steel reactor was setup under laboratory fume hood without vacuum system and in presence of oxygen and it was fully closed system. Reactor was heated by electrical power and reactor capable temperature range was 25-500°C. For experiment purpose temperature rang was 100-420°C. Experimental set up were describe in Figure 1 and all number describe such as 1 = Low density polyethylene waste plastic, 2= Steel reactor, 3 = Fractional distillation column, 4= 1<sup>st</sup> fraction temperature, 5= 2<sup>nd</sup> fraction temperature, 6=3<sup>rd</sup> fraction temperature, 7= 4<sup>th</sup> fraction temperature, 8= 5<sup>th</sup> fraction temperature, 9= light gas cleaning system, 10= 1<sup>st</sup> fraction fuel collection tank, 11=2<sup>nd</sup> fraction fuel collection tank, 12=3<sup>rd</sup> fraction fuel collection tank, 13=4<sup>th</sup> fraction fuel collection tank, 14 = 5<sup>th</sup> fraction fuel collection tank, 15 = small pump, 16 = Teflon bag for light gas storage. In this experiment LDPE waste plastic was used only 1000 gm (1kg) and this experiment did not use any kind of chemical or catalyst. After setup the experiment started temperature was 100 °C and temperature increased up 420 °C gradually. Initial raw material LDPE plastic melting point temperature 120 °C and experimental temperature was 100 °C. Fractional column temperature was setup by using electrical coil and temperature profile was for 1<sup>st</sup> fractional at 40-65 °C, 2<sup>nd</sup> fractional at 110-135 °C, 3<sup>rd</sup> fractional at 180-205 °C, 4<sup>th</sup> fractional at 260-285 °C and 5<sup>th</sup> fractional at 340-365 °C. In the experiment the main goal was to collect heavy fuel from LDPE waste plastic. By using this technology waste plastic converted into

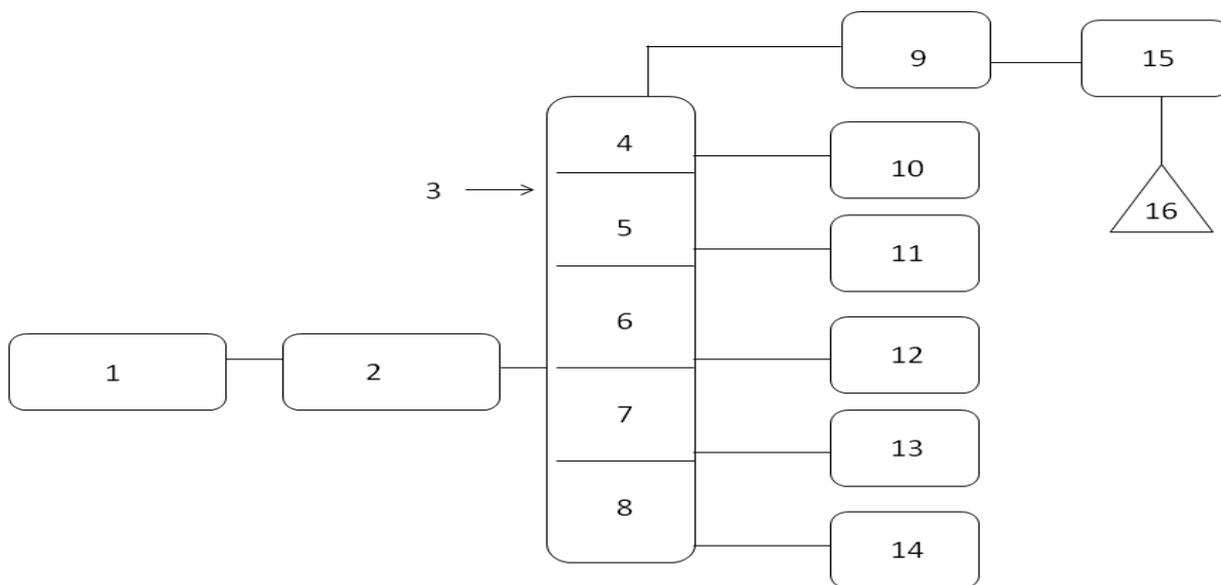
liquefaction from 100-420 °C and fractional column was setup for collection heavy fuel and other grade fuels. LDPE waste plastic melt due to heat applies then turn into liquid slurry when temperature increased gradually. Liquid slurry turn into vapor then vapor passed through into fractional distillation column surface and at the end vapor transform to fuel and the product was collected based on different fractional boiling point range wise. Negative boiling point vapor come out as light gas and this light gas hydrocarbon mixture of methane, ethane, propane and butane. Rest of all fractional fuels was collected according to their boiling point range like minimum temperature to maximum temperature wise such as 1<sup>st</sup> fractional to 5<sup>th</sup> fractional fuel. In diagram number 14 is 5<sup>th</sup> fractional fuel or heavy fuel and this fractional tower temperature was 340-365°C. During LDPE to heavy fuel production process didn't escape or leakage any gases materials into the environment and capture light gas was purified by using alkali solution then light gas transfer into Teflon bag by using small pump. Collected produced fuel was purified by using RCI technology provided RCI fuel purifier with centrifugal force and micron filter. In this experimental process heavy fuel production percentage was 18.1% and other fractional fuels was 73.9%. Remaining solid black residue was 3% and light gas was only 5% from total 1000 gm of LDPE waste plastic. In mass balance calculation from 1000 gm of LDPE waste plastic to heavy fuel conversion rate was 181 gm sample, rest of other grade such as gasoline, naphtha, aviation and diesel grade fuels conversion is total 739 gm sample, light gas generated from 1000 gm waste plastic to 50 gm sample and finally left over residue was 30 gm from total sample. Residue has also good Btu value and this Btu value more than 5000/lb. Residue could be used as substantial coal, roof carpeting or road carpeting. Produced fuel density is 0.81 g/ml. Total experiment runtime was 5-6 hours and input electricity was 7.89 kWh according to the laboratory scale. In this experimental process produced light gas could be use for reactor heating purposes and that will significantly reduce the production cost and increase the back up electricity stock.

