

# Sustainable Valorization of Municipal Wastes Plastics for Fuel with Environmental Safety via Medium Temperature Thermolysis Process

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## ABSTRACT

Waste plastics are increasing day by day all over the world. USA households alone generate 48 million ton of waste plastic and rest of the world is generating 230 million ton of waste plastic. Waste plastic are creating environmental problems as they are not bio degradable. The waste plastic dumped into landfill does not decay for a long period of time. From the total waste plastic only 6-10 % is recyclable, 25 % is incinerated and the remaining 65% waste plastic is dumped into landfills. Waste plastic dumping has a financial impact also. One ton waste plastic dumping costs almost 2800 US Dollars. More than 100 million ton of waste plastic is dumped into sea. This huge amount of waste plastic is affecting ocean current and creating ecological problems. Sunlight and ocean waves break it down into small pieces which severely affect the marine life causing death to many oceanic animals. Plastic is made from crude oil and waste plastic can be turned into petroleum again. Established technology can convert all of waste plastic into valuable energy or hydrocarbon liquid fuel. This fuel can be used in all kind of combustion engines.

**Keywords:** *Waste plastic, valuable energy, thermal, degradation, fuel, environmental, sustainable*

## 1. INTRODUCTION

Waste plastics are a major cause of environmental and social problems causing loss of natural resources, environmental pollution, and depletion of landfill space. Ever increasing demand for an environment-oriented society requires a solution to Waste Plastics. Production of plastics in the world amounted to about 230–250 million tons in 2005 (about 45–50 million tones only in the EU) [1,2]. Developed countries are major consumers of plastic products. In Japan, the consumption of plastics amounted to more than 10 million tones/per year in 2004 [3] and in China rose from 23 (in 2000) to 31.2 million metric tons in 2003, with an average annual growth rate of 11.8% [4]. In Poland, plastics consumption exceeded 1.67 million tons in 2007 and over 75% of them were polyolefins [5]. The consumption of plastics per capita differs very much in the world even in developed countries; in Europe the consumption of plastics was about 24–150 kg/person in the years 2003–2005 while 10 years earlier the average consumption in the EU had been about 50–60 kg/person [2,6]; in Poland it was about 45 kg/person in 2007 [5]. The amount of post-consumer plastics was estimated for 22–25 million tones only in EU, in 2005 [2,6]. They represent only 7–9% of total wastes in terms of mass but 30% in terms of volume (in household wastes). Their amount has been increasing 6–7% year by year and will be increasing due to low consumption of plastics in developing countries [1, 7, 8]. The main part (over 70% by mass) of household waste plastics stream are polyolefins (LDPE, HDPE, LLDPE, PP), and polystyrene (PS).

At least, 30-40 commercial technologies are available for thermal degradation of post-consumer plastics, based on pyrolysis or catalytic cracking, to fuel like liquid mixture of hydrocarbons as basic product [1, 2, 9–16]. They are usually carried out at temperature 350–430 °C. However, the industrial plants are rare or have been running for a very short time. It means that proposed

reactors and technologies were imperfect and their profitability was weak. The unfavorable situation of feedstock recycling of waste polymers is mostly based on the high investments costs of recycling, necessity of frequent cleaning of the reactor, costs of catalysts and other economic circumstances, e.g. taxes. During the period 2004–2006, over 30 small industrial plants were built in Poland and waste plastics were liquefied with the yield of 70–80% (for the liquid product). The processes were based on three different technologies that exploited thermal or thermo-catalytic cracking. All of them were closed due to decreased profitability during 2007. Therefore, searching for new technologies and reactors is strongly recommended. The new technologies (and reactors) should have following features: – Low operating costs and investments costs are needed because the plastics, waste plastics, the products of degradation are not expensive and running of the conversion process has to be profitable for investors. – The process should be carried out without catalysts due to difficulties and cost of their recovering. – The yield of liquid product should have been high as it is usually more valuable than gaseous product. – Frequency of cleaning of the reactor has to be low. – The heat transfer resistance between particles of wastes and heating medium should be minimized. – Cooking process should be minimized or even eliminated. – The plant in the industrial scale should have modular construction. It allows for greater flexibility and enables construction of small or large plants with almost the same profitability. In some local and economical conditions, small plants may be more profitable and in other larger industrial plants will be more efficient (e.g. if it be constructed in the area of oil refinery plant). At present, it is almost impossible to dispose of waste plastics by landfill due to the law, high costs, and higher ecological consciousness of people. However, there are also some technological and economic constrains that limit the full and efficient recycling of plastic wastes into useful products, e.g. contaminated waste plastics can be only

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partly recycled into new products and reuse of packaging containers is limited by the collection systems. Mechanical recycling that probably is the best way of reclaiming plastics refers to the processes which involve sorting, shredding or melting and re-granulation. It may be applied only for the same type and clean plastics [17].

