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Alternative Liquid Hydrocarbon Fuel Production Experimental Comparative Study for LDPE Waste and LDPE Standard Plastic

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Table of Content **Page No.**

1. Introduction

Currently there is a large amount of waste plastics generated in the world. The consumption and production of polymers are increasing worldwide. This increasing amount of polymers wastes generates environmental problems. Utilization of these wastes is important from energetic and political aspects [1-4]. The rapid rate of plastic consumption throughout the world has led to the creation of increasing amounts of waste and this in turn poses greater difficulties for disposal. This is due to the fact that the duration of life of waste plastics is very small [5] and depending on the area of application, the service life of plastic products ranges from 1 to 35 years [6]. The weighted average service life of all plastics products are different in various countries based on their life style and economy. Waste plastics can be classified as industrial and municipal waste, according to their origins; these groups have different qualities and properties and are subjected to different management strategies [7]. Waste plastics represent a considerable part of municipal wastes; furthermore huge amounts of waste plastic arise as a byproduct of faulty product in industry and agriculture [8].

There are several methods of chemical recycling are presently in use, such as direct chemical treatment involving gasification, smelting by blast furnace [9] or coke oven [10], degradation by liquefaction [11], and gasification [12]. Condensation polymers such as PETE and nylon undergo degradation to produce monomer units [13], while from vinyl polymers such as polyolefins, a mixture containing numerous components may be obtained for use as a fuel. Catalytic cracking and reforming facilitate the selective degradation of waste plastics. The use of solid catalysts such as silica-alumina, ZSM-5, Zeolites, and mesoporous, materials has been reported for this purpose [14-17]. These materials effectively convert polyolefins into liquid fuel, giving lighter fractions as compared to thermal cracking. Thermal degradation of mixed plastics is currently receiving renewed interest as route for disposal, if the large quantities of plastic wastes collected by different collecting systems. The advantage of thermal degradation of macromolecules in the absence of air (pyrolysis) compared to combustion is a reduction in the volume of product gases by a factor of 5-20 which leads to considerable savings in the gas conditioning equipment. Furthermore, it is possible to obtain valuable hydrocarbon compounds.

The pyrolysis is complicated by the fact that plastics show poor thermal conductivity while the degradation of macromolecules requires large amounts of energy. Other studies in the literature [18-23] have investigated the degradation of polyethylene or polypropylene and polystyrene mixtures, and the results of the interactions between these polymers. William and William have analyzed the binary degradation of polystyrene and polypropylene, and it was found that the overall degradation rate of mixture was greater than the combined degradation rates of the individual components. According to the results of the products of polyethylene, polypropylene and polystyrene cracking have the most favourable properties for further energetic application. Linear paraffin content in the gas oil fraction is advantageous because this hydrocarbon structure has the highest cetane rate, but it also has the lowest octane number in the naphtha fraction. Further tests are being performed on how to generate the best quality fuel from these waste plastic. The optimal quality of fuel will represent similar characteristics and chemical properties to commercial fuels. Overall, we have seen that when mixture of waste plastics is processed through the thermal degradation process, the quality and efficiency is achieved.

Keywords: hydrocarbon, liquid fuel, waste plastic, ldpe, thermal, GC/MS, FT-IR

2. Material and Method

2.1. Materials

Low density polyethylene (LDPE) waste plastic collected from Stamford local city grocery store and LDPE waste plastic was shopping bags. Low density polyethylene (LDPE) waste plastic color was varieties type such as transparent, white, black etc. Collected waste plastic comes with foreign raw materials such as food particles, paper,

sand and dust etc. All foreign materials separated by manually and waste plastic washed with liquid detergent. During waste plastic washing period also generating waste water and this waste water keep into separate container for treatment purpose. This process main goal is environmental protection and reduce waste plastic problem from the environment. Waste water treatment process applied only alkali and acidic solution for coagulation and flocculation process. After retreat clean waste water can be use for waste plastic washing purpose. Wash out waste plastic dried into laboratory room temperature and cut into small pieces manually by using cutting scissor. Standard LDPE plastic collected from Sigma Aldrich Company, CAS number is 9002-88-4, lot number is MKBG7350V, Chemical structure is C_2H_4 and catalog number is 428043-1kg. Standard LDPE plastic color is transparent and small pellet size.

2.2. Pre-analysis

Low density polyethylene (LDPE) raw waste plastic and standard LDPE raw plastic was pre-analyzed by using GC/MS, FT-IR, TGA, EA-2400 and ICP. By using GC/MS analysis was showed LDPE waste and standard plastics compound structure identification. FT-IR analysis showed LDPE waste and standard plastic functional group identification and TGA analysis result showed onset temperature which are help to liquefaction temperature determination. By EA- 2400 analysis result showed raw materials carbon, hydrogen and nitrogen percentage. Finally ICP test analysis result showed trace metal present into raw materials which are help to breakdown long chain hydrocarbon to shorter chain hydrocarbon in thermal degradation process. Above all pre-analysis results are described into pre-analysis discussion section.

2.3. Process Description

Low density polyethylene (LDPE) waste plastic and LDPE standard plastic to liquid hydrocarbon fuel production purpose thermal degradation process applied. In the two types experimental process raw sample was used 1 kg of LDPE waste plastic and 1 kg of standard plastic as well. Both experiment performed same parameter and same procedure. Catalyst and vacuum system was not applied in the two experiments. Under Labconco fume hood in present of oxygen and fully close system experiment were performed. Both experiments performed into stainless steel reactor and temperature range was 25- 430 ºC. Every experiment temperature was monitored watlow meter and experiment temperature was increase gradually from room temperature to 430ºC. For LDPE waste and standard plastic to fuel production set up temperature determine from TGA result based on onset temperature (see **table 4**). 1st experiment was performed with LDPE standard plastic to liquid fuel and 2nd experiment was performed LDPE waste plastic to liquid fuel in the same procedure. 1 kg (1000gm) of standard plastic inserted into reactor chamber and reactor cover was tighten properly, then condensation unit, liquid fuel collection unit, light gas cleaning device, small pump and light gas storage device was set up properly(Seen **fig.1**). LDPE standard plastic started to melt from 25 ºC to 430 ºC, subsequently reactor temperature increased gradually. When temperature was increased gradually from 25 ºC to 430 ºC observed that some vapor started to come out through the condenser unit. Temperature range when 250 ºC overcome, found that vapor started to condensed and ultimately turned into drop wise liquid fuel. Because the thermal degradation experimental process first able standard plastic melted, then turn into liquid slurry, then converted to vapor and vapor passed through into condenser unit and at the end liquid fuel produced and collected in the container. In this experiment without vacuum system thermal conversion process was done in presence of moisture and the moistures were not affecting conversion process. Plastic to fuel production process reaction are heterogeneous and strongly endothermic reaction. Plastic hydrocarbon chain bonds are breaking down by heat as well as carbon and moisture produce compounds which is not affecting conversion process. Polymer carbon chain and moisture are reacted each other and possible reaction are mentioned such as $C + H_2O = CO + H_2$, $C + CO_2 = 2CO$, $C + \frac{1}{2} O_2 = CO$, $C + O_2 = CO_2$, $CO + H_2O = CO_2 + H_2$, $C + 2H_2 = CH_4$, $CO + 3H_2 = CH_4 + H_2O$, $CO_2 + 4H_2 = CH_4 + 2H_2O$. Standard plastic to fuel production period some light fraction gas also generated and those gas mixtures of methane, ethane, propane and butane respectively. Produced light gas was purified by using alkali wash solution

and alkali solution normality was 0.25 (N) and the solution was sodium bicarbonate and in water solvent. Produced light gas was storage into Teflon bag by using small pump.

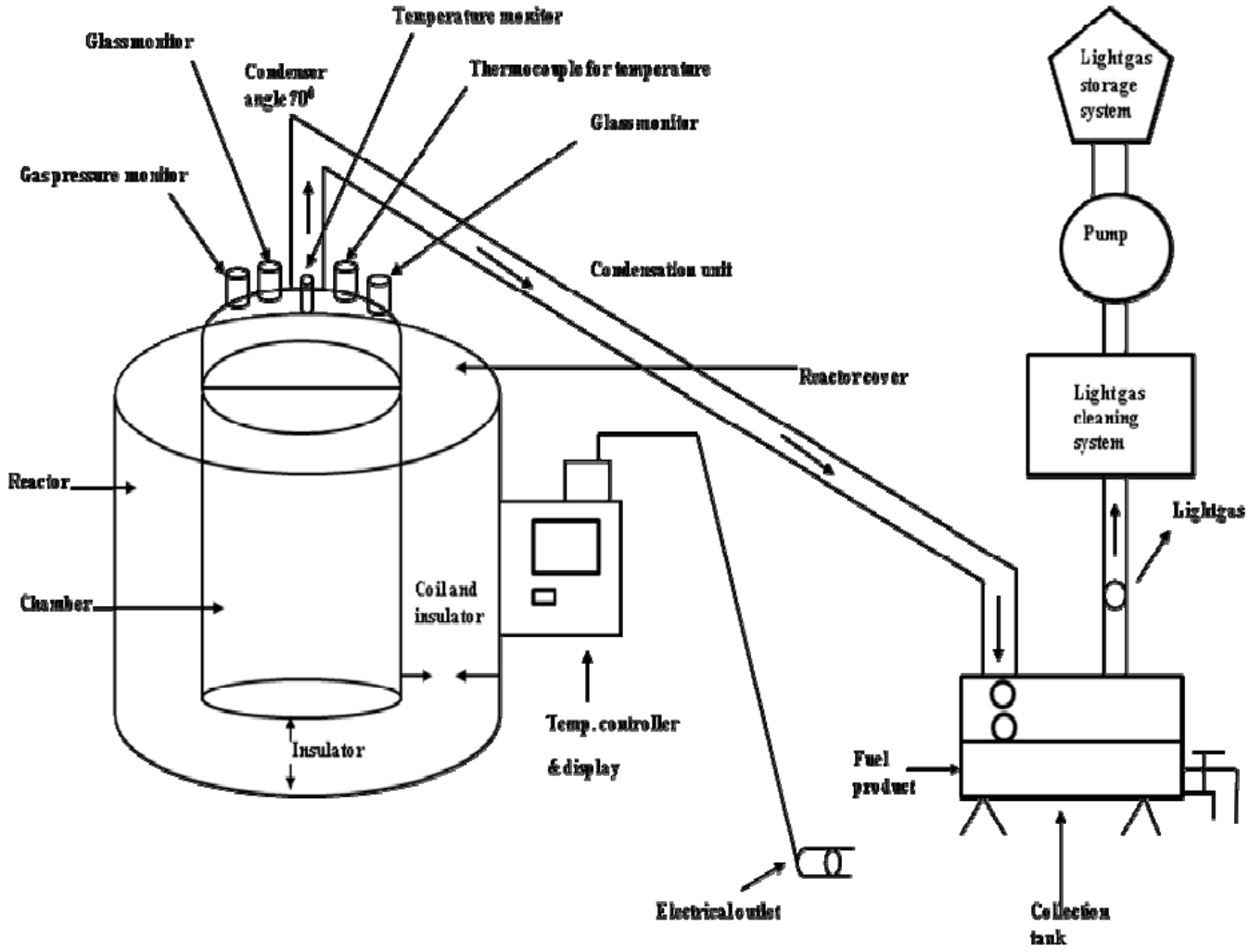

Figure 1: LDPE waste plastic and standard plastic to fuel production process

Liquid fuel was purified by using RCI purification technology and provided RCI filter purification system used to remove fuel sediment and water portion. From 1 kg standard plastic to liquid fuel production percentage is 80.84%, light gas production percentage is 18.95% and solid black residue percentage is 0.21%. LDPE standard plastic density is 0.78 g/ml. Solid black residue percentage is less because of experimental purposes used 99.99 % pure standard LDPE plastic for liquefaction process to liquid fuel. Standard plastic has low amount of additives content and standard plastic has additives level is parts per billion (ppb). Standard plastic to fuel production mass balance result indicates that from 1 kg of plastic conversion into liquid fuel 808.40 gm, light gas conversion into 189.5 gm and left over residue is 2.1 gm. 1000 gm standard plastic to 1040 ml liquid fuel production input electricity was 6.84 kWh and total time was consumed for whole process 4 hours and 56 minutes. On the other experiment we used waste plastic 1kg (1000gm) and same parameter and same temperature profile. LDPE Waste plastic to fuel production percentage is 80.64%, light gas production percentage is 17.91 % and left over residue percentage is 1.45%. LDPE waste plastic residue percentage is little high because LDPE waste plastic has high percentage

additives. LDPE waste plastic to fuel density is 0.79 g/ml. 1 kg of LDPE waste plastic to 1020 ml fuel production need electricity was 7.25 kWh. LDPE waste plastic to liquid fuel production electricity input was little higher than LDPE standard plastic to liquid fuel. Waste plastic to fuel production total time consumed also higher than standard plastic to fuel production because waste plastic has high amount of metal content and more additives compare with pure standard plastic. Manufacture Company is adding different type of additive for better shape of plastic use. These types of additives we are getting as a solid black residue. Both plastics to liquid fuel production comparison result **table 1** showed for visual understanding. Waste plastic to fuel production technology is patent pending technology and convert all types of waste plastic to fuel for next generation.