## 3. Results and Discussion

Perkin Elmer GC/MS (Gas Chromatography and Mass Spectrometer) analysis of 5<sup>th</sup> fractional fuel/ heavy fuel (Figure 2 and Table 1) hydrocarbon compound list is analysed based on their peak intensity. GC/MS chromatogram analysis is showing higher concentration level peak intensity. This fuel's fractional temperature is 340- 365 °C. This fuel is similar to fuel oil category. Chromatogram analysis starting compound is Cyclopropane, ethyl- (C<sub>5</sub>H<sub>10</sub>) at retention time is 1.91 minutes. From data table (Table1) we saw all hydrocarbon compounds are straight chain hydrocarbon compounds and some are branch chain hydrocarbon compounds are as well. From the fuel we found alkane group and alkene group compound. Long

chain hydrocarbon compound showing at retention time 28.45 minutes and compound is Octacosane ( $C_{28}H_{58}$ ) and molecular weight is 394. In the fuel all hydrocarbon compounds contains heavy hydrocarbon and their derivatives as well as hydrocarbon range is  $C_5$ - $C_{28}$ . In the detail analysis prospects maximum compounds are mention from the analysis result index. Such as in detail analysis according to the retention 1.95 and trace mass 42, compound is Pentane ( $C_5H_{10}$ ), retention time 2.53 and trace mass 41, compound is Cyclopropane,1-ethyl-2-methyl -cis- ( $C_6H_{12}$ ), retention time 2.61 and trace mass, compound is Hexane ( $C_6H_{12}$ ), retention time 3.65 and trace mass 41, compound is 1-Heptene ( $C_7H_{14}$ ), retention time 3.78 and trace mass 41, compound is Heptane ( $C_7H_{16}$ ), retention time 5.19 and trace mass 41, compound is 1-Octene ( $C_8H_{16}$ ), retention time 5.35 and trace mass 43, compound is Octane ( $C_8H_{18}$ ), retention time 6.92 and trace mass 41, compound is 1-Nonene ( $C_9H_{18}$ ), retention time 7.07 and trace mass 43, compound is Nonane ( $C_9H_{20}$ ), retention time 8.65 and trace mass 41, compound is 1-Decene ( $C_{10}H_{20}$ ), retention time 8.79 and trace mass 43, compound is compound is Decane ( $C_{10}H_{22}$ ), retention time 10.30 and trace mass 43, compound is 1-Undecene ( $C_{11}H_{22}$ ), retention time 10.43 and trace mass 43, compound is Undecane ( $C_{11}H_{24}$ ), retention time 11.85 and trace mass 41, compound is 1-Decene ( $C_{10}H_{24}$ ), retention time 11.98 and trace mass 43, compound is Dodecane ( $C_{12}H_{26}$ ), retention time 13.32 and trace mass 41, compound is 1-Tridecane ( $C_{13}H_{28}$ ), retention time 13.43 and trace mass 43, compound is Tridecane ( $C_{13}H_{28}$ ), retention time 14.70 and trace mass 41, compound is