## 2. METHOD AND MATERIALS

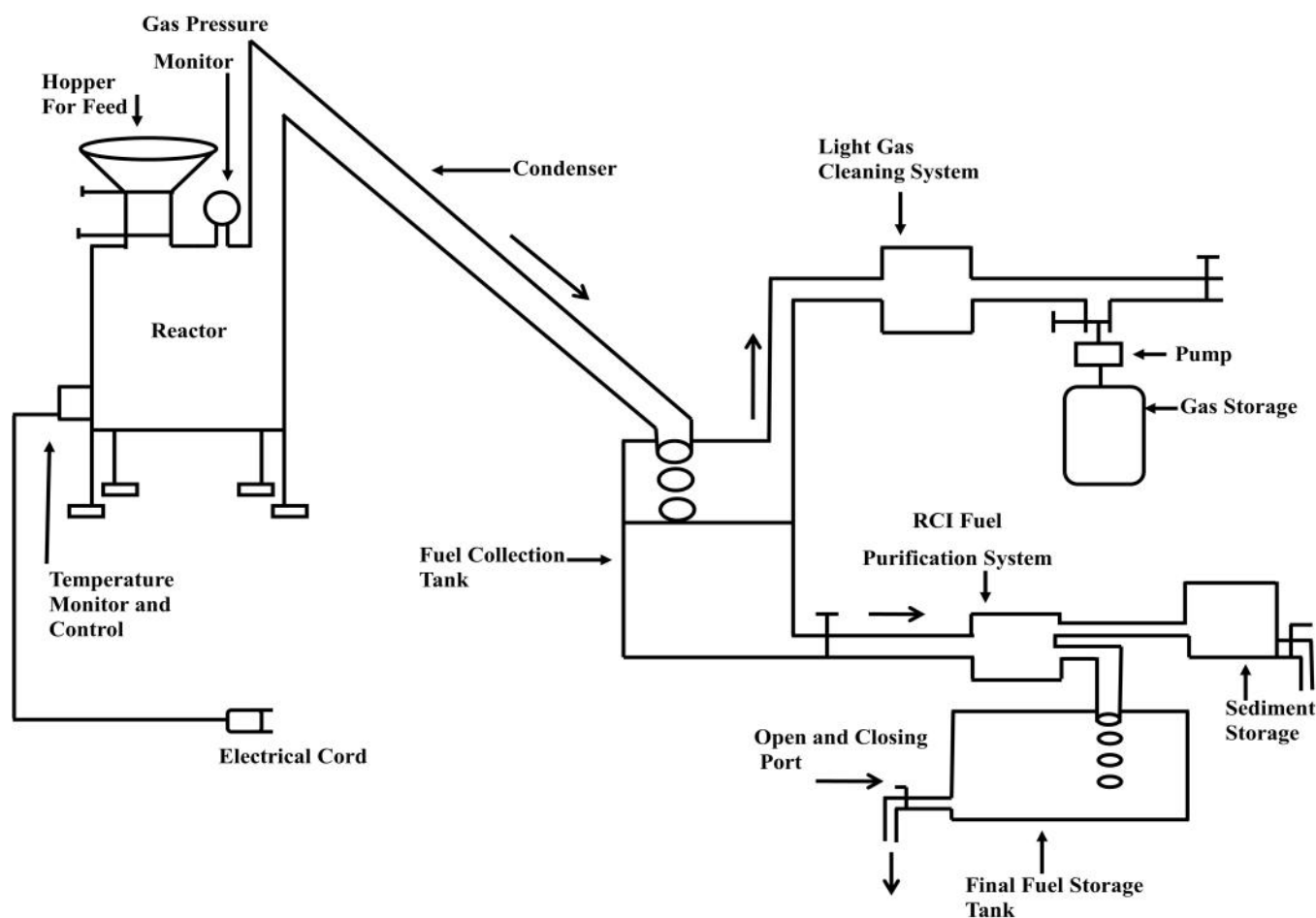
### 2.1 Sample Collection And Preparation

Waste plastic samples were collected from local grocery store. Collected waste plastic was low density polyethylene (LDPE), high density polyethylene (HDPE) and Polystyrene (PS). These waste plastic were with foreign materials such as food particle, dust, sand and liquid products. These waste plastic were separated from foreign material and washed with detergent. Washed out waste plastic was cut into 3 inch - 4 inch pieces using scissor. These 3-4 inch pieces were put into grinder machine and grounded to size 3-4 mm for reactor setup.

### 2.2 Sample Pre-Analysis

HDPE/LDPE/PS raw sample was analyzed by different types of equipment such as Perkin Elmer gas chromatography and mass spectrometer, FT-IR (Spectrum 100), TGA (pyris-1) and EA-2400 (CHN mode). By using GC/MS with CDS 5000 series pyroprobe the raw samples LDPE/HDPE/PS were analyzed. From the results of GC/MS analysis we found that most of the compound was double bonded. The GC/MS analysis of LDPE and HDPE waste plastics showed long chain aliphatic hydrocarbon with different retention time. PS waste plastic has also aliphatic hydrocarbon but PS has also aromatic hydrocarbon compound mixture. Polystyrene made with styrene for that reason we performed PS GC/MS chromatogram analysis most of the hydrocarbon compound were mixed with aromatic group compound. FT-IR (spectrum 100) ATR system used for raw sample analysis and determine raw sample functional group and band energy. TGA analysis provided us raw sample onset temperature and from onset temperature we were able to determine experimental process temperature profile. By using EA-2400 analysis of raw material LDPE/HDPE/PS provided us carbon (C) %, Hydrogen (H) % and Nitrogen (N) %.