Table 1: LDPE waste plastic and standard plastic to fuel production percentage data

Plastics Name	Sample Weight (g.)	Liquid Fuel (g.)	Liquid Fuel (ml)	Sample as Light Gas (g.)	Residue Weight (g.)	Electricity Consumption kWh	Liquid Fuel Yield %	Light Gas Yield %	Solid Residue Yield %
Standard LDPE	1000	808.40	1040	189.5	2.1	6.84	80.84	18.95	0.21
LDPE Waste Plastic	1000	806.4	1020	179.1	14.5	7.25	80.64	17.91	1.45

3. Result and Discussion

3.1. Analytical Procedure

Perkin Elmer TGA pyris-1 was used for raw materials onset and inflection temperature measuring. Helium gas was use for purge and temperature range was used 50-800 ºC. Temperature increased range was 20ºC/ minute. From this analysis we calculated how much percentage conversion rate from plastic to fuel by using thermal degradation process. TGA analysis gives us liquefaction temperature for plastic and leftover residue percentage. Perkin Elmer FT-IR spectrum 100 was used for two type of sample analysis. 1st pre-analysis of solid raw LDPE standard and LDPE waste plastic and secondly was used for liquid fuel from LDPE standard and waste plastic. Solid sample analysis purpose use ATR system and liquid sample analysis purpose was used NaCl cell system. For liquid sample analysis scan number was 32, resolution was 4 cm^{-1} and wave range was 4000-400 cm^{-1}. By using FT-IR analysis was giving us wave functional group bend energy which is resemble to calorific value. By using GC/MS analysis was solid hard standard and waste plastic also both liquid fuels. Sold sample was analysis by using pyroprobe and temperature was 1200 ºC to sample make volatile for GC column. When liquid fuel was analysis by using GC/MS that time was used auto sample system. Solid and liquid sample analysis purpose was same GC/MS column. Carrier gas was use for sample carrier helium. GC/MS program set up for liquid fuel analysis initial temperature 40 ºC and hold for 1 minute, final temperature 325 ºC and temperature ramping rate 10 ºC per minute. Final temperature hold 15 minutes, equilibration time 0.5 minute and total experiment run time 45.50 minutes. Carrier gas used Helium and Perkin Elmer Elite 5MS capillary column used for GC. Column length 30 m, ID 0.25 mm and DF 0.5 um. Column temperature range was - 60 to 350 ºC. MS method set up for mass scan Ion mode EI +, data format Centroid, start mass 35.00, end mass 528, scan time 0.25 sec and inter scan time 0.15 sec. Perkin Elmer EA -2400 used for raw waste plastics CHN percentage analysis. Finally ICP (Induced Couple Plasma) was used for trace metal analysis from raw materials and solid residue.

3.2. Pre-analysis Discussion

Table 2: LDPE waste and standard plastic analysis by ICP

Test Method Name	Trace Metal Name	Raw LDPE Waste Plastic (ppm)	Raw LDPE Standard Plastic (ppb)
ASTM D1976	Silver	<1.0	<1.0
	Aluminum	197.4	99.7
	Boron	2.8	47.1
	Barium	<1.0	42.6
	Calcium	962.6	738.8
	Chromium	<1.0	23.7
	Copper	<1.0	2.2
	Iron	6.0	<1.0
	Potassium	35.4	<50.0
	Lithium	<1.0	<1.0
	Magnesium	25.1	<1.0
	Molybdenum	<1.0	<1.0
	Sodium	45.2	10181.0
	Nickel	<1.0	4.3
	Phosphorus	26.7	<1.0
	Lead	<1.0	<1.0
	Antimony	<1.0	2.5
	Silicon	90.2	<1.0
	Tin	<1.0	<1.0
	Strontium		2.7
	Titanium	2.7	<1.0
	Thallium		<1.0
	Vanadium	<1.0	<1.0
	Zinc	2.6	21.3

American Standard and Testing Method (ASTM D1976) analysis was performed by ICP (Induced Couple Plasma) of raw waste LDPE plastic numerous metal contents are found in the analysis (**table 2**). We noticed that LDPE waste and standard plastic some metal content are very high compare to less contents metal in the residue. In raw waste LDPE plastic metal contents are measured in ppm that's Parts per Million and for raw standard LDPE plastic metal contents are measured in ppb that is Parts per Billion. Because of standard plastics is much more pure than waste plastics. LDPE waste plastic has high and low contents metal elements such as Silver <1.0 ppm, Aluminium 197.4 ppm, Boron 2.8 ppm, Barium <1.0 ppm, Calcium 962.6 ppm, Chromium <1.0 ppm, Copper <1.0 ppm, Iron 6.0 ppm, Potassium 35.4 ppm, Lithium <1.0 ppm, Magnesium 25.1 ppm, Molybdenum <1.0 ppm, Sodium 45.2 ppm, Nickel <1.0 ppm, Phosphorus 26.7 ppm, Lead <1.0 ppm, Antimony <1.0 ppm, Silicon 90.2 ppm, Tin <1.0 ppm, Strontium 0 ppm, Titanium 2.7 ppm, Thallium 0 ppm, Vanadium <1.0 ppm and Zinc 2.6 ppm etc. On the other hand Standard Raw LDPE plastic same metal contents are appeared in the analysis but metal quantity contents are making differ of each other. In some case found same quantity but in some case quantity varies on metal to metal including less content and high content. In the analysis of standard LDPE plastic metal quantity contents are found comparative with raw standard LDPE plastic metal contents are following such as Silver <1.0 ppb, Aluminium 99.7 ppb, Boron 47.1 ppb, Barium 42.6 ppb, Calcium 738.8 ppb, Chromium 23.7 ppb, Copper 2.2 ppb, Iron <1.0 ppb, Potassium <50.0 ppb, Lithium <1.0 ppb, Magnesium <1.0 ppb, Molybdenum <1.0 ppb, Sodium 10181.0 ppb, Nickel 4.3 ppb, Phosphorus <1.0 ppb, Lead <1.0 ppb, Antimony 2.5 ppb, Silicon <1.0 ppb, Tin <1.0 ppb, Strontium 2.7 ppb, Titanium <1.0 ppb, Thallium <1.0 ppb, Vanadium <1.0 ppb and Zinc 21.3 ppb etc. In some parameter

found that raw standard LDPE plastic and raw waste LDPE plastic metal quantity contents are similar. On the other hand in raw Standard LDPE plastic same metal contents are appeared in the analysis but metal quantity contents are making differ of each other. In some case found same quantity but in some case quantity varies on metal to metal including less content and high content as well. LDPE waste plastic metal content more than standard plastic because when manufacturing company making plastic for consumer that times manufacture company adding extra additives for plastic good shape such as hardness, softness and thickness. Also raw LDPE waste plastics are abandoning in the open nature for long run as well as contaminated with different types of metal as appeared in the analysis.

Table 3: LDPE waste and standard plastic C, H and N percentage by EA-2400

Test Method Name	Plastics Name	Carbon (C) %	Hydrogen (H) %	Nitrogen (N)%
ASTM D5291_a	Raw LDPE Waste Plastics	85.33	14.31	<0.30
	Raw LDPE Standard Plastics	86.00	13.68	<0.30

ASTM D5291_a, (American Standard and Testing Method) analysis (**table 3**) was performed of raw waste LDPE plastic and raw standard LDPE plastic analysis by Elemental Analyzer 2400 (EA-2400) following percentage of Carbon, Hydrogen and Nitrogen contents are appeared. In the analysis of both raw waste and raw standard plastics such as in raw waste LDPE Carbon 85.33%, Hydrogen 14.31% and ultimately Nitrogen % <0.30% as well .On the other hand raw LDPE standard plastics Carbon 86.00%, Hydrogen 13.68% and ultimately Nitrogen <0.30% respectively. In the comparative analysis of carbon, hydrogen and nitrogen contents found that raw standard LDPE plastic has more carbon and hydrogen percentage content than raw waste LDPE plastic and Nitrogen contents are same percentage <0.30% in the both residue as well. Fundamentally raw Standard LDPE plastic is more pure than waste LDPE plastic and waste LDPE plastic are exists in the nature for long run as well as contaminated with metal and other substances. Also during manufacturing different type's additives and dyes are added into the waste LDPE plastics in order to give durable shape and color of waste plastics. Therefore in raw standard LDPE much more pure then raw waste LDPE plastic as aspect of carbon and hydrogen percentage contents.

Table 4: TGA analysis result of LDPE waste plastic and standard LDPE plastic

Sample Name	Sample weight (g.)	Onset temperature (ºC)	Inflection point temperature (ºC)
LDPE waste plastic	3.13	421.53	457.11
LDPE standard plastic	2.72	434.11	466.57

LDPE waste plastic and LDPE standard plastic was per analysis by using Thermogravimetric analyzer (TGA Pyris-1) for raw sample (**Table 4)** onset temperature measured. TGA analysis purposed helium gas was use as carrier gas and temperature profile was use 50 ºC to 800 ºC and temperature ramping rate was use 20 ºC per minutes. In table 4 analysis result showed LDPE waste plastic onset temperature was 421.53 ºC and LDPE standard plastic onset temperature was 434.11 ºC from TGA analysis. By using this equipment raw samples onset temperature determined and this temperature was help to setup liquefaction process because before start liquefaction process waste plastic to fuel need to know first temperature profile.

Table 5: FT-IR spectrum of LDPE waste plastic functional group name

Number of Peak	Band Number (cm^{-1})	Functional Group Name	Number of Peak	Band Number (cm^{-1})	Functional Group Name
1	2916.01	CH_2	5	1377.72	CH_3

2	2848.31	C-CH_3	6	729.84	-CH=CH-(cis)
3	1645.62	Conjugated	7	719.08	-CH=CH-(cis)
4	1462.89	CH_3			

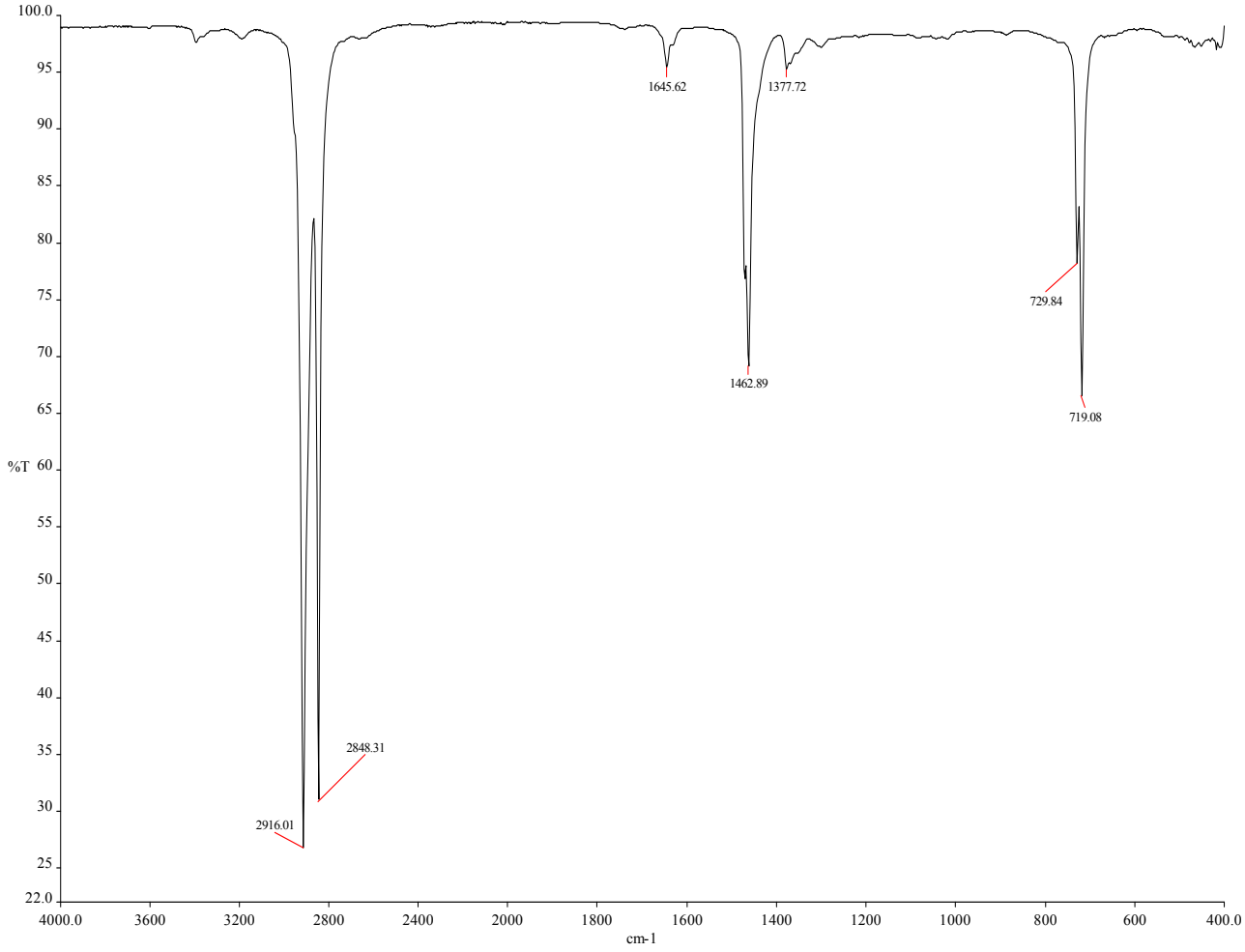

Figure 2: FT-IR spectrum of LDPE waste plastic

Perkin Elmer FT-IR analysis of LDPE raw waste plastic (**fig.2 and table 5**) according to their wave number and spectrum band following types of functional groups are appeared in the analysis. In the spectrum field we noticed that higher wave number are emerged in the initial phase and middle index of the spectrum and in higher wave number small and bulky both functional groups are available and in low wave number double bond and single bond functional groups are available such as methane group, cis and trans alkene etc. Hereafter wave number 2916.01 cm^{-1}, functional group is CH_2, 2848.31 cm^{-1} functional group is C-CH_3, wave number 1645.62 cm^{-1}, functional group is Non-Conjugated, wave number 1462.89 cm^{-1} and 1377.72 cm^{-1} functional group is CH_3, and ultimately wave number 729.84 cm^{-1} and 719.08 functional group is -CH=CH-(cis) as well. Energy values are calculated, using formula is E=hυ, Where h=Planks Constant, h =$6.626x10^{-34}$ J, υ= Frequency in Hertz (sec^{-1}), Where υ=c/λ, c=Speed of light, where, c=$3x10^{10}$ m/s, W=1/λ, where λ is wave length and W is wave number in cm^{-1}. Therefore the equation E=hυ, can substitute by the following equation, E=hcW. According to their wave number several energy values are calculated such as for 2916.01 (cm^{-1}) calculated energy, E=$5.79x10^{-20}$ J, wave number 2848.31 (cm^{-1}), calculated energy, E=$5.65x10^{-20}$ J, wave number 1645.62 (cm^{-1}), calculated energy, E=$3.26x10^{-20}$ J, wave number

1462.89 (cm^{-1}), calculated energy, $E=2.90x10^{-20}$ J , wave number 1377.72 (cm^{-1}), calculated energy, $E=2.73x10^{-20}$ J, wave number 729.84 (cm^{-1}), calculated energy, $E=1.44x10^{-20}$ J, Similarly, wave number 719.08 (cm^{-1}) energy, $E=1.42x10^{-20}$ J respectively.