1-Tetradecene ( $C_{14}H_{28}$ ), retention time 14.81 and trace mass 43, compound is Tetradecane ( $C_{14}H_{30}$ ), retention time 16.00 and trace mass 41, compound is 1-Pentadecene ( $C_{15}H_{30}$ ), retention time 16.11 and trace mass 43, compound is Pentadecane ( $C_{15}H_{32}$ ), retention time 17.23 and trace mass 41, compound is 1-Hexadecene ( $C_{16}H_{32}$ ), retention time 17.33 and trace mass 57, compound is Hexadecane ( $C_{16}H_{34}$ ), retention time 18.40 and trace mass 41, compound is E-14-hexadecenal, ( $C_{16}H_{30}O$ ), retention time 18.48 and trace mass 57, compound is Heptadecane ( $C_{17}H_{36}$ ), retention time 19.50 and trace mass 41, compound is 1-Nonadecene ( $C_{19}H_{38}$ ), retention time 20.65 and trace mass 57, compound is Nonadecane ( $C_{19}H_{40}$ ), retention time 21.65 and trace mass 85, compound is Eicosane ( $C_{20}H_{42}$ ), retention time 22.62 and trace mass 57, compound is Heneicosane ( $C_{20}H_{42}$ ) etc. In the ultimate phase of the analysis index at retention time 23.54 and trace mass 43, compound is Heneicosane ( $C_{20}H_{42}$ ), retention time 24.42 and trace mass 85, and compound is Heneicosane ( $C_{20}H_{42}$ ) as well, retention time 25.26 and trace mass 57, compound is Tetracosane ( $C_{24}H_{50}$ ), retention time 26.09 and trace mass 71, compound is Heneicosane ( $C_{21}H_{44}$ ), retention time 26.88 and trace mass 57, compound is Heneicosane ( $C_{21}H_{44}$ ), retention time 27.67 and trace mass 57, compound is Octacosane ( $C_{28}H_{58}$ ), retention time 28.45 and trace mass 57, compound is Octacosane ( $C_{28}H_{58}$ ), retention time 29.21 and trace mass 57, compound is Heptacosane ( $C_{28}H_{58}$ ) and eventually retention time 29.99 and trace mass 57, compound is same as previous peak that is Heptacosane ( $C_{28}H_{58}$ ) respectively.