### 2.3 Process Description



**Fig 1:** Schematic diagram of HDPE, LDPE and PS waste plastic mixture to fuel production process

Three types of waste plastics HDPE/LDPE/PS mixture of grounded plastic was put into reactor chamber (seen fig. 1). Reactor chamber was made of stainless steel and reactor's temperature range is 0-500 °C. 70 °C angle condenser unit set for condensation. Condenser is 5 feet long with one end attached to the reactor and another end hook up with collection tank. Collection tank has two ports, one port is set up with gas cleaning system and the other bottom port is setup with RCI fuel purification system. Horizontal steel reactor is covered by insulator to conserve heat. Reactor sample capacity is 2-3 kg but for our experiment we used only 1 kg waste plastic mixture. Fully closed the system and under labconco fume hood the experiment was performed. Mixture of waste plastic was put into reactor chamber by using hopper and then the hopper port was closed by screw system. During the process no vacuum was created and no extra catalyst or any kind of chemical was added in this experiment. After setting up everything the experiment was started at temperature 150 °C to 430 °C and temperature was increased every 15 minute by 10°C. Our experiment started at 150 °C because of raw sample LDPE and HDPE plastic have melting temperature below 150 °C and only PS plastic has melting temperature 240 °C. The reactor was heated electrically. The reactor's electric input for the complete experiment was 6.83 kWh for 1 kg waste plastic conversion into fuel. Reactor's temperatures were controlled electricity using watlow device by manual system. During the heating period the waste plastics mixture inside of reactor broke down into long chain hydrocarbon to short chain hydrocarbon and creating endothermic reaction. Melted waste plastic turn into liquid form when heat was increased gradually producing gas vapor which at the end came out and through the condenser unit and at the end produced liquid mixture of hydrocarbon fuel. During the process light gas was produced and light gases are methane, ethane, propane butane and Pentane. This experiment did not apply any vacuum it has some moisture such as water, oxygen, nitrogen, carbon dioxide etc. During waste plastic heating period moisture are react with carbon  $C + H_2O = CO + H_2$ ,  $C + CO_2 = 2CO$ , these two reaction are heterogeneous and strongly endothermic thus the rise in temperature. Above two reactions are accompanied by other exothermic reactions, which contribute to the formation and depletion of the above discussed compound. These are for instance  $C + \frac{1}{2} O_2 = CO$ ,  $C + O_2 = CO_2$ ,  $CO + H_2O = CO_2 + H_2$ ,  $C + 2H_2 = CH_4$ ,  $CO + 3H_2 = CH_4 + H_2O$ ,  $CO_2 + 4H_2 = CH_4 + 2H_2O$ . Above all reaction we can calculate without vacuum is not affecting production and is not realize any harmful gas into environment. Using this technology can solve this environmental waste plastic problem. Collected fuel transfer into RCI centrifugal purification system removed all kind of fuel sediment. Produced light gas transfer into gal cleaning device after cleaned light gas send back to Teflon bag for future use.

### 3. RESULT AND DISCUSSION

#### 3.1 Analysis Technique

Perkin Elmer FT-IR (Spectrum 100) used for raw sample per analysis and liquid fuel sample analysis. Raw waste plastic sample analyzed by diamond crystal plate KRS 5 check there functional group and band energy value. Liquid fuel sample was analyzed by NaCl cell 0.025 mm thickness. Both samples analysis by same parameter used such as scan number was 32, resolution 4 and range 4000-450  $cm^{-1}$ .

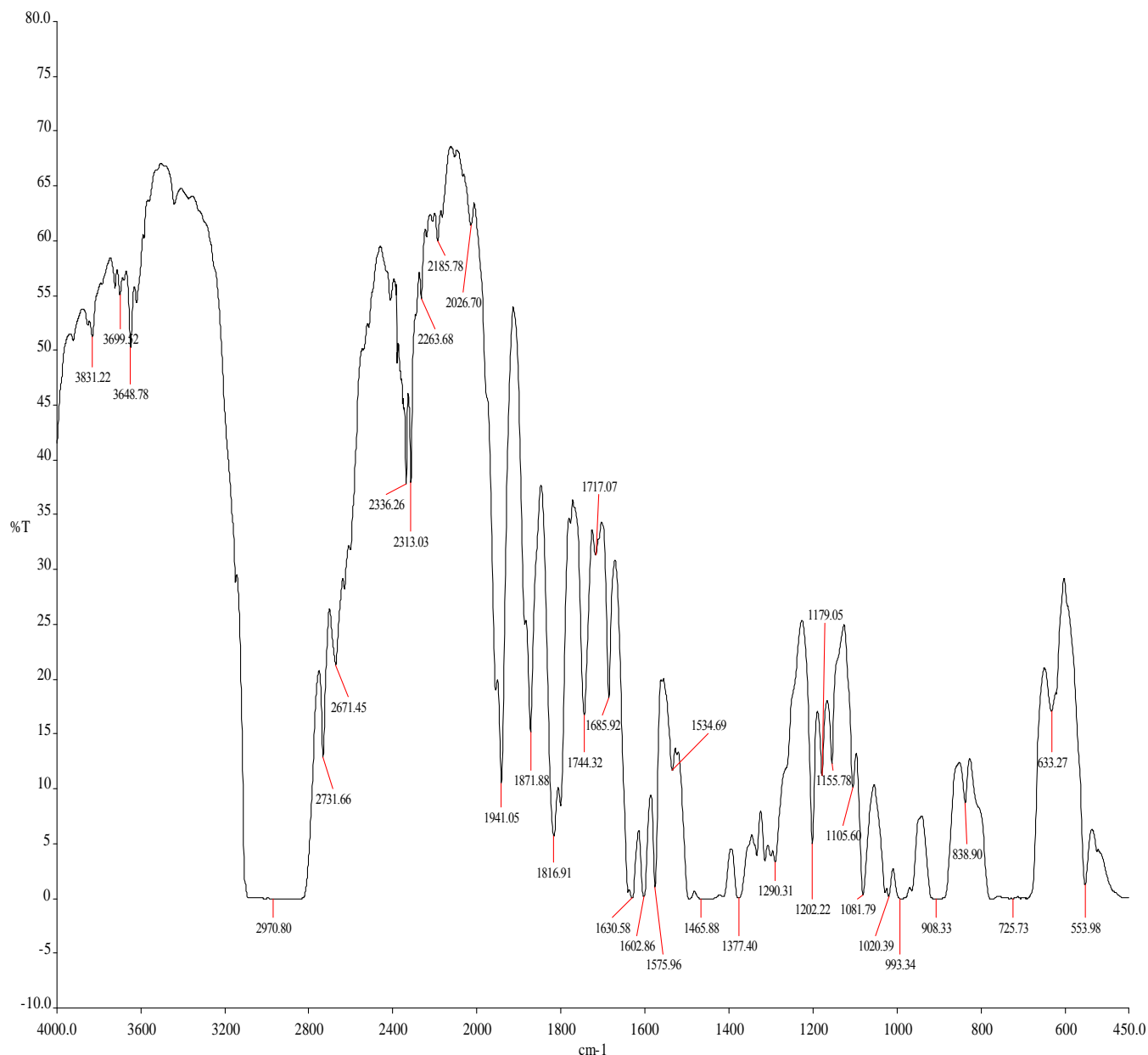
Perkin Elmer EA-2400 analyzer was used for raw waste plastics carbon; hydrogen and nitrogen percentages determine and follow ASTM method ASTM D5291.a. Carrier gas was used helium, oxygen and nitrogen.