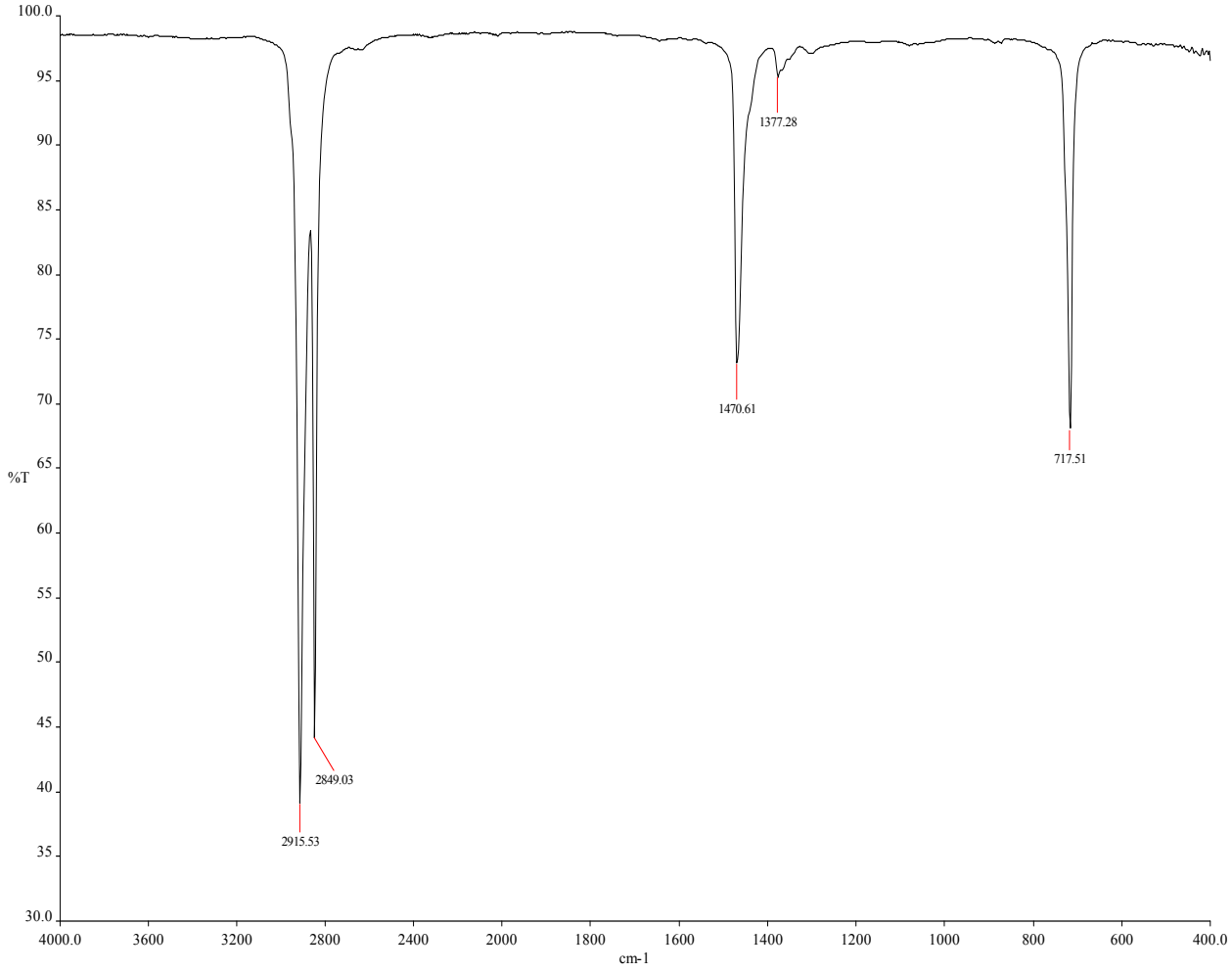

Figure 3: FT-IR spectrum of LDPE standard plastic

Table 6: FT-IR spectrum of LDPE standard plastic functional group name

Number of Peak	Band Number (cm^{-1})	Functional Group Name	Number of Peak	Band Number (cm^{-1})	Functional Group Name
1	2915.53	CH_2	4	1377.28	CH_3
2	2849.03	CH_2	5	717.51	-CH=CH-(cis)
3	1470.61	CH_3			

From FT-IR analysis of LDPE raw standard plastic (**fig.3 and table 6**) according to their wave number and spectrum band following types of functional groups are appeared in the analysis. In the spectrum field we noticed that higher wave number are emerged in the initial phase and middle index of the spectrum and in higher wave number small and bulky both functional groups are available and in low wave number double bond and single bond functional groups are available such as methane group, cis and trans alkene etc. Hereafter wave number 2915.53 cm^{-1},

functional group is CH_2, 2849.03 cm^{-1} functional group is C-CH_3, wave number 1470.61 cm^{-1}, functional group is CH_3, wave number 1377.28 cm^{-1} functional group is CH_3, and ultimately wave number 717.51 cm^{-1} functional group is -CH=CH-(cis) as well. Energy values are calculated, using formula is E=hυ, Where h=Planks Constant, h =6.626x10^{-34} J, υ= Frequency in Hertz (sec^{-1}), Where υ=c/λ, c=Speed of light, where, c=3x10^{10} m/s, W=1/λ, where λ is wave length and W is wave number in cm^{-1}. Therefore the equation E=hυ, can substitute by the following equation, E=hcW. According to their wave number several energy values are calculated such as for 2915.53 (cm^{-1}) calculated energy, E=5.79x10^{-20} J, wave number 2848.03 (cm^{-1}), calculated energy, E=5.65x10^{-20} J, wave number 1470.61 (cm^{-1}), calculated energy, E=2.92x10^{-20} J , wave number 1377.28 (cm^{-1}), calculated energy, E=2.73x10^{-20} J and Similarly, wave number 717.51 (cm^{-1}) energy, E =1.42x10^{-20} J respectively.

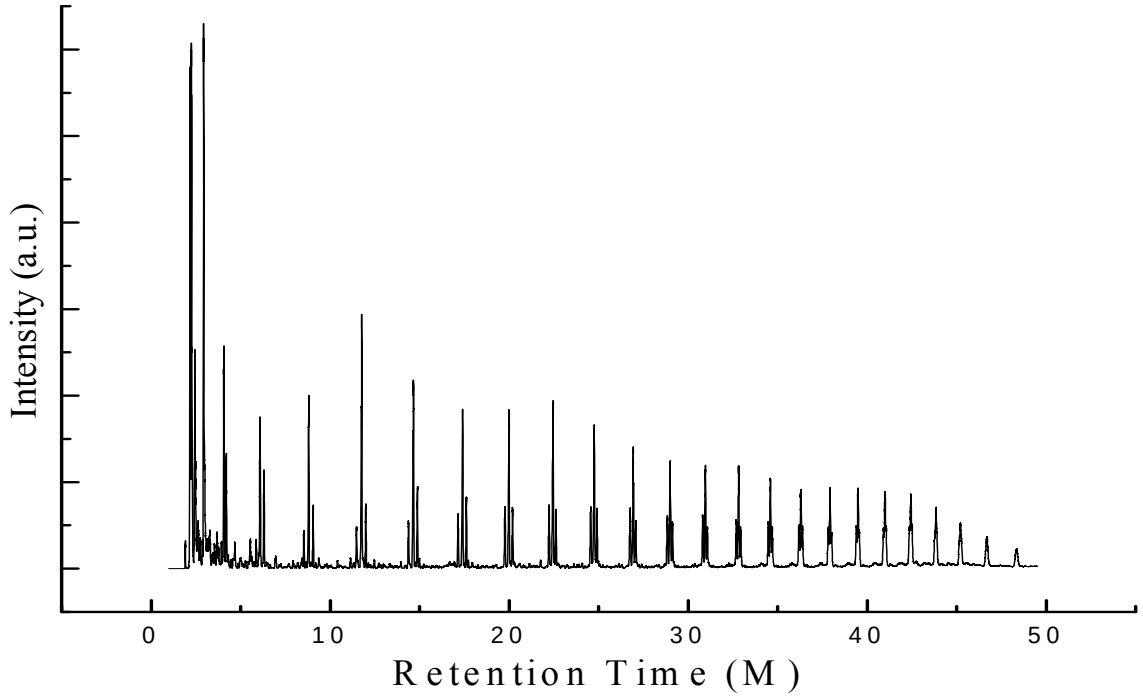

Figure 4: GC/MS chromatogram of LDPE waste plastic

Table 7: LDPE waste plastic GC/MS chromatogram compound list

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	2.18	41	Cyclopropane	C_3H_6	42	40.3	18854
2	2.25	41	2-Butene, (E)-	C_4H_8	56	16.3	105
3	2.44	42	Cyclopropane, ethyl-	C_5H_{10}	70	39.4	114410
4	2.58	67	1,4-Pentadiene	C_5H_8	68	24.6	114494
5	2.63	66	Cyclopropane, ethylidene-	C_5H_8	68	10.2	152269
6	2.73	67	Cyclopentene	C_5H_8	68	22.3	19032
7	2.86	67	1,5-Hexadiene	C_6H_{10}	82	30.3	227588
8	2.94	41	Cyclopropane, propyl-	C_6H_{12}	84	26.3	60624

9	3.54	67	Cyclopentene, 3-methyl-	C_6H_{10}	82	13.6	114408
10	3.68	78	Benzene	C_6H_6	78	73.5	114388
11	3.77	79	Cyclopentene,3-methylene-	C_6H_8	80	19.9	151094
12	3.93	67	Cyclohexene	C_6H_{10}	82	19.0	114431
13	4.07	41	1-Heptene	C_7H_{14}	98	16.6	19704
14	4.20	43	Heptane	C_7H_{16}	100	46.3	61276
15	4.68	83	Cyclohexane, methyl-	C_7H_{14}	98	36.1	118503
16	4.99	81	1,4-Hexadiene, 4-methyl-	C_7H_{12}	96	7.35	113135
17	5.13	55	1-Octyn-3-ol	$C_8H_{14}O$	126	8.34	113255
18	5.28	67	1,3-Pentadiene, 2,4-dimethyl-	C_7H_{12}	96	13.4	114450
19	5.44	79	Cyclopentanepropanol, 2-methylene-	$C_9H_{16}O$	140	19.2	160878
20	5.52	91	Cyclobutene, 2-propenylidene-	C_7H_8	92	18.0	29595
21	5.62	81	Cyclopentene, 4,4-dimethyl-	C_7H_{12}	96	8.49	38642
22	5.75	82	3,4-Nonadiene	C_9H_{16}	124	8.23	54088
23	5.87	67	1,4-Octadiene	C_8H_{14}	110	30.5	113431
24	6.09	41	1-Octene	C_8H_{16}	112	11.0	191147
25	6.31	43	Hexane, 3-ethyl-	C_8H_{18}	114	21.06	113940
26	6.51	67	Bicyclo[5.1.0]octane	C_8H_{14}	110	9.46	149566
27	6.65	55	2-Octene	C_8H_{16}	112	11.1	118191
28	6.96	67	1,4-Octadiene	C_8H_{14}	110	24.5	113431
29	7.17	41	1,9-Nonanediol	$C_9H_{20}O_2$	160	11.0	114694
30	7.93	91	Cyclohexanol, 1-ethynyl-, carbamate	$C_9H_{13}NO_2$	167	26.0	246016
31	8.44	55	Cyclohexane, cyclopropyl-	C_9H_{16}	124	20.9	26670
32	8.53	55	1,8-Nonadiene	C_9H_{16}	124	29.8	107523
33	8.81	55	1-Nonene	C_9H_{18}	126	10.3	142583
34	9.05	43	Nonane	C_9H_{20}	128	16.5	2665
35	9.37	83	Cyclopentane, 1-methyl-2-(2-propenyl)-, trans-	C_9H_{16}	124	43.0	26931
36	10.41	67	Cyclopentene, 1-(3-methylbutyl)-	$C_{10}H_{18}$	138	10.7	61018
37	10.54	56	5-Dodecene, (E)-	$C_{12}H_{24}$	168	4.86	61866
38	11.13	56	Nonane, 5-methylene-	$C_{10}H_{20}$	140	29.4	61927
39	11.47	41	1,9-Decadiene	$C_{10}H_{18}$	138	32.2	118291
40	11.77	55	1-Decene	$C_{10}H_{20}$	140	5.50	118883
41	11.99	57	Decane	$C_{10}H_{22}$	142	27.0	114147
42	12.47	55	Cyclohexane, 1-methyl-2-propyl-	$C_{10}H_{20}$	140	30.4	114020
43	12.72	55	1,11-Dodecadiene	$C_{12}H_{22}$	166	11.0	113595
44	13.95	56	Cyclobutane, 1-hexyl-2,3-dimethyl-	$C_{12}H_{24}$	168	4.65	60877
45	14.38	41	1,10-Undecadiene	$C_{11}H_{20}$	152	24.1	113574
46	14.66	41	1-Undecanol	$C_{11}H_{24}O$	172	5.78	114087
47	14.88	57	Undecane	$C_{11}H_{24}$	156	28.1	249213