**Figure 1.** LDPE (Low density polyethylene) waste plastic to heavy fuel production process diagram

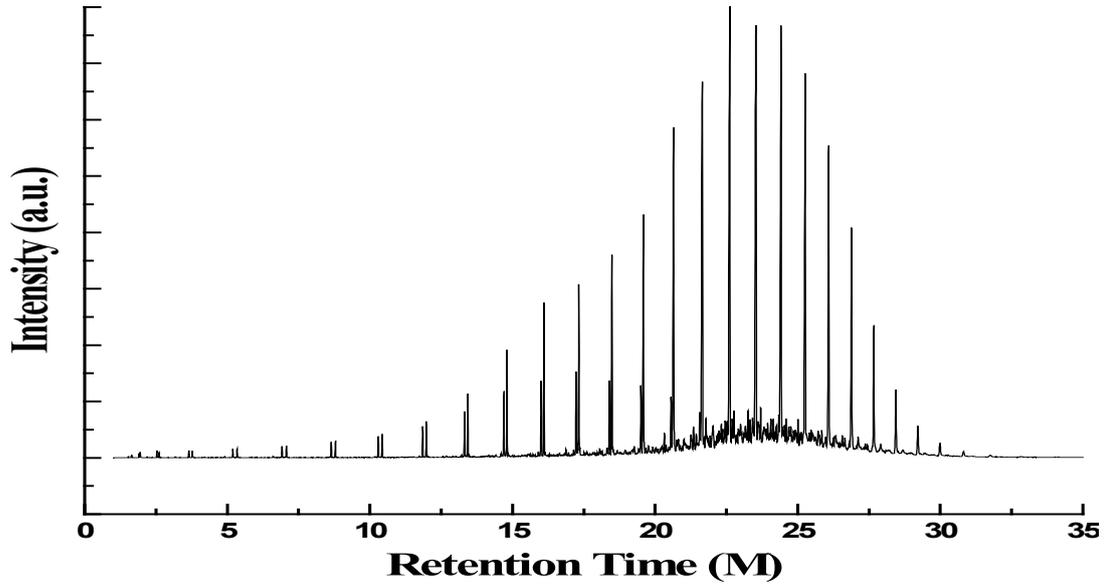


Figure 2. GC/MS (Gas Chromatography and Mass Spectrometer) Chromatogram of LDPE waste plastic to heavy fuel