Perkin Elmer Thermogravimetric (TGA Pyris-1) was used for raw waste plastics onset temperature measuring. Temperature range used starting 50 to 800 °C and temperature ramping range used for onset temperature 10 °C/min. Helium gas used as a carrier at 20 psi.

Perkin Elmer Gas Chromatography and Mass Spectrometer (Clarue 500 series) were used for raw waste plastic and liquid fuel analysis. Raw sample analysis was performed using pyroprobe (CDS 5000 series) to volatile solid sample and transfer into GC column. Liquid sample analysis was done using auto sampler system. GC temperature profile for liquid sample analysis was done at initial temperature 40°C and hold for 1 min and final temperature 325 °C, hold for 15 min. total experiment run time 44.50 minutes. GC column length 30 meter and mass program set up start mass 35 to 528 and ion mode EI+. Perkin Elmer Elite- 5MS Capillary Column Length is 30 meter, 0.25 mm ID, 0.5 um df, Maximum Program Temperature 350°C, Minimum Bleed at 330 °C. GC Program set up for sample analysis. Initial temperature 40 °C, in temperature 325 °C, temperature ramping 10 °C per minute, final temperature hold for 15 minute. Total sample run time is 44.50 minute. Sample inject volume is 0.5 µL, helium used as a carrier gas, Split Flow=101.0 ml/minute and mass program set up type MS scan, Ion Mode EI+, Data format - Centroid, Start Mass 35.00, End Mass 528.00, Scan Time (Sec) 0.25, Start Time (min) 1.00, End Time (min) 44.50. For Perkin Elmer GCMS analysis purposes a National Institute of Standard Testing (NIST-2002) mass spectral libraries software is used as library compound and in the analysis only those compounds are detected by their trace mass and retention time.

Perkin Elmer Differential Scanning Calorimeter (DSC) was used for liquid fuel boiling point and fuel enthalpy value indication. Program temperature range was 0-400 °C and temperature increased rate was 10 °C/min. Carrier gas was use nitrogen at 20 ml/ min.