48	14.99	55	3-Undecene, (E)-	$C_{11}H_{22}$	154	5.83	60565
49	17.15	41	1,11-Dodecadiene	$C_{12}H_{22}$	166	13.4	113595
50	17.40	41	1-Tridecanol	$C_{13}H_{28}O$	200	4.51	114368
51	17.61	57	Dodecane	$C_{12}H_{26}$	170	15.7	291499
52	17.95	55	6-Dodecene, (Z)-	$C_{12}H_{24}$	168	5.27	142611
53	19.77	41	1,11-Dodecadiene	$C_{12}H_{22}$	166	8.03	113595
54	20.00	55	1-Tridecanol	$C_{13}H_{28}O$	200	8.10	114368
55	20.19	57	Tridecane	$C_{13}H_{28}$	184	28.7	107767
56	21.76	56	2-Butyl-1-decene	$C_{14}H_{28}$	196	24.3	113609
57	22.23	55	1,13-Tetradecadiene	$C_{14}H_{26}$	194	12.7	113612
58	22.45	41	Cyclotetradecane	$C_{14}H_{28}$	196	4.46	61052
59	22.62	57	Tetradecane	$C_{14}H_{30}$	198	31.3	113925
60	24.56	55	1,13-Tetradecadiene	$C_{14}H_{26}$	194	18.1	113612
61	24.75	55	Cyclopentadecane	$C_{15}H_{30}$	210	6.52	114876
62	24.91	43	Pentadecane	$C_{15}H_{32}$	212	22.3	22620
63	26.76	55	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	7.82	108369
64	26.93	41	1-Hexadecanol	$C_{16}H_{34}O$	242	6.55	114116
65	27.07	57	Nonadecane	$C_{19}H_{40}$	268	25.4	114098
66	27.39	55	1-Hexadecene	$C_{16}H_{32}$	224	5.03	118882
67	28.84	55	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	8.92	108369
68	30.96	83	1-Docosene	$C_{22}H_{44}$	308	6.54	113878
69	31.07	57	Nonadecane	$C_{19}H_{40}$	268	17.7	114098
70	32.69	82	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	11.1	108369
71	32.83	83	1-Nonadecene	$C_{19}H_{38}$	266	8.38	113626
72	32.93	57	Nonadecane	$C_{19}H_{40}$	268	29.8	114098
73	34.48	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	8.98	241604
74	34.60	83	1-Docosene	$C_{22}H_{44}$	308	8.82	113878
75	34.70	71	Nonadecane	$C_{19}H_{40}$	268	21.8	114098
76	36.19	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	10.2	241604
77	36.31	83	1-Docosene	$C_{22}H_{44}$	308	10.2	113878
78	36.39	57	Nonadecane	$C_{19}H_{40}$	268	8.38	114098
79	37.83	55	1,15-Pentadecanediol	$C_{15}H_{32}O_2$	244	10.8	113063
80	37.94	97	1-Eicosanol	$C_{20}H_{42}O$	298	10.7	113075
81	38.02	71	Heneicosane	$C_{21}H_{44}$	296	7.46	107569
82	39.40	55	1,15-Pentadecanediol	$C_{15}H_{32}O_2$	244	11.5	113063
83	39.50	83	1-Eicosanol	$C_{20}H_{42}O$	298	9.71	113075
84	39.56	57	Nonadecane	$C_{19}H_{40}$	268	7.47	114098
85	40.92	82	1,19-Eicosadiene	$C_{20}H_{38}$	278	9.30	241604
86	41.00	83	1-Eicosanol	$C_{20}H_{42}O$	298	12.6	113075
87	41.07	57	Tetracosane	$C_{24}H_{50}$	338	11.0	248196
88	42.44	55	9-Tricosene, (Z)-	$C_{23}H_{46}$	322	7.69	70967
89	42.51	57	Octacosane	$C_{28}H_{58}$	394	10.5	149865
90	43.77	82	1,19-Eicosadiene	$C_{20}H_{38}$	278	8.90	241604
91	45.21	97	1-Eicosanol	$C_{20}H_{42}O$	298	13.1	113075
92	46.72	83	1-Eicosanol	$C_{20}H_{42}O$	298	11.4	113075
93	48.34	83	1-Eicosanol	$C_{20}H_{42}O$	298	13.5	113075

From GC-MS pyroprobe analysis of raw LDPE waste plastics inside of pyroprobe raw solid waste plastics turns into volatile gas with high temperature at 1200 °C and that volatile gas passed through the column to gas chromatography, helium (He) is used as a carrier gas and then sends the volatile gas to the mass spectroscopy and in mass compounds are detected according to the boiling point of individual compound and among those only several compounds are introduced as well elaborated in the analysis (**fig.4 and table7**). In accordance with the retention time and trace masses numerous different types of hydrocarbon compound and benzene derivatives compounds are appeared in the analysis result index. Many compounds are emerged on the analysis carbon range C_3 to C_{28}. In the initial state of the analysis index according to the retention time such as retention time 2.18 and trace mass 41,compound is single bond Cyclopropane (C_3H_6), retention time 2.25 and trace mass 41 compound is double bond 2-Butene,(E)- (C_4H_8), retention time 2.44 and trace mass 42, compound is single bond Cyclopropane,ethyl-(C_5H_{10}), retention time 2.58 and trace mass 67, compound is 1-4 Pentadiene (C_5H_8), retention time 2.94 and trace mass 41, compound is Cyclopropane, Propyl (C_6H_{12}), retention time 3.54 and trace mass 67, compound is double bond Cyclopentene, 3-methyl- (C_6H_{10}), retention time 3.93 and trace mass 67, compound is Cyclohexane (C_6H_{10}), retention time 4.07 and trace mass 41,compound name is 1-Heptene (C_7H_{14}), retention time 4.20 and trace mass 43, compound is Heptane (C_7H_6), retention time 4.68 and trace mass 83, compound is Cyclohexane, methyl- (C_7H_{14}), retention time 4.99 and trace mass 81,compound is 1,4-Hexadiene, 4-methyl- (C_7H_{12}), retention time 5.28 and trace mass 67, compound is 1,3-Pentadiene, 2,4-dimethyl- (C_7H_{12}) , retention time 5.87 and trace mass 67, compound is double bond 1,4-Octadiene (C_8H_{14}), retention time 6.65 and trace mass 55,compound is double bonding 2-Octene (C_8H_{16}), retention time 7.93 and trace mass 91,compound is Cyclohexanol, 1-ethynyl-, carbamate ($C_9H_{13}NO_2$) here appearing that oxygen compound are produced because in the reactor during reaction phase oxygen induce from moisture, retention time 8.81 and trace mass 55, compound is 1-Nonene (C_9H_{18}), retention time 9.37 and trace mass 83, compound is Cyclopentane, 1-methyl-2-(2-propenyl)-, trans- (C_9H_{16}), retention time 10.54 and trace mass 56, compound name is double bond 5-Dodecene, (E)- ($C_{11}H_{24}$), retention time 11.99 and trace mass 57, compound is single bond Decane ($C_{10}H_{22}$), retention time 13.95 and trace mass 56, compound is Cyclobutane, 1-hexyl-2,3-dimethyl- ($C_{11}H_{24}$), retention time 17.95 and trace mass 55, compound is 6-Dodecene, (Z)- ($C_{12}H_{24}$), retention time 20.19 and trace mass 57, compound is single bond Tridecane ($C_{13}H_{26}$) etc. As well retention time21.76 and trace mass 56, compound is 2-Butyl-1-decene ($C_{14}H_{28}$), retention time 31.07 and trace mass 57, compound is single bond Nonadecane ($C_{19}H_{40}$), retention time 36.19 and trace mass 55, compound is double bond 1, 19-Eicosadiene ($C_{20}H_{38}$), retention time 37.94 and trace mass 97, compound is alcoholic Eicosanol ($C_{20}H_{42}O$), retention time 39.40 and trace mass 55, compound is 1, 15-Pentadecanediol ($C_{15}H_{32}O_2$) etc. At the last phase of the analysis index retention time 40.92 and trace mass 82, compound is 1, 19-Eicosadiene ($C_{20}H_{38}$), retention time 42.44 and trace mass 55, compound is double bond 9-Tricosene, (Z)- ($C_{23}H_{46}$), retention time 43.77 and trace mass 82, compound is 1,19-Eicosadiene ($C_{20}H_{38}$), retention time 46.72 and trace mass 83, compound is 1-Eicosanol ($C_{20}H_{42}O$) and ultimately retention time 48.34 and trace mass 43 compound is alcoholic 1-eicosanol ($C_{20}H_{42}O$) etc.

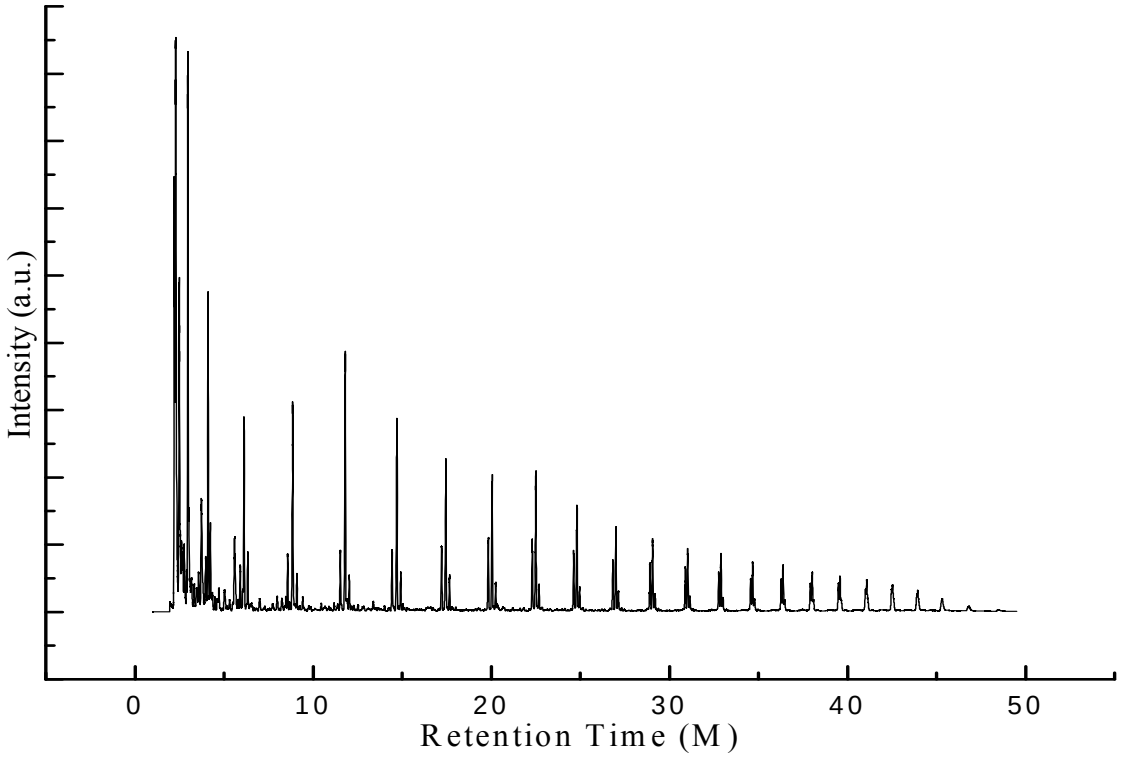

Figure 5: GC/MS chromatogram of LDPE standard plastic

Table 8: LDPE standard plastic GC/MS chromatogram compound list

Peak Number	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	2.21	41	Cyclopropane	C_3H_6	42	32.7	18854
2	2.28	41	2-Butene, (E)-	C_4H_8	56	14.0	105
3	2.48	55	Cyclopropane, 1,2-dimethyl-, trans-	C_5H_{10}	70	17.2	114453
4	2.61	67	1,3-Pentadiene	C_5H_8	68	17.3	291890
5	2.76	67	Cyclopentene	C_5H_8	68	20.8	19032
6	2.90	67	1,5-Hexadiene	C_6H_{10}	82	35.2	227588
7	2.97	42	1-Hexene	C_6H_{12}	84	25.0	227613
8	3.57	67	Cyclopentene, 1-methyl-	C_6H_{10}	82	11.5	231297
9	3.73	78	Benzene	C_6H_6	78	74.2	221957
10	3.96	67	Cyclohexene	C_6H_{10}	82	14.6	114431
11	4.09	56	1-Heptene	C_7H_{14}	98	33.5	19704
12	4.23	43	Heptane	C_7H_{16}	100	43.3	61276
13	4.49	55	2-Heptene	C_7H_{14}	98	12.6	113119
14	4.62	81	Norbornane	C_7H_{12}	96	10.6	114371
15	4.66	67	1,4-Heptadiene	C_7H_{12}	96	20.0	113639