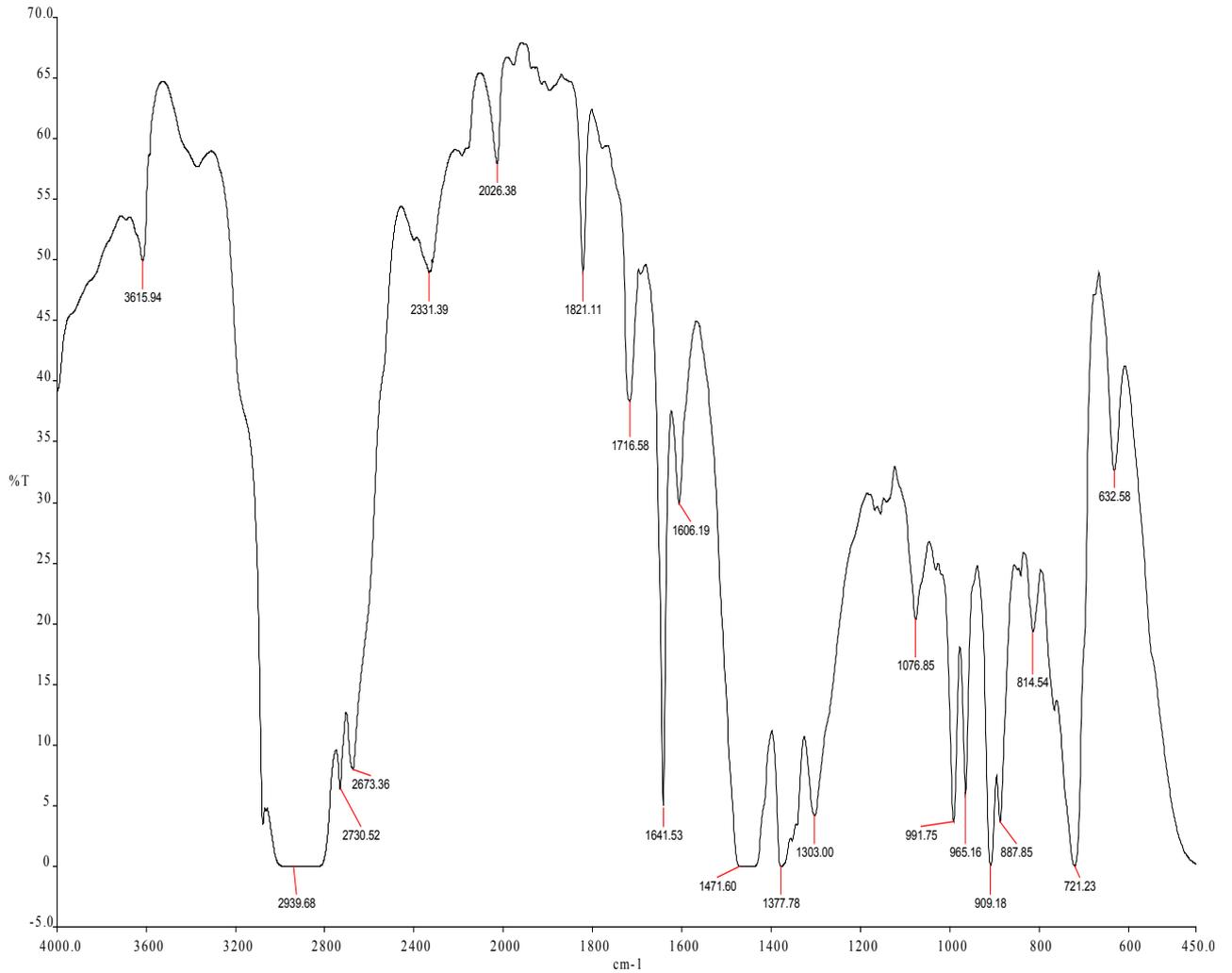


Figure 3. FT-IR (Fourier transform infrared spectroscopy) Spectrum of LDPE waste plastic to heavy fuel

**Table 1.** GC/MS (Gas Chromatography and Mass Spectrometer) Chromatogram of LDPE waste plastic to heavy fuel compound list

Number of Peak	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	NIST (National Institute of Standards and Technology) Library Number
1	1.91	42	Cyclopropane, ethyl-	C <sub>5</sub> H <sub>10</sub>	70	114410
2	1.95	43	Pentane	C <sub>5</sub> H <sub>12</sub>	72	114462
3	2.53	41	Cyclopropane, 1-ethyl-2-methyl-, cis-	C <sub>6</sub> H <sub>12</sub>	84	113658
4	2.61	41	Hexane	C <sub>6</sub> H <sub>14</sub>	86	61280
5	3.65	41	1-Heptene	C <sub>7</sub> H <sub>14</sub>	98	107734
6	3.78	41	Heptane	C <sub>7</sub> H <sub>16</sub>	100	61276
7	5.19	41	1-Octene	C <sub>8</sub> H <sub>16</sub>	112	1604
8	5.35	43	Octane	C <sub>8</sub> H <sub>18</sub>	114	229407
9	6.92	41	1-Nonene	C <sub>9</sub> H <sub>18</sub>	126	107756
10	7.07	43	Nonane	C <sub>9</sub> H <sub>20</sub>	128	228006
11	8.65	41	1-Decene	C <sub>10</sub> H <sub>20</sub>	140	118883
12	8.79	43	Decane	C <sub>10</sub> H <sub>22</sub>	142	114147
13	10.30	41	1-Undecene	C <sub>11</sub> H <sub>22</sub>	154	5022
14	10.43	43	Undecane	C <sub>11</sub> H <sub>24</sub>	156	107774
15	11.85	41	1-Decene	C <sub>10</sub> H <sub>20</sub>	140	118883
16	11.98	43	Dodecane	C <sub>12</sub> H <sub>26</sub>	170	291499
17	13.32	41	1-Tridecene	C <sub>13</sub> H <sub>26</sub>	182	34733
18	13.43	43	Tridecane	C <sub>13</sub> H <sub>28</sub>	184	114282
19	14.70	41	1-Tetradecene	C <sub>14</sub> H <sub>28</sub>	196	34720
20	14.81	43	Tetradecane	C <sub>14</sub> H <sub>30</sub>	198	113925
21	16.00	41	1-Pentadecene	C <sub>15</sub> H <sub>30</sub>	210	69726
22	16.11	43	Pentadecane	C <sub>15</sub> H <sub>32</sub>	212	107761
23	17.23	41	1-Hexadecene	C <sub>16</sub> H <sub>32</sub>	224	69727
24	17.33	57	Hexadecane	C <sub>16</sub> H <sub>34</sub>	226	114191
25	18.40	41	E-14-Hexadecenal	C <sub>16</sub> H <sub>30</sub> O	238	130980
26	18.48	57	Heptadecane	C <sub>17</sub> H <sub>36</sub>	240	107308
27	19.50	41	1-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113626
28	19.59	57	Nonadecane	C <sub>19</sub> H <sub>40</sub>	268	114098
29	20.56	41	1-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113626
30	20.65	57	Nonadecane	C <sub>19</sub> H <sub>40</sub>	268	114098
31	21.65	85	Eicosane	C <sub>20</sub> H <sub>42</sub>	282	290513
32	22.62	57	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
33	23.54	43	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
34	24.42	85	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
35	25.26	57	Tetracosane	C <sub>24</sub> H <sub>50</sub>	338	248196
36	26.09	71	Heneicosan	C <sub>21</sub> H <sub>44</sub>	296	107569
37	26.88	57	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
38	27.67	57	Octacosane	C <sub>28</sub> H <sub>58</sub>	394	134306
39	28.45	57	Octacosane	C <sub>28</sub> H <sub>58</sub>	394	134306
40	29.21	57	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380	79427
41	29.99	57	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380	79427