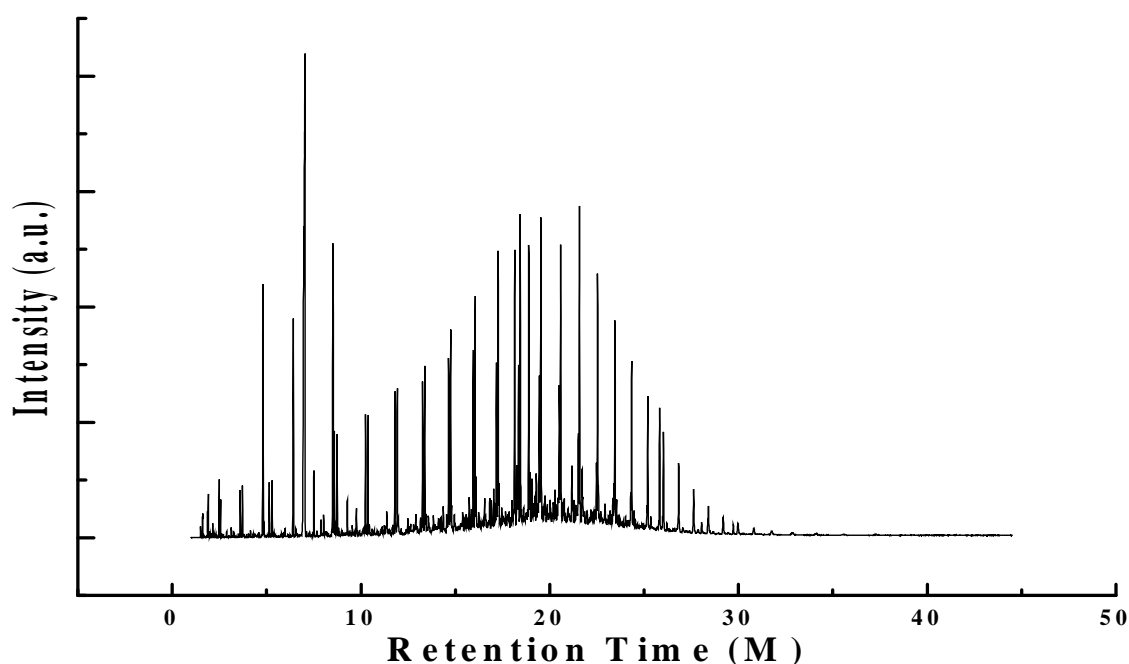
### 3.2 Liquid Fuel Analysis



**Fig 2: FT-IR Spectrum of Product Fuel**

FT-IR (spectrum 100) analysis of LDPE, HDPE & PS waste plastic mixture to fuel (fig. 2) in accordance with the wave number various kinds of compounds are appeared. According to wave number such as wave number 2970.80 (cm<sup>-1</sup>), 2671.66 (cm<sup>-1</sup>) functional group is C-CH<sub>3</sub>. Wave number 1871.88 cm<sup>-1</sup>, 1816.91 cm<sup>-1</sup> and 1744.32 cm<sup>-1</sup>, 1717.07 cm<sup>-1</sup> and 1630.58 cm<sup>-1</sup> functional group is Non-Conjugated, wave number 1602.86 cm<sup>-1</sup>, 1575.96 cm<sup>-1</sup> functional group is Conjugated etc. In the middle of the spectrum wave number 1465.88 cm<sup>-1</sup> and 1377.40 cm<sup>-1</sup> functional group is CH<sub>2</sub> and CH<sub>3</sub>, wave number 1020.39 cm<sup>-1</sup> functional group is Acetates etc. Eventually at the end of the spectrum peaks wave number 993.34 cm<sup>-1</sup> and 908.33 cm<sup>-1</sup> functional group is –

CH=CH<sub>2</sub> and wave number 725.73 cm<sup>-1</sup> functional group is –CH=CH– (cis). Energy values are calculated, using formula is  $E=h\nu$ , Where  $h$ =Planks Constant,  $h=6.626 \times 10^{-34}$  J,  $\nu$  = Frequency in Hertz (sec<sup>-1</sup>), Where  $\nu=c/\lambda$ ,  $c$  = Speed of light, where,  $c=3 \times 10^{10}$  m/s,  $W=1/\lambda$ , where  $\lambda$  is wave length in cm and  $W$  is wave number in cm<sup>-1</sup>. Therefore the equation  $E=h\nu$ , can substitute by the following equation,  $E=hcW$ . According to their wave number such as for 2970.80 (cm<sup>-1</sup>) calculated energy,  $E=5.90 \times 10^{-20}$  J. Similarly, wave number 1871.88 (cm<sup>-1</sup>) energy,  $E=3.71 \times 10^{-20}$  J, wave number 1377.40 (cm<sup>-1</sup>) energy,  $E=2.73 \times 10^{-20}$  J and eventually wave number 993.34 (cm<sup>-1</sup>) functional group is  $1.97 \times 10^{-20}$  J respectively.



**Fig 3:** GCMS chromatogram of product fuel

**Table 1:** Produce fuel GC/MS chromatogram compound list with different retention time

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	NIST Library Number
1	1.50	41	Propane	C <sub>3</sub> H <sub>8</sub>	44	18863
2	1.61	43	Butane	C <sub>4</sub> H <sub>10</sub>	58	18940
3	1.87	42	Cyclopropane, ethyl-	C <sub>5</sub> H <sub>10</sub>	70	19072
4	1.91	43	Pentane	C <sub>5</sub> H <sub>12</sub>	72	114462
5	1.95	55	2-Pentene, (E)-	C <sub>5</sub> H <sub>10</sub>	70	291780
6	2.49	41	Cyclopropane, 1-ethyl-2-methyl-, cis-	C <sub>6</sub> H <sub>12</sub>	84	113658
7	2.56	41	Hexane	C <sub>6</sub> H <sub>14</sub>	86	61280
8	3.13	67	Cyclopentene, 3-methyl-	C <sub>6</sub> H <sub>10</sub>	82	114408
9	3.25	78	Benzene	C <sub>6</sub> H <sub>6</sub>	78	114388
10	3.60	41	Cyclopentane, 1,2-dimethyl-, cis-	C <sub>7</sub> H <sub>14</sub>	98	114027
11	3.72	41	Heptane	C <sub>7</sub> H <sub>16</sub>	100	61276
12	4.81	39	1,5-Heptadien-3-yne	C <sub>7</sub> H <sub>8</sub>	92	142710
13	5.14	41	1-Octene	C <sub>8</sub> H <sub>16</sub>	112	1604
14	5.29	43	Octane	C <sub>8</sub> H <sub>18</sub>	114	229407
15	5.98	41	2,4-Dimethyl-1-heptene	C <sub>9</sub> H <sub>18</sub>	126	113516
16	6.42	91	Ethylbenzene	C <sub>8</sub> H <sub>10</sub>	106	158804
17	7.01	103	1,3,5,7-Cyclooctatetraene	C <sub>8</sub> H <sub>8</sub>	104	1259
18	7.03	51	Benzene, 1-azido-4-methyl-	C <sub>7</sub> H <sub>7</sub> N <sub>3</sub>	133	39082
19	7.50	105	Benzene, (1-methylethyl)-	C <sub>9</sub> H <sub>12</sub>	120	2135
20	7.88	117	Benzene, 2-propenyl-	C <sub>9</sub> H <sub>10</sub>	118	114744
21	8.03	91	Benzene, propyl-	C <sub>9</sub> H <sub>12</sub>	120	113930
22	8.52	103	-Methylstyrene	C <sub>9</sub> H <sub>10</sub>	118	30236
23	8.59	41	1-Decene	C <sub>10</sub> H <sub>20</sub>	140	118883