16	4.72	55	Cyclohexane, methyl-	C_7H_{14}	98	27.7	118503
17	5.02	81	Cyclohexene, 4-methyl-	C_7H_{12}	96	18.7	125422
18	5.59	91	Toluene	C_7H_8	92	47.9	61211
19	5.79	67	7-Methylbicyclo[4.2.0]octane	C_9H_{16}	124	7.68	210902
20	5.91	41	1,7-Octadiene	C_8H_{14}	110	16.5	62191
21	6.12	55	1-Octene	C_8H_{16}	112	17.1	227923
22	6.34	43	Octane	C_8H_{18}	114	40.2	61242
23	7.00	67	1,4-Octadiene	C_8H_{14}	110	28.3	113431
24	7.28	55	2,7-Octadien-1-ol	$C_8H_{14}O$	126	10.3	237434
25	7.99	91	Ethylbenzene	C_8H_{10}	106	38.5	114918
26	8.25	91	p-Xylene	C_8H_{10}	106	20.2	150787
27	8.47	55	Cyclopentane, 1-methyl-2-(2-propenyl)-, trans-	C_9H_{16}	124	24.5	26931
28	8.57	54	1,8-Nonadiene	C_9H_{16}	124	31.7	107523
29	8.85	56	1-Nonene	C_9H_{18}	126	14.7	107756
30	9.08	43	Nonane	C_9H_{20}	128	38.8	228006
31	10.46	67	2-Nonen-1-ol, (Z)-	$C_9H_{18}O$	142	13.2	53342
32	11.53	55	1,9-Decadiene	$C_{10}H_{18}$	138	21.8	232355
33	11.80	41	1-Decene	$C_{10}H_{20}$	140	12.8	118883
34	12.04	57	Decane	$C_{10}H_{22}$	142	41.0	114147
35	13.38	115	Benzene, 1-ethynyl-4-methyl-	C_9H_8	116	22.9	43759
36	14.44	55	1,10-Undecadiene	$C_{11}H_{20}$	152	36.3	113574
37	14.70	41	1-Undecene	$C_{11}H_{22}$	154	5.52	5022
38	14.92	57	Undecane	$C_{11}H_{24}$	156	29.3	249213
39	15.05	55	5-Undecene, (E)-	$C_{11}H_{22}$	154	4.68	114227
40	17.21	41	1,11-Dodecadiene	$C_{12}H_{22}$	166	26.6	113595
41	17.45	43	1-Dodecene	$C_{12}H_{24}$	168	6.65	107688
42	17.66	57	Dodecane	$C_{12}H_{26}$	170	27.4	291499
43	19.84	41	1,13-Tetradecadiene	$C_{14}H_{26}$	194	15.5	113612
44	20.06	55	1-Tridecene	$C_{13}H_{26}$	182	10.3	107768
45	20.25	57	Tridecane	$C_{13}H_{28}$	184	37.6	114282
46	22.30	41	1,13-Tetradecadiene	$C_{14}H_{26}$	194	19.2	113612
47	22.51	41	1-Tetradecene	$C_{14}H_{28}$	196	5.03	69725
48	22.68	57	Tetradecane	$C_{14}H_{30}$	198	33.5	113925
49	24.63	55	1,13-Tetradecadiene	$C_{14}H_{26}$	194	8.10	113612
50	24.81	41	1-Pentadecanol	$C_{15}H_{32}O$	228	5.53	154949
51	24.97	57	Pentadecane	$C_{15}H_{32}$	212	20.1	107761
52	26.83	55	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	13.9	108369
53	27.01	41	1-Hexadecene	$C_{16}H_{32}$	224	8.10	118882
54	27.14	57	Hexadecane	$C_{16}H_{34}$	226	22.7	114191
55	27.32	57	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	5.51	245485
56	28.91	55	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	6.54	108369
57	29.06	55	E-14-Hexadecenal	$C_{16}H_{30}O$	238	8.68	130980
58	29.20	57	Heptadecane	$C_{17}H_{36}$	240	17.7	107308

59	30.89	55	11-Hexadecen-1-ol, (Z)-	$C_{16}H_{32}O$	240	6.44	108369
60	31.03	55	E-15-Heptadecenal	$C_{17}H_{32}O$	252	9.30	130979
61	31.14	57	Octadecane	$C_{18}H_{38}$	254	17.0	57273
62	31.34	57	Oxirane, tetradecyl-	$C_{16}H_{32}O$	240	8.07	113147
63	32.78	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	9.35	241604
64	32.90	55	1-Nonadecene	$C_{19}H_{38}$	266	12.5	113626
65	33.01	57	Nonadecane	$C_{19}H_{40}$	268	26.6	114098
66	34.58	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	15.2	241604
67	34.68	43	1-Nonadecene	$C_{19}H_{38}$	266	7.49	113626
68	34.79	57	Eicosane	$C_{20}H_{42}$	282	14.9	149863
69	36.28	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	18.0	241604
70	36.38	57	1-Docosene	$C_{22}H_{44}$	308	11.3	113878
71	36.46	57	Heneicosane	$C_{21}H_{44}$	296	18.7	107569
72	37.92	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	17.7	241604
73	38.01	55	1-Docosene	$C_{22}H_{44}$	308	12.9	113878
74	38.10	57	Heneicosane	$C_{21}H_{44}$	296	10.0	107569
75	39.49	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	11.8	241604
76	39.58	43	1-Docosene	$C_{22}H_{44}$	308	8.99	113878
77	41.02	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	9.60	241604
78	41.08	55	1-Docosene	$C_{22}H_{44}$	308	10.4	113878
79	42.47	55	1,19-Eicosadiene	$C_{20}H_{38}$	278	10.4	241604
80	42.53	57	1-Docosene	$C_{22}H_{44}$	308	9.47	113878
81	43.94	55	1-Eicosanol	$C_{20}H_{42}O$	298	7.27	113075
82	45.32	57	1-Eicosanol	$C_{20}H_{42}O$	298	21.2	113075
83	46.82	55	1-Eicosanol	$C_{20}H_{42}O$	298	20.2	113075

Perkin Elmer GC/MS pyroprobe analysis (**Fig.5 and table 8**) of raw LDPE standard plastics inside of pyroprobe raw solid standard plastics turns into volatile gas with high temperature at 1200 °C and that volatile gas passed through the column to gas chromatography, helium (He) is used as a carrier gas and then sends the volatile gas to the mass spectroscopy and in mass compounds are detected according to the boiling point of individual compound and among those only several compounds are introduced as well elaborated in the analysis. In accordance with the retention time and trace masses numerous different types of hydrocarbon compound and benzene derivatives compounds are appeared in the analysis result index. Many compounds are emerged on the analysis carbon range C_3 to C_{22}. In the initial state of the analysis index according to the retention time such as retention time 2.21 and trace mass 41,compound is single bond Cyclopropane (C_3H_6), retention time 2.28 and trace mass 41 compound is double bond 2-Butene,(E)- (C_4H_8), retention time 2.48 and trace mass 55, compound is single bond Cyclopropane,1,2-dimethyl-,trans (C_5H_{10}), retention time 2.61 and trace mass 67, compound is 1-3 Pentadiene (C_5H_8), retention time 2.97 and trace mass 42, compound is 1-Hexene (C_6H_{12}), retention time 3.57 and trace mass 67, compound is double bond Cyclopentene, 1-methyl- (C_6H_{10}), retention time 3.96 and trace mass 67, compound is Cyclohexene (C_6H_{10}), retention time 4.09 and trace mass 56,compound name is 1-Heptene (C_7H_{14}), retention time 4.23 and trace mass 43, compound is Heptane (C_7H_6), retention time 4.66 and trace mass 67, compound is 1,4-Heptadiene (C_7H_{12}), retention time 5.02 and trace mass 81,compound is Cyclohexane, 4-methyl- (C_7H_{12}), retention time 5.59 and trace mass 91, compound is Toluene (C_7H_8) , retention time 5.79 and trace mass 67, compound is double bond 7-Methylbicyclo[4.2.0]octane (C_9H_{16}), retention time 6.12 and trace mass 55,compound is double bonding 1-Octene (C_8H_{16}), retention time 7.00 and trace mass 67,compound is 1,4-Octadiene (C_8H_{14}), retention time 7.18 and trace mass 55, compound is 2,7-Octdoine-1-ol Octadiene ($C_8H_{14}O$) , retention time 8.85 and trace mass 55, compound is

1-Nonene (C_9H_{18}), retention time 9.08 and trace mass 43, compound is Nonane (C_9H_{20}), retention time 10.46 and trace mass 67, compound name is 2-Nonene-1-ol (Z)-, ($C_9H_{18}O$), retention time 11.80 and trace mass 41, compound is double bond 1-Decene ($C_{10}H_{20}$), retention time 13.38 and trace mass 115, compound is Benzene, 1-ethynyl-4-methyl- (C_9H_8), retention time 14.92 and trace mass 57, compound is Undecane, ($C_{11}H_{24}$), retention time 17.66 and trace mass 57, compound is single bond Dodecane ($C_{12}H_{26}$) etc. As well retention time22.68 and trace mass 57, compound is Tetradecane ($C_{14}H_{30}$), retention time 31.03 and trace mass 55, compound is alcoholic E-15-Heptadecenal ($C_7H_{32}O$), retention time 36.46 and trace mass 57, compound is Heneicosane ($C_{21}H_{44}$), retention time 37.92 and trace mass 55, compound is 1,19- Eicosandiene ($C_{20}H_{38}$), retention time 39.58 and trace mass 43, compound is 1-Docosene ($C_{22}H_{44}$) etc. At the last phase of the analysis index retention time 42.47 and trace mass 55, compound is 1, 19-Eicosadiene ($C_{20}H_{38}$), retention time 42.53 and trace mass 57, compound is double bond 1-Docosene ($C_{22}H_{44}$), retention time 43.94 and trace mass 55, compound is alcoholic 1-Eicosanol ($C_{20}H_{42}O$), retention time 45.32 and trace mass 57, compound is 1-Eicosanol ($C_{20}H_{42}O$) and ultimately retention time 46.82 and trace mass 55 compound is alcoholic 1-Eicosanol ($C_{20}H_{42}O$) etc. here appearing that several oxygen compounds are produced because in the reactor during reaction phase oxygen induce from steam and moisture as well**.**

3.3. Liquid Fuel Analysis

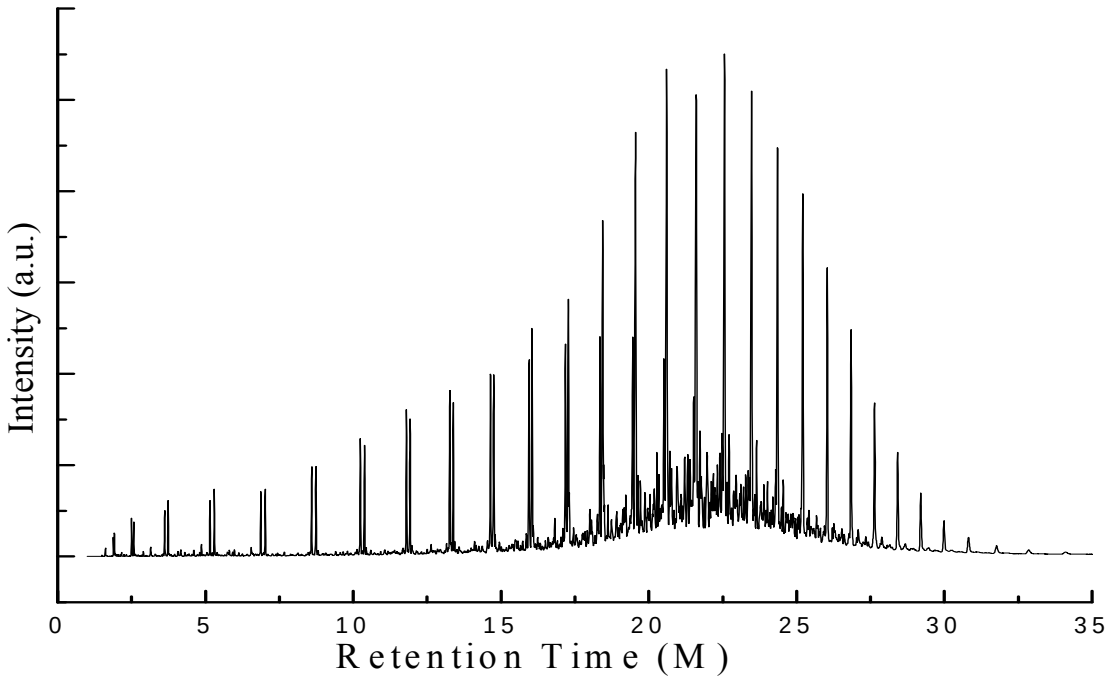

Figure 6: GC/MS Chromatogram of LDPE waste plastic to fuel

Table 9: LDPE waste plastic to fuel GC/MS chromatogram compound list

Peak Number	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	1.50	39	Propane	C_3H_8	44	87.5	18863
2	1.61	43	Butane	C_4H_{10}	58	63.5	18940