**Table 2.** LDPE (Low density polyethylene) waste plastic to heavy fuel functional group name

Number of Wave	Wave Number (cm <sup>-1</sup> )	Functional Group Name	Number of Wave	Wave Number (cm <sup>-1</sup> )	Functional Group Name
1	3615.94	Free OH	11	1471.60	CH <sub>3</sub>
2	2939.68	C-CH <sub>3</sub>	12	1377.78	CH <sub>3</sub>
3	2730.52	C-CH <sub>3</sub>	15	991.75	-CH=CH <sub>2</sub>
4	2673.36	C-CH <sub>3</sub>	16	965.16	-CH=CH-(cis)
7	1821.11	Non-Conjugated	17	909.18	-CH=CH <sub>2</sub>
8	1716.58	Non-Conjugated	18	887.85	C=CH <sub>2</sub>
9	1641.53	Non-Conjugated	20	721.23	-CH=CH-(cis)
10	1606.19	Conjugated			

Perkin Elmer FT-IR (Fourier transform infrared spectroscopy, Spectrum 100 ) analysis of LDPE waste plastic to heavy fuel oil (Figure 3 and Table 2) shows the following types of functional groups starting at wave number 3615.94 cm<sup>-1</sup>, derived functional group is Free OH, wave number 2939.68 cm<sup>-1</sup>, 2730.52 cm<sup>-1</sup> and 2673.36 cm<sup>-1</sup> functional group is C-CH<sub>3</sub>, wave number 1821.11 cm<sup>-1</sup>, 1716.58 cm<sup>-1</sup>, and 1641.53 cm<sup>-1</sup> functional group is Non-Conjugated, wave number 1606.19 cm<sup>-1</sup> functional group is Conjugated. As well as wave number 1471.60 cm<sup>-1</sup> and 1377.78 cm<sup>-1</sup> functional group is CH<sub>3</sub>, wave number 991.75 cm<sup>-1</sup> and 909.18 cm<sup>-1</sup>, functional group is -CH=CH<sub>2</sub> and ultimately wave number 887.85 cm<sup>-1</sup> functional group is C=CH<sub>2</sub> and wave number 721.33 cm<sup>-1</sup> functional group is -CH=CH-(cis). Energy values are calculated, using formula is E=hv, Where h=Planks Constant, h =6.626x10<sup>-34</sup> J, v= Frequency in Hertz (sec<sup>-1</sup>), Where v=c/λ, c=Speed of light, where, c=3x10<sup>10</sup> m/s, W=1/λ, where λ is wave length and W is wave number in cm<sup>-1</sup>. Therefore the equation E=hv, can