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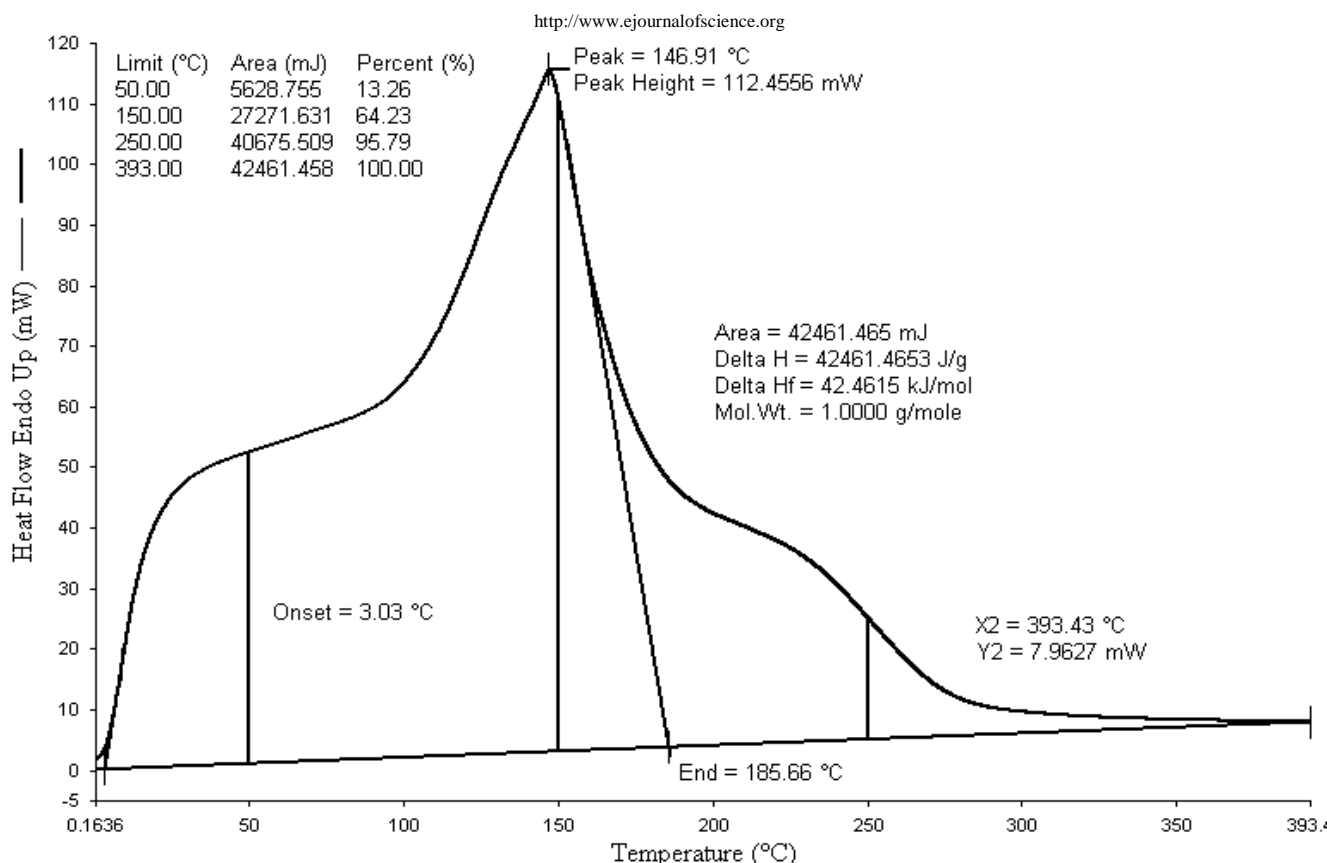
24	8.74	43	Decane	C <sub>10</sub> H <sub>22</sub>	142	114147
25	9.28	117	Benzene, 2-propenyl-	C <sub>9</sub> H <sub>10</sub>	118	114744
26	9.54	91	Benzene, 3-butenyl-	C <sub>10</sub> H <sub>12</sub>	132	113933
27	9.76	91	1,2,3,4,5,8-Hexahydronaphthalene	C <sub>10</sub> H <sub>14</sub>	134	113559
28	10.24	41	1-Undecene	C <sub>11</sub> H <sub>22</sub>	154	5022
29	10.38	43	Undecane	C <sub>11</sub> H <sub>24</sub>	156	114185
30	11.36	91	Benzene, pentyl-	C <sub>11</sub> H <sub>16</sub>	148	113915
31	11.80	41	3-Dodecene, (E)-	C <sub>12</sub> H <sub>24</sub>	168	113960
32	11.92	43	Dodecane	C <sub>12</sub> H <sub>26</sub>	170	291499
33	12.91	91	Benzene, hexyl-	C <sub>12</sub> H <sub>18</sub>	162	113954
34	13.27	41	2-Tridecene, (E)-	C <sub>13</sub> H <sub>26</sub>	182	142614
35	13.38	41	Tridecane	C <sub>13</sub> H <sub>28</sub>	184	114282
36	14.36	91	Benzene, heptyl-	C <sub>13</sub> H <sub>20</sub>	176	60570
37	14.64	43	1-Tetradecene	C <sub>14</sub> H <sub>28</sub>	196	34720
38	14.76	57	Tetradecane	C <sub>14</sub> H <sub>30</sub>	198	113925
39	15.73	91	Benzene, octyl-	C <sub>14</sub> H <sub>22</sub>	190	113879
40	15.94	41	1-Pentadecene	C <sub>15</sub> H <sub>30</sub>	210	69726
41	16.05	85	Pentadecane	C <sub>15</sub> H <sub>32</sub>	212	107761
42	16.55	91	Benzene, 1,1'-(1,2-ethanediyl)bis-	C <sub>14</sub> H <sub>14</sub>	182	187213
43	17.03	91	Benzene, nonyl-	C <sub>15</sub> H <sub>24</sub>	204	113903
44	17.18	41	1-Hexadecene	C <sub>16</sub> H <sub>32</sub>	224	118882
45	17.27	85	Hexadecane	C <sub>16</sub> H <sub>34</sub>	226	114191
46	18.14	91	Benzene, 1,1'-(1,3-propanediyl)bis-	C <sub>15</sub> H <sub>16</sub>	196	133399
47	18.26	92	Benzene, [3-(2-cyclohexylethyl)-6-cyclopentylhexyl]-	C <sub>25</sub> H <sub>40</sub>	340	23414
48	18.34	55	9-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113627
49	18.44	57	Heptadecane	C <sub>17</sub> H <sub>36</sub>	240	107308
50	18.34	55	9-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113627
51	18.44	57	Heptadecane	C <sub>17</sub> H <sub>36</sub>	240	107308
52	18.89	104	Naphthalene, 1,2,3,4-tetrahydro-2-phenyl-	C <sub>16</sub> H <sub>16</sub>	208	9510
53	19.06	115	1,2-Diphenylcyclopropane	C <sub>15</sub> H <sub>14</sub>	194	135351
54	19.29	91	Benzene, 1,1'-(1,4-butanediyl)bis-	C <sub>16</sub> H <sub>18</sub>	210	118778
55	19.45	55	1-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113626
56	19.53	71	Octadecane	C <sub>18</sub> H <sub>38</sub>	254	57273
57	20.51	55	1-Nonadecene	C <sub>19</sub> H <sub>38</sub>	266	113626
58	20.58	56	Eicosane	C <sub>20</sub> H <sub>42</sub>	282	290513
59	21.51	43	1-Docosene	C <sub>22</sub> H <sub>44</sub>	308	113878
60	21.58	71	Eicosane	C <sub>20</sub> H <sub>42</sub>	282	290513
61	21.71	204	2-Phenylnaphthalene	C <sub>16</sub> H <sub>12</sub>	204	113420
62	22.48	43	1-Docosene	C <sub>22</sub> H <sub>44</sub>	308	113878
63	22.54	85	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
64	23.40	55	1-Docosene	C <sub>22</sub> H <sub>44</sub>	308	113878
65	23.46	57	Eicosane	C <sub>20</sub> H <sub>42</sub>	282	290513
66	24.34	57	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	107569
67	25.19	57	Octacosane	C <sub>28</sub> H <sub>58</sub>	394	134306
68	25.82	91	(2,3-	C <sub>22</sub> H <sub>20</sub> OS	332	142947