3	1.88	42	Cyclopropane, ethyl-	C_5H_{10}	70	18.0	250
4	1.91	43	Pentane	C_5H_{12}	72	83.1	114462
5	1.95	55	1-Butene, 3-methyl-	C_5H_{10}	70	18.1	114463
6	2.02	55	Cyclopropane, 1,2-dimethyl-, cis-	C_5H_{10}	70	25.5	19070
7	2.06	67	1,3-Pentadiene	C_5H_8	68	21.0	291890
8	2.13	67	1,4-Pentadiene	C_5H_8	68	18.2	114494
9	2.25	67	2,3-Diazabicyclo[2.2.1]-hept-2-ene	$C_5H_8N_2$	96	14.2	142950
10	2.50	41	1-Hexene	C_6H_{12}	84	17.3	500
11	2.57	57	Hexane	C_6H_{14}	86	73.4	291337
12	2.72	67	3-Hexen-1-ol, (Z)-	$C_6H_{12}O$	100	13.4	114154
13	2.84	67	1,3-Hexadiene,c&t	C_6H_{10}	82	7.85	231295
14	2.90	56	Cyclopentane, methyl-	C_6H_{12}	84	66.5	114428
15	3.00	67	4-Methyl-2-pentyne	C_6H_{10}	82	16.6	231299
16	3.14	67	Cyclopentene, 3-methyl-	C_6H_{10}	82	14.0	114408
17	3.30	56	Cyclohexane	C_6H_{12}	84	24.5	228008
18	3.62	41	Cyclopentane, 1,2-dimethyl-, cis-	C_7H_{14}	98	30.3	114027
19	3.74	43	Heptane	C_7H_{16}	100	69.0	61276
20	4.06	81	Cyclopentane, 1-methyl-2-methylene-	C_7H_{12}	96	8.69	62523
21	4.16	55	Cyclohexane, methyl-	C_7H_{14}	98	58.9	118503
22	4.31	69	Cyclopentane, ethyl-	C_7H_{14}	98	40.3	940
23	4.44	67	Norbornane	C_7H_{12}	96	9.79	114371
24	4.61	67	1-Ethylcyclopentene	C_7H_{12}	96	37.3	114407
25	4.80	91	Toluene	C_7H_8	92	24.5	291301
26	4.86	81	Cyclohexene, 4-methyl-	C_7H_{12}	96	12.7	125422
27	5.05	79	1,3,6-Heptatriene	C_7H_{10}	94	16.3	113127
28	5.15	41	1-Octene	C_8H_{16}	112	24.1	1604
29	5.30	41	Octane	C_8H_{18}	114	55.3	229407
30	5.39	55	3-Octene, (Z)-	C_8H_{16}	112	12.3	113895
31	5.47	95	1-Methyl-2-methylenecyclohexane	C_8H_{14}	110	8.30	113437
32	5.65	67	Cyclopentene, 1-(1-methylethyl)-	C_8H_{14}	110	8.37	113932
33	5.74	81	Cyclohexane, ethylidene-	C_8H_{14}	110	8.98	1494
34	5.91	41	2,4-Decadien-1-ol	$C_{10}H_{18}O$	154	6.65	136415
35	5.98	55	Cyclohexane, ethyl-	C_8H_{16}	112	50.6	113476
36	6.12	67	4-Octyne	C_8H_{14}	110	12.3	118189
37	6.25	41	2,4-Decadien-1-ol	$C_{10}H_{18}O$	154	7.79	136415
38	6.55	81	Cyclohexanol, 1-ethynyl-, carbamate	$C_9H_{13}NO_2$	167	13.8	313023
39	6.61	67	1-Methyl-2-methylenecyclohexane	C_8H_{14}	110	5.15	113437
40	6.87	41	cis-2-Nonene	C_9H_{18}	126	10.6	113508
41	6.96	91	Bicyclo[2.1.1]hexan-2-ol, 2-ethenyl-	$C_8H_{12}O$	124	32.1	221372
42	7.02	43	Nonane	C_9H_{20}	128	34.4	228006

43	7.44	67	Ethylidenecycloheptane	C_9H_{16}	124	17.6	113500
44	7.66	55	Cyclopentane, butyl-	C_9H_{18}	126	21.8	114172
45	8.12	41	Cyclopentanol, 1-(1-methylene-2-propenyl)-	$C_9H_{14}O$	138	7.53	152742
46	8.24	41	2-Decen-1-ol	$C_{10}H_{20}O$	156	12.6	136260
47	8.41	55	E-1,6-Undecadiene	$C_{11}H_{20}$	152	4.56	245712
48	8.59	41	1-Decene	$C_{10}H_{20}$	140	25.5	118883
49	8.74	43	Decane	$C_{10}H_{22}$	142	58.2	114147
50	8.81	55	2-Decene, (Z)-	$C_{10}H_{20}$	140	15.2	114151
51	9.40	55	Cyclodecane	$C_{10}H_{20}$	140	6.73	113565
52	9.56	67	Cyclopentene, 1-pentyl-	$C_{10}H_{18}$	138	10.0	139585
53	9.65	41	Tricyclo[4.2.1.1(2,5)]decan-3-ol	$C_{10}H_{16}O$	152	9.72	191707
54	9.80	41	Cyclohexene, 3-(2-methylpropyl)-	$C_{10}H_{18}$	138	15.2	27008
55	10.07	41	Carane, 4,5-epoxy-, trans	$C_{10}H_{16}O$	152	5.23	156142
56	10.13	41	3-Undecene, (E)-	$C_{11}H_{22}$	154	7.67	60565
57	10.24	41	1-Undecene	$C_{11}H_{22}$	154	6.39	5022
58	10.38	43	Undecane	$C_{11}H_{24}$	156	50.5	114185
59	10.44	41	5-Undecene, (E)-	$C_{11}H_{22}$	154	10.3	114227
60	10.59	41	2-Pentadecyn-1-ol	$C_{15}H_{28}O$	224	12.8	36724
61	11.07	41	3-Undecene, (E)-	$C_{11}H_{22}$	154	6.82	60565
62	11.18	67	1-Undecyne	$C_{11}H_{20}$	152	7.22	36306
63	11.40	41	Cyclopentaneacetaldehyde, 2-formyl-3-methyl-α-methylene-	$C_{10}H_{14}O_2$	166	5.72	57743
64	11.80	41	3-Dodecene, (E)-	$C_{12}H_{24}$	168	9.23	113960
65	11.92	43	Dodecane	$C_{12}H_{26}$	170	32.3	291499
66	11.98	41	3-Dodecene, (E)-	$C_{12}H_{24}$	168	15.8	70642
67	13.15	41	2-Tridecene, (Z)-	$C_{13}H_{26}$	182	5.66	142613
68	13.27	41	1-Tridecene	$C_{13}H_{26}$	182	8.29	107768
69	13.39	71	Tridecane	$C_{13}H_{28}$	184	36.6	114282
70	13.43	41	5-Tridecene, (E)-	$C_{13}H_{26}$	182	7.54	142619
71	13.58	41	4-Nonene, 5-butyl-	$C_{13}H_{26}$	182	6.84	34734
72	13.99	41	1,12-Tridecadiene	$C_{13}H_{24}$	180	7.10	7380
73	14.10	41	1-Nonadecanol	$C_{19}H_{40}O$	284	4.35	13666
74	14.64	41	1-Tetradecene	$C_{14}H_{28}$	196	6.78	34720
75	14.76	57	Tetradecane	$C_{14}H_{30}$	198	27.1	113925
76	14.80	41	7-Tetradecene	$C_{14}H_{28}$	196	8.54	70643
77	15.85	41	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	8.55	245485
78	15.95	41	1-Pentadecene	$C_{15}H_{30}$	210	5.75	69726
79	10.04	57	Pentadecane	$C_{15}H_{32}$	212	25.3	107761
80	16.08	41	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	13.2	131101
81	16.82	41	E-2-Octadecadecen-1-ol	$C_{18}H_{36}O$	268	7.09	131102
82	17.18	41	1-Hexadecene	$C_{16}H_{32}$	224	9.91	118882
83	17.28	43	Hexadecane	$C_{16}H_{34}$	226	2.6	114191
84	17.31	55	Hexadecen-1-ol, trans-9-	$C_{16}H_{32}O$	240	5.37	141055
85	18.00	41	1-Docosanol	$C_{22}H_{46}O$	326	5.95	23377

86	18.35	55	1-Heptadecanol	$C_{17}H_{36}O$	256	7.46	113250
87	18.44	43	Heptadecane	$C_{17}H_{36}$	240	19.9	107308
88	18.47	55	8-Heptadecene	$C_{17}H_{34}$	238	8.23	113620
89	19.46	83	1-Octadecanol	$C_{18}H_{38}O$	270	5.04	221125
90	19.55	57	Octadecane	$C_{18}H_{38}$	254	18.3	12337
91	19.63	55	1-Eicosanol	$C_{20}H_{42}O$	298	7.01	113075
92	20.61	71	Eicosane	$C_{20}H_{42}$	282	26.1	290513
93	21.52	55	1-Docosene	$C_{22}H_{44}$	308	7.07	113878
94	21.61	43	Eicosane	$C_{20}H_{42}$	282	25.3	290513
95	21.97	97	1-Eicosene	$C_{20}H_{40}$	280	8.35	13488
96	22.56	70	Eicosane	$C_{20}H_{42}$	282	15.4	290513
97	23.48	99	Eicosane	$C_{20}H_{42}$	282	14.1	290513
98	23.65	55	1-Eicosanol	$C_{20}H_{42}O$	298	8.30	113075
99	24.36	43	Eicosane	$C_{20}H_{42}$	282	12.3	290513
100	25.21	99	Eicosane	$C_{20}H_{42}$	282	12.8	290513
101	25.94	55	1-Docosanol	$C_{22}H_{46}O$	326	10.4	23377
102	26.03	57	Eicosane	$C_{20}H_{42}$	282	12.5	290513
103	26.84	57	Heneicosane	$C_{21}H_{44}$	296	11.8	107569
104	27.64	57	Heneicosane	$C_{21}H_{44}$	296	11.8	107569
105	28.42	57	Heneicosane	$C_{21}H_{44}$	296	6.67	107569
106	28.68	57	17-Pentatriacontene	$C_{35}H_{70}$	490	14.9	233160
107	29.20	57	Hexacosane	$C_{26}H_{54}$	366	8.06	107147
108	29.99	57	Tetratetracontane	$C_{44}H_{90}$	618	9.63	23773
109	30.82	57	Heptacosane	$C_{27}H_{56}$	380	17.6	79427
110	32.86	57	Heptacosane	$C_{27}H_{56}$	380	15.8	79427