substitute by the following equation, E=hcW. All functional group band energy is reflecting calorific value. According to their wave number such as for 3615.94 (cm<sup>-1</sup>) calculated energy, E=7.18x10<sup>-20</sup> J. Similarly, wave number 2939.68 (cm<sup>-1</sup>) calculated energy , E=5.83x10<sup>-20</sup> J, wave number 2730.52 (cm<sup>-1</sup>) calculated energy, E=5.42x10<sup>-20</sup> J, wave number 2673.36 (cm<sup>-1</sup>) calculated energy, E=5.31x10<sup>-20</sup> J, wave number 1821.11 (cm<sup>-1</sup>) calculated energy, E=3.61x10<sup>-20</sup> J, wave number 2730.52 (cm<sup>-1</sup>) calculated energy, E=5.42x10<sup>-20</sup> J, wave number 1716.58 (cm<sup>-1</sup>) energy, E =3.40x10<sup>-20</sup> J, wave number 1471.60 (cm<sup>-1</sup>) calculated energy, E=2.92x10<sup>-20</sup> J, wave number 1377.78 (cm<sup>-1</sup>) energy, E = 2.73x10<sup>-20</sup> J, wave number 991.75 (cm<sup>-1</sup>) calculated energy, E=1.97x10<sup>-20</sup> J, wave number 965.16 (cm<sup>-1</sup>) calculated energy, E=1.91x10<sup>-20</sup> J, wave number 887.85 (cm<sup>-1</sup>) calculated energy, E=1.80x10<sup>-20</sup> J, wave number 909.18 (cm<sup>-1</sup>) calculated energy, E=1.80x10<sup>-20</sup> J and eventually wave number 721.23 (cm<sup>-1</sup>) calculated energy is , E=1.43x10<sup>-20</sup> J 1.97x10<sup>-20</sup> J respectively.

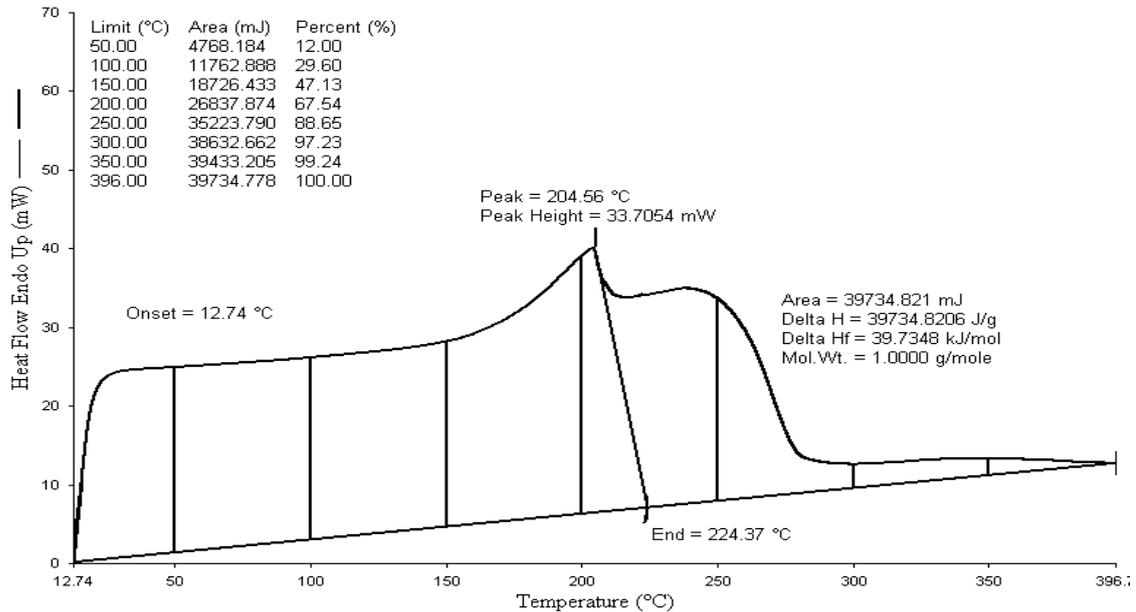


Figure 4. Differential Scanning Calorimeter (DSC) graph of LDPE waste plastic to heavy fuel

Table 3. Low density polyethylene to solid black residue analysis result by ICP (Induced Coupled Plasma)