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			Diphenylcyclopropyl)methyl phenyl sulfoxide, trans-			
69	26.02	57	Octacosane	C <sub>28</sub> H <sub>58</sub>	394	134306
70	26.83	57	Nonacosane	C <sub>29</sub> H <sub>60</sub>	408	150573
71	27.62	57	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380	79427
72	28.41	57	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380	79427
73	29.73	306	1,1':3',1''-Terphenyl, 5'- phenyl-	C <sub>24</sub> H <sub>18</sub>	306	57402
74	29.97	57	Heptacosane	C <sub>27</sub> H <sub>56</sub>	380	79427

GC-MS Analysis of HDPE, LDPE & PS mixture waste plastics to Fuel (fig. 3 table 1) in accordance with the various retention times and trace masses different types of hydrocarbon compound and benzene derivatives compounds are appeared in the analysis result index. Many compounds on analysis emerged to be of carbon range C<sub>3</sub> to C<sub>27</sub>. Three types of plastics fuel are mixed together in order to produce fuel and in the produced fuel different types of blended hydrocarbon compound are available. Based on the retention time and trace mass following hydrocarbon compounds were noticed, at the initial phase of the analysis at retention time 1.50 and trace mass 41, compound is Propane (C<sub>3</sub>H<sub>8</sub>), retention time 1.61 and trace mass 43, compound is Butane (C<sub>4</sub>H<sub>10</sub>), retention time 1.87 and trace mass 42, compound is Cyclopropane,1-ethyl-2-methyl-,cis-(C<sub>6</sub>H<sub>12</sub>), retention time 2.56 and trace mass 41, compound is Hexane (C<sub>6</sub>H<sub>14</sub>), retention time 3.72 and trace mass 41, compound is Heptane (C<sub>7</sub>H<sub>16</sub>), retention time 4.81 and trace mass 39, compound is 1,5-Heptadien-3-yne (C<sub>7</sub>H<sub>8</sub>), retention time 5.98 and trace mass 41, compound is 2,4-Dimethyl-1-heptene (C<sub>9</sub>H<sub>18</sub>), retention time 6.42 and trace mass 91, compound name is Ethylbenzene, (C<sub>8</sub>H<sub>10</sub>), retention time 7.50 and trace mass 105, compound name is Benzene,1-azido-4-methyl, (C<sub>7</sub>H<sub>7</sub>N<sub>3</sub>), retention time 8.59 and trace mass 41, compound is 1-Decene (C<sub>10</sub>H<sub>20</sub>), retention time 9.76 and trace mass 91, compound is 1,2,3,4,5,8-Hexahydronaphthalene (C<sub>10</sub>H<sub>14</sub>), retention time 10.24 and trace mass 41, compound is 1-Undecene (C<sub>11</sub>H<sub>22</sub>), retention time 11.92 and trace mass 43, compound is Dodecane (C<sub>12</sub>H<sub>26</sub>), retention time 12.91 and trace mass 91 compound is Benzene, hexyl- (C<sub>12</sub>H<sub>18</sub>), retention time 14.76 and trace mass 57, compound is Tetradecene (C<sub>14</sub>H<sub>28</sub>), retention time 15.94 and trace mass 41, compound is 1-Pentadecene (C<sub>15</sub>H<sub>30</sub>), retention time 17.03 and trace mass 91, compound is Benzene,