From GC/MS analysis of waste LDPE plastic to fuel (**fig.6 and table 9**) in accordance with retention time and trace mass indicate various types of compound are present. High intensity compounds are preferred in the analysis. An investigated carbon range in the analyzed plastic is C_3 to C_{44} because large carbon chains are breaking down into small chain resulting in lower carbon range. Sometimes noticed that for high peak intensity compound probability factor is low percentage, where as in low peak intensity compound probability factor is high percentage. Most of the peaks are considered in the analysis and as per their retention time and trace mass maximum peaks are mentioned, in accordance to retention time 1.49 and trace mass 41, derived compound is Cyclopropane (C_3H_6) with probability 67.2%, retention time 1.59 and trace mass 41, compound is 2-Butene, (E)-, (C_4H_8) with probability 18.5%, retention time 1.89 and trace mass 43, compound is Pentane (C_5H_{12}) with probability 79.8%, retention time 2.03 and trace mass 67, compound is 1,3-Pentadiene (C_5H_8) with probability factor 17.4%, retention time 2.96 and trace mass 79, compound is 1,3-Cyclopentadiene, 5-methyl- (C_6H_8) with probability 30.0%, retention time 3.09, trace mass 67, compound is Cyclopentene, 3-methyl- (C_6H_{10}) with probability 12.2%, retention time 3.90 and trace mass 81, compound is 2,3-Dimethyl-1,4-pentadiene, (C_7H_{12}) with probability 7.20%, retention time 4.01 and trace mass 81, compound is Cyclohexene, 3-methyl-, (C_7H_{12}) with probability 9.73%, retention time 4.81 and trace mass 81, compound is Cyclohexene, 3-methyl-, (C_7H_{12}) with probability 8.73%, retention time 5.11 and trace mass 41, compound is 1-Octene (C_8H_{16}) with probability 19.8%, retention time 5.94 and trace mass 83, compound is Cyclohexane, ethyl-, (C_8H_{16}) with probability 56.2%, retention time 6.85 and trace mass 56, compound is trans-7-Methyl-3-octene (C_9H_{18}) with probability 27.5%, retention time 7.00 and trace mass 43,compound is Nonane (C_9H_{20}) with probability 28.8%, retention time 7.85 and trace mass 67, compound is Cyclopentene, 1-butyl- (C_9H_{16}) with probability 42.9% etc. Also in the middle of the analysis index retention time 8.80 and trace mass 41,

compound is 2-Decene, (Z)- ($C_{10}H_{20}$) with probability 16.6%, retention time 10.24 and trace mass 41, compound is 1-Undecene ($C_{11}H_{22}$) with probability 8.04%, retention time 10.58 and trace mass 41, compound is 2-Pentadecyn-1-ol, ($C_{15}H_{28}O$) with probability 11.9%, retention time 11.98 and trace mass 41, compound is 3-Dodecene, (E)- ($C_{12}H_{24}$) with probability 10.2% etc. As well as Retention time 13.59 and trace mass 142, compound is Bicyclo[4.4.1]undeca-1,3,5,7,9-pentaene, ($C_{11}H_{10}$) with probability 29.2%, retention time 14.95 and trace mass 41, compound is Dodecylsuccinic anhydride ($C_{16}H_{28}O_3$) with probability 4.78%, retention time 15.96 and trace mass 41, compound is Cyclopentadecane ($C_{15}H_{30}$) with the probability 7.23% etc. Accordingly retention time 16.10 and trace mass 41, Compound is E-2-Hexadecacen-1-ol ($C_{16}H_{32}O$) with probability 10.9%, retention time 20.55 and trace mass 41, compound is 9-Nonadecene ($C_{19}H_{38}$) with probability 10.7% , retention time 21.65 and trace mass 43, compound is 4-Tetradecene, (E)- ($C_{20}H_{42}$) with probability 41.2% etc. At the end phase of the analysis index high retention time and trace mass such as retention time 22.64 and trace mass 57, compound is Hexadecane ($C_{21}H_{42}$) with probability 31.7%, retention time 23.59 and trace mass 85, compound is Heneicosane ($C_{21}H_{44}$) with probability 10.8%, and ultimately retention time 27.80 and trace mass 57, compound is Octacosane ($C_{28}H_{58}$) with probability 15.9% and retention time 24.53 and trace mass 57 ,compound is Octacosane ($C_{28}H_{58}$) with probability 10.7% and ultimately retention time 32.86 and trace mass 57,compound is Heptacosane ($C_{27}H_{56}$) as well. In the earlier phase analysis appearing that in several oxygen compounds are produced because in the reactor during reaction oxygen induced from steam and water. Also noticed in the standard HDPE plastic to fuel including double bond compound as well as benzene and benzene derivatives compounds are available. In the middle of the analysis index also noticed that one or more alcoholic compounds are appeared as well.

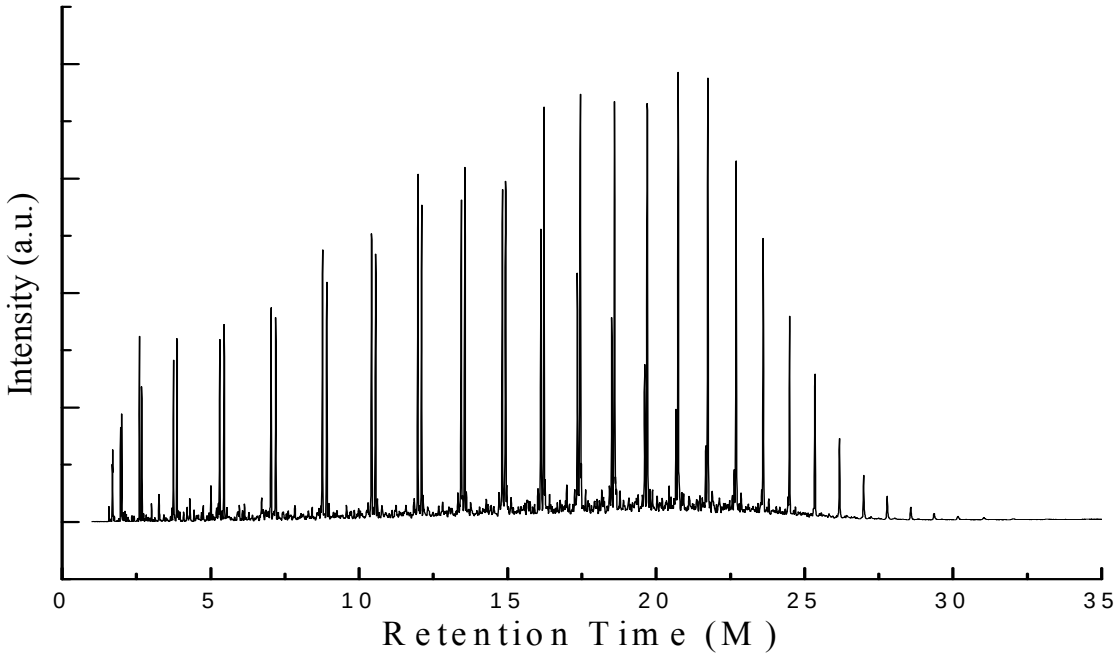

Figure 7: GC/MS Chromatogram of LDPE standard plastic to fuel

Table 10: LDPE standard plastic to fuel GC/MS chromatogram compound list

Peak Number	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number

1	1.57	41	Propane	C_3H_8	44	49.2	18863
2	1.65	43	Isobutane	C_4H_{10}	58	52.8	18936
3	1.69	41	1-Propene, 2-methyl-	C_4H_8	56	34.3	61293
4	1.70	43	Butane	C_4H_{10}	58	69.6	18940
5	1.75	41	1-Propene, 2-methyl-	C_4H_8	56	21.2	61293
6	1.97	42	Cyclopropane, ethyl-	C_5H_{10}	70	24.8	19072
7	2.00	43	Pentane	C_5H_{12}	72	86.1	114462
8	2.11	55	Cyclopropane, 1,2-dimethyl-, cis-	C_5H_{10}	70	24.4	19070
9	2.16	39	1,3-Pentadiene	C_5H_8	68	19.4	291890
10	2.36	67	2,3-Diazabicyclo[2.2.1]-hept-2-ene	$C_5H_8N_2$	96	9.55	194998
11	2.42	42	1-Pentene	C_5H_{10}	70	8.38	19081
12	2.60	41	Cyclopropane, 1-ethyl-2-methyl-, cis-	C_6H_{12}	84	19.3	113658
13	2.68	41	Hexane	C_6H_{14}	86	79.7	61280
14	2.74	55	3-Hexene, (Z)-	C_6H_{12}	84	41.8	114381
15	2.83	67	1,3-Butadiene, 2-ethyl-	C_6H_{10}	82	12.5	118159
16	2.96	67	trans-1,4-Hexadiene	C_6H_{10}	82	8.78	113648
17	3.01	56	Cyclopentane, methyl-	C_6H_{12}	84	63.0	114428
18	3.12	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	14.5	113646
19	3.26	67	Cyclopentene, 3-methyl-	C_6H_{10}	82	10.6	114408
20	3.42	41	Cyclohexane	C_6H_{12}	84	12.3	228008
21	3.74	41	1-Heptene	C_7H_{14}	98	16.4	107734
22	3.86	43	Heptane	C_7H_{16}	100	69.0	61276
23	3.96	41	3-Heptene	C_7H_{14}	98	28.9	113117
24	4.09	81	1,2-Hexadiene, 5-methyl-	C_7H_{12}	96	7.97	27634
25	4.30	55	Cyclohexane, methyl-	C_7H_{14}	98	55.3	118503
26	4.44	41	Cyclopentane, ethyl-	C_7H_{14}	98	34.2	231044
27	4.75	67	1-Ethylcyclopentene	C_7H_{12}	96	38.8	114407
28	5.01	81	Cyclohexene, 3-methyl-	C_7H_{12}	96	8.09	19639
29	5.30	41	1-Octene	C_8H_{16}	112	25.3	1604
30	5.45	43	Octane	C_8H_{18}	114	38.6	229407
31	5.55	55	3-Octene, (Z)-	C_8H_{16}	112	11.1	113895
32	5.97	67	1-Methyl-2-methylenecyclohexane	C_8H_{14}	110	29.8	113437
33	6.08	41	3-Decyn-2-ol	$C_{10}H_{18}O$	154	8.71	53449
34	6.14	83	Cyclohexane, ethyl-	C_8H_{16}	112	55.1	113476
35	6.29	67	3-Octyne	C_8H_{14}	110	11.1	118185
36	6.72	81	Cyclohexene, 1,2-dimethyl-	C_8H_{14}	110	8.39	113912
37	7.04	41	cis-2-Nonene	C_9H_{18}	126	11.4	113508
38	7.19	43	Nonane	C_9H_{20}	128	30.6	228006
39	7.27	55	4-Nonene	C_9H_{18}	126	14.2	113904
40	7.61	67	Ethylidenecycloheptane	C_9H_{16}	124	19.2	113500
41	7.83	55	Cyclopentane, butyl-	C_9H_{18}	126	12.5	114172
42	8.05	67	Cyclopentene, 1-butyl-	C_9H_{16}	124	35.9	113491
43	8.42	56	2-Methyl-1-nonene	$C_{10}H_{20}$	140	11.0	113561

44	8.65	56	trans-3-Decene	$C_{10}H_{20}$	140	6.74	113881
45	8.77	41	1-Decene	$C_{10}H_{20}$	140	23.1	118883
46	8.91	57	Decane	$C_{10}H_{22}$	142	49.0	114147
47	8.99	55	2-Decene, (Z)-	$C_{10}H_{20}$	140	13.8	114151
48	9.57	55	2,4-Undecadien-1-ol	$C_{11}H_{20}O$	168	8.58	136410
49	9.73	67	Cyclopentene, 1-pentyl-	$C_{10}H_{18}$	138	7.10	139585
50	10.30	56	4-Undecene, (Z)-	$C_{11}H_{22}$	154	6.33	142600
51	10.42	41	1-Undecene	$C_{11}H_{22}$	154	5.48	34717
52	10.56	43	Undecane	$C_{11}H_{24}$	156	50.8	114185
53	10.62	55	5-Undecene, (E)-	$C_{11}H_{22}$	154	11.9	114227
54	10.76	41	2-Pentadecyn-1-ol	$C_{15}H_{28}O$	224	20.1	36724
55	11.24	41	2,4-Pentadien-1-ol, 3-pentyl-, (2Z)-	$C_{10}H_{18}O$	154	6.44	142197
56	11.86	41	3-Dodecene, (E)-	$C_{12}H_{24}$	168	4.00	70642
57	12.11	57	Dodecane	$C_{12}H_{26}$	170	34.2	291499
58	12.16	41	3-Dodecene, (E)-	$C_{12}H_{24}$	168	15.3	70642
59	13.33	41	9-Octadecenal	$C_{18}H_{34}O$	266	5.16	35819
60	13.44	41	1-Tridecene	$C_{13}H_{26}$	182	7.48	107768
61	13.56	57	Tridecane	$C_{13}H_{28}$	184	38.8	114282
62	13.61	55	5-Tridecene, (E)-	$C_{13}H_{26}$	182	7.68	142619
63	14.28	41	1-Nonadecanol	$C_{19}H_{40}O$	284	6.59	13666
64	14.71	41	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	7.23	245485
65	14.82	41	3-Tetradecene, (Z)-	$C_{14}H_{28}$	196	4.41	62806
66	14.93	85	Tetradecane	$C_{14}H_{30}$	198	35.1	113925
67	14.97	55	3-Tetradecene, (E)-	$C_{14}H_{28}$	196	5.61	139981
68	15.12	55	7-Tetradecene	$C_{14}H_{28}$	196	6.70	70643
69	16.02	41	4-Tridecene, (Z)-	$C_{13}H_{26}$	182	7.93	142617
70	16.12	41	1-Pentadecene	$C_{15}H_{30}$	210	5.59	69726
71	16.23	57	Pentadecane	$C_{15}H_{32}$	212	22.5	107761
72	16.41	41	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	5.01	131101
73	16.99	41	1-Nonadecanol	$C_{19}H_{40}O$	284	11.9	13666
74	17.35	41	1-Hexadecene	$C_{16}H_{32}$	224	5.81	118882
75	17.45	71	Hexadecane	$C_{16}H_{34}$	226	36.6	114191
76	17.63	41	2-Methyl-E-7-hexadecene	$C_{17}H_{34}$	238	3.91	130870
77	18.18	41	1-Eicosanol	$C_{20}H_{42}O$	298	6.05	23222
78	18.43	41	E-2-Octadecadecen-1-ol	$C_{18}H_{36}O$	268	9.95	131102
79	18.51	41	1-Nonadecene	$C_{19}H_{38}$	266	5.70	113626
80	18.60	71	Heptadecane	$C_{17}H_{36}$	240	29.8	107308
81	18.78	41	2-Methyl-E-7-hexadecene	$C_{17}H_{34}$	238	9.78	130870
82	19.62	41	1-Docosene	$C_{22}H_{44}$	308	5.60	113878
83	19.70	57	Octadecane	$C_{18}H_{38}$	254	19.9	57273
84	20.67	41	9-Nonadecene	$C_{19}H_{38}$	266	10.1	113627
85	20.75	71	Eicosane	$C_{20}H_{42}$	282	14.0	290513
86	21.67	41	1-Docosene	$C_{22}H_{44}$	308	7.16	113878
87	21.74	57	Eicosane	$C_{20}H_{42}$	282	25.4	290513
88	21.88	55	1-Eicosene	$C_{20}H_{40}$	280	10.7	13488
89	22.63	43	10-Heneicosene (c,t)	$C_{21}H_{42}$	294	8.05	113073