Test Method Name	Trace Metal Name	LDPE Waste Plastic to Residue (ppm)	Test Method Name	Trace Metal Name	LDPE Waste Plastic to Residue (ppm)
ASTM D1976	Silver	<1.0	ASTM D1976	Magnesium	221.6
	Aluminium	7806		Manganese	17.8
	Arsenic	23.6		Sodium	1201
	Boron	24.3		Nickel	148.7
	Barium	11.4		Lead	10.8
	Beryllium	<1.0		Antimony	<1.0
	Calcium	1041		Selenium	<1.0
	Cadmium	<1.0		Silicon	77.0
	Chromium	29.2		Tin	274.3
	Copper	82.4		Titanium	191.1
	Iron	4280		Vanadium	17.0
	Potassium	106.7		Zinc	1617
	Lithium	<1.0			

LDPE waste plastic to 5<sup>th</sup> fractional fuel or heavy fuel was (Figure 4) analysed by DSC (Differential scanning calorimeter) and measured the boiling point temperature and enthalpy value in this fuel. After analysis fuel sample we found onset temperature is 12.74 °C, Peak temperature is 204.56 °C and peak height is 33.7054 mW. Peak height represents the heat flow Endo up 40 % from total 100%. The graph showed area is 39734.821 mJ and enthalpy delta H value is 39734.8206 J/g. This produce fuel hydrocarbon compounds are heavier and making heavy fuel we used higher temperature profile in the fractionation process and temperature range was 340-365 °C. Fifth (5<sup>th</sup>) fractional or heavy fuel boiling starts from at 12.74 °C and end boiling temperature finished almost close to 300 °C, because this fuel has heavier straight long chain hydrocarbon compounds like alkane or alkene compounds.

In Table 3 showed trace metal analysis result by using ICP from LDPE waste plastic to heavy fuel production. Solid black residue generated 3% from total initial feed. This residue was left over because plastic manufacturing company adding different types of additives for plastic hard shape and thickness. This additive was come out or left over after fuel production process and this solid residue have also good Btu (British thermal units) value. ICP (American Standard Testing Method) (ASTM) D1976 test result showed that in LDPE waste plastic to residue trace metal content are Aluminium <1.0 ppm (Parts per million), Arsenic 23.6 ppm, Boron 24.3 ppm, Barium 11.4 ppm, Beryllium <1.0 ppm, Calcium 1041 ppm, Cadmium <1.0 ppm, Chromium 29.2 ppm, Copper 82.4 ppm, Iron 4280 ppm, Potassium 106.7 ppm, Lithium <1.0 ppm, Silver <1.0 ppm, Magnesium 221.6 ppm, Manganese 17.8 ppm, Sodium 1201 ppm, Nickel 148.7 ppm, Lead 10.8 ppm, Antimony <1.0 pp, Selenium <1.0 ppm, Silicon 77.0 ppm, Tin 274.3 ppm, Titanium 191.1 ppm, Vanadium 17.0 ppm, Zinc 1617 ppm.

## 4. Conclusions

Thermal cracking with fractional distillation process was performed with LDPE waste plastic and produced fractional heavy fuel without using any kind of catalyst. Two types of temperature were used for this experiment one was liquefaction temperature and another one was fractional distillation column temperature for LDPE waste plastic to heavy fuel generation. Produced fuel was analysis by using various types of equipment such as GC/MS, FT-IR and DSC. GC/MS analysis result indicates that produced fuel has short chain hydrocarbon to long chain hydrocarbon compounds and starting short chain hydrocarbon compound carbon number is C5 and long chain hydrocarbon compound carbon number is C28. By using FT-IR analysis result showed also produced fuel functional group band energy. LDPE waste plastic to heavy fuel has alkane and alkene group compound which is aliphatic compound because in the initial raw material compound was only

straight chain hydrocarbon compounds. Produced fuel could be use all heavy equipment engine or feed for feed stock refinery or feed for electricity generation. By using this established technology could be solve the LDPE waste plastic related environmental problem and boost up the renewable energy generation from LDPE waste plastic.

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