nonyl- (C<sub>15</sub>H<sub>24</sub>), retention time 18.14 and trace mass 91, functional group is Benzene,1,1'-(1,3-propanediyl)bis-(C<sub>15</sub>H<sub>16</sub>), benzene compounds are formed because when raw polystyrene are made styrene are added into the as a reactants. Also at retention time 18.44 and trace mass 47, compound is Heptadecane (C<sub>17</sub>H<sub>36</sub>), retention time 18.89 and trace mass 104, compound is Naphthalene, 1,2,3,4-tetrahydro-2-phenyl-(C<sub>16</sub>H<sub>16</sub>), polystyrene aromatic hydrocarbon it burns with an orange-yellow flame, giving off soot, as is characteristic of materials containing aromatic rings. More over hydrocarbon single bond, double bond and conjugated compound appeared because of low density polyethylene and high density polyethylene is mixed with the PS in the experiment. Retention time 19.53 and trace mass 71, compound is Octadecane, (C<sub>18</sub>H<sub>38</sub>) etc. In the middle phases of the analysis index results in accordance with the retention time and trace masses various kinds of compounds are detected such as at retention time 20.58 and trace mass 56, compound is Eicosane (C<sub>20</sub>H<sub>42</sub>), retention time 21.71 and trace mass 204, compound is 2-Phenyl naphthalene (C<sub>16</sub>H<sub>12</sub>). Retention time 22.48 and trace mass 43, compound is 1-Docosene (C<sub>22</sub>H<sub>44</sub>), retention time 24.34 and trace mass 57, compound is Heneicosane (C<sub>21</sub>H<sub>44</sub>), retention time 23.46 and trace mass 57, compound is Eicosane, (C<sub>20</sub>H<sub>42</sub>), at retention time 25.19 and trace mass 57, compound is Octacosane (C<sub>28</sub>H<sub>58</sub>), retention time 26.02 and trace mass 57, compound is Octacosane (C<sub>28</sub>H<sub>58</sub>) etc. In the ultimate phase of the analysis index several compound are detected as according to their retention time and trace masses such as retention time 26.83 and trace mass 57, compound is Nonacosane (C<sub>29</sub>H<sub>60</sub>), retention time 27.62 and trace mass 57, compound is Heptacosane (C<sub>27</sub>H<sub>56</sub>), and ultimately retention time 29.97 and retention time 57, compound is Heptacosane (C<sub>27</sub>H<sub>56</sub>) as well.



**Fig 4:** DSC Graph of Product Fuel

Produced fuel analysis by DSC (fig. 4) and fuel used 50  $\mu$ L. DSC analysis graph shown onset temperatures only 3.03 °C. Three types of mixture plastic fuel used in this experiment and peak temperature show 146.91 °C and peak height 112.4556 mW. Peak end temperature was seen this graph 185.66 °C. Peak temperature is reflecting boiling point temperature. This produced fuel boiling point temperature 146.91 °C. DSC analyzed fuel graph area 42461.465 mJ, enthalpy value delta H is 42461.4653 J/g. Fuel mol. weight 1.0000 g/mol. From this graph shown 50 °C fuel boiling percentage was 13.26%, after 150 °C fuel boiling percentage 64.23%, 250 °C boiling percentage 95.79% and finally 100% boil fuel when temperature 393°C.

#### 4. CONCLUSION

The characteristics of the liquid product obtained from the thermal degradation process of a waste plastic mixture HDPE, LDPE and PS at low temperature 150 °C to high temperature 430 °C in stainless steel reactor. The yield of liquid product from this experiment 88%, light gas yield 8% and 4% solid black residue. After characterization of liquid fuel used by GC/MS result indicate that produce fuel has lots of aromatic group compound such as Benzene, Ethylbenzene, -Methylstyrene, Benzene, 1-azido-4-methyl-, Benzene, (1-methylethyl)-, Benzene, 2-propenyl-, Benzene, propyl-, Benzene, 3-butenyl-, Benzene, 1,1'-(1,2-ethanediy)bis-, Benzene, 1,1'-(1,4-butanediyl)bis- etc. Aromatic compound has our starting raw materials polystyrene.

Aliphatic hydrocarbons mixture appeared from combination of low and high density polyethylene and polystyrene mixtures. Produce mixture of hydrocarbon range C3-C27 and light gas hydrocarbon range C1-C5. After analysis this produce fuel can be use only heating fuel or can be use only feed stock refinery or power plant for producing electricity.

#### ACKNOWLEDGEMENT

The author acknowledges the support of Dr. Karin Kaufman, the founder and sole owner of Natural State Research, Inc. The author also acknowledges the valuable contributions NSR laboratory team members during the preparation of this manuscript.

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