90	22.70	43	Heneicosane	$C_{21}H_{44}$	296	26.9	107569
91	22.86	55	1-Heneicosanol	$C_{21}H_{44}O$	312	7.56	233005
92	23.55	43	1-Docosene	$C_{22}H_{44}$	308	9.68	113878
93	23.61	71	Heneicosane	$C_{21}H_{44}$	296	12.5	107569
94	23.79	55	1-Docosanol	$C_{22}H_{46}O$	326	12.7	23377
95	24.49	43	Heneicosane	$C_{21}H_{44}$	296	11.0	107569
96	25.35	57	Tetracosane	$C_{24}H_{50}$	338	9.46	248196
97	26.18	57	Heptacosane	$C_{27}H_{56}$	380	7.68	150574
98	26.98	57	Octacosane	$C_{28}H_{58}$	394	10.2	134306
99	27.78	57	Octacosane	$C_{28}H_{58}$	394	12.7	134306
100	28.57	57	Heptacosane	$C_{27}H_{56}$	380	20.1	79427

GC/MS analysis of solid standard LDPE plastic to fuel (**Fig.7 and table 10**) in accordance with retention time and trace mass indicate various types of compound are present. High intensity compounds are preferred in the analysis. An investigated carbon range in the analyzed plastic is C_3 to C_{28} because large carbon chains are breaking down into small chain resulting in lower carbon range. Sometimes noticed that for high peak intensity compound probability factor is low percentage, where as in low peak intensity compound probability factor is high percentage. Most of the peaks are considered in the analysis and as per their retention time and trace mass maximum peaks are mentioned, in accordance to retention time 1.57 and trace mass 41, derived compound is Propane (C_3H_6) with probability 49.2%, retention time 1.65 and trace mass 43, compound is Isobutane, (C_4H_{10}) with probability 52.8%, retention time 1.69 and trace mass 41, compound is 1-Propene, 2-Methyl- (C_4H_8) with probability 34.3%, retention time 1.70 and trace mass 43, compound is Butane (C_4H_{10}) with probability factor 69.6%, retention time 2.00 and trace mass 43, compound is Pentane, (C_5H_{12}) with probability 86.1%, retention time 2.11, trace mass 55, compound is Cyclopropane, 1,2-dimethyl-,cis- (C_5H_{10}) with probability 24.4%, retention time 2.16 and trace mass 39, compound is 1,3-Pentadiene, 2-ethyl-, (C_5H_8) with probability 19.4%, retention time 3.01 and trace mass 56, compound is Cyclopentane, methyl-,(C_6H_{12}) with probability 63%, retention time 3.74 and trace mass 41, compound is 1-Heptene (C_7H_{14}) with probability 16.4%, retention time 3.86 and trace mass 43, compound is Heptane (C_7H_{16}) with probability 69.0%, retention time 4.09 and trace mass 81, compound is 1,2-Hexadiene, 5-methyl- (C_7H_{12}) with probability 7.97%, retention time 4.75 and trace mass 67, compound is 1-Ethylcyclopentene (C_7H_{12}) with probability 38.8%, retention time 5.97 and trace mass 67,compound is 1-Methyl-2-methylenecyclohexane (C_8H_{14}) with probability 29.8%, retention time 6.72 and trace mass 81, compound is Cyclohexene, 1,2-dimethyl- (C_8H_{14}) with probability 8.39% etc. Also in the middle of the analysis index retention time 6.72 and trace mass 81, compound is Cyclohexene, 1,2-dimethyl- (C_8H_{14}) with probability 8.39%, retention time 7.61 and trace mass 67, compound is Ethylidenecycloheptane (C_9H_{16}) with probability 19.2%, retention time 7.83 and trace mass 55, compound is Cyclopentane, butyl- (C_9H_{18}) with probability 12.5%, retention time 8.99 and trace mass 55, compound is 2-Decene, (Z) - ($C_{10}H_{20}$) with probability 13.8% etc. As well in the middle phase of the analysis index retention time 9.57 and trace mass 55, compound is 2,4-Undecadien-1-ol ($C_{11}H_{20}O$) with probability 8.58%, retention time 10.76 and trace mass 41, compound is 2-Pentadecyn-1-ol ($C_{15}H_{28}O$) with probability 20.10%, retention time 12.11 and trace mass 57, compound is Dodecane ($C_{12}H_{26}$) with the probability 34.2% accordingly. Also at the end phase of the analysis retention time 13.61 and trace mass 55, Compound is 5-Tridecene, (E)- ($C_{13}H_{26}$) with probability 9.82%, retention time 39.58 and trace mass 57, compound is Heneicosane ($C_{21}H_{44}$) with probability 7.68% , retention time 14.28 and trace mass 41, compound is Nonadecanol, ($C_{19}H_{40}O$) with probability 6.59%, retention time 17.45 and trace mass 71, compound is Hexadecane ($C_{16}H_{34}$) with probability 36.6%, retention time 19.62 and trace mass 41, compound is 1-Docosene ($C_{22}H_{44}$) with probability 5.60%, and retention time 27.78 and trace mass 57, compound is Octacosane ($C_{28}H_{58}$) with probability 12.7% and ultimately retention time 28.57 and trace mass 57,compound is Heptacosane ($C_{27}H_{56}$) with probability 20.1% as well. In the analysis appearing that in several oxygen compounds are produced

because in the reactor during reaction oxygen induced from steam and water. Also noticed in the standard LDPE plastics including single and double bond compound as well as aliphatic and aromatic derivatives compounds are also available.

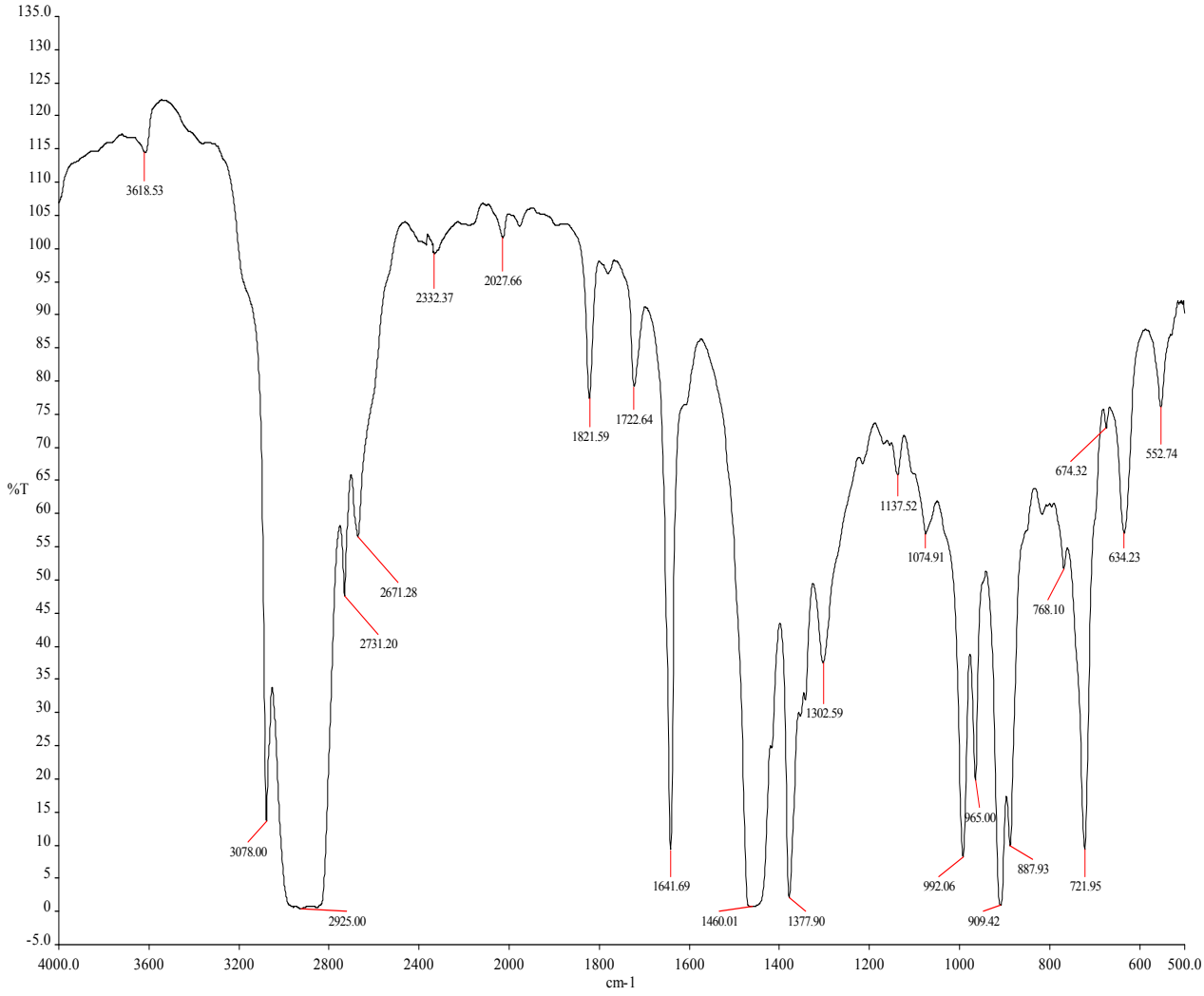

Figure 8: FT-IR spectrum of LDPE waste plastic to fuel

Table 11: FT-IR spectrum of LDPE waste plastic to fuel functional group

Number of Peak	Band Number (cm^{-1})	Functional Group Name	Number of Peak	Band Number (cm^{-1})	Functional Group Name
1	3618.53	Free OH	13	1302.59	
2	3078.00	H Bonded NH	14	1137.52	
3	2925.00	C-CH_3	15	1074.91	
4	2731.20	C-CH_3	16	992.06	-CH=CH_2
5	2671.28	C-CH_3	17	965.00	-CH=CH-(trans)
6	2332.37		18	909.42	-CH=CH_2
7	2027.66		19	887.93	C=CH_2
8	1821.59	Non-Conjugated	20	768.10	
9	1722.64	Non-Conjugated	21	721.95	-CH=CH-(cis)

10	1641.69	Conjugated	22	674.32	-CH=CH-(cis)
11	1460.01	CH_3	23	634.23	
12	1377.90	CH_3	24	552.74	

FT-IR analysis of LDPE raw waste plastic to fuel **(fig. 8 and table 11**) according to their wave number and spectrum band following types of functional groups are appeared in the analysis. In the spectrum field we noticed that higher wave number are emerged in the initial phase and middle index of the spectrum and in higher wave number small and bulky both functional groups are available and in low wave number double bond and single bond functional groups are available such as methane group, cis and trans alkene etc. Hereafter wave number 3618.53 cm^{-1} ,functional group is Free OH, wave number 3078.00 cm^{-1} , functional group is H Bonded NH, wave number 2925.00 cm^{-1}, functional group is C-CH_3, 2731.20 cm^{-1} functional group is C-CH_3, wave number 1821.59 cm^{-1}, functional group is Non-Conjugated, wave number 1722.64 cm^{-1} , functional group is Non-Conjugated, wave number 1641.69 cm^{-1}, functional group is Conjugated, wave number 1460.01 cm^{-1} and 1377.90 cm^{-1} functional group is CH_3, wave number 992.06 cm^{-1} functional group is -CH=CH_2, wave number 965.00 cm^{-1}, functional group is -CH=CH-(trans), wave number 887.93, functional group is C=CH_2, wave number 721.95 cm^{-1} , functional group is -CH=CH-(cis) and ultimately wave number 674.32 cm^{-1} , functional group is -CH=CH-(cis) as well. For several wave number energy values are calculated, using formula is E=hυ, Where h=Planks Constant, h =$6.626x10^{-34}$ J, υ= Frequency in Hertz (sec^{-1}), Where υ=c/λ, c=Speed of light, where, c=$3x10^{10}$ m/s, W=1/λ, where λ is wave length and W is wave number in cm^{-1}. Therefore the equation E=hυ, can substitute by the following equation, E=hcW. According to their wave number several energy values are calculated such as for 2925.00 (cm^{-1}) calculated energy, E=$5.79x10^{-20}$ J, wave number 2731.20 (cm^{-1}), calculated energy, E=$5.42x10^{-20}$ J, wave number 1641.69 (cm^{-1}), calculated energy, E=$3.26x10^{-20}$ J, wave number 1460.01 (cm^{-1}), calculated energy, E=$2.90x10^{-20}$ J , wave number 1377.90 (cm^{-1}), calculated energy, E=$2.73x10^{-20}$ J, wave number 721.95 (cm^{-1}), calculated energy, E=$1.44x10^{-20}$ J, Similarly, wave number 674.32 (cm^{-1}) energy, E =$1.33x10^{-20}$ J respectively.

Table 12: FT-IR spectrum of LDPE standard plastic to fuel functional group

Number of Peak	Band Number (cm^{-1})	Functional Group Name	Number of Peak	Band Number (cm^{-1})	Functional Group Name
1	3617.44	Free OH	13	1302.51	
2	3078.01	H Bonded NH	14	1137.62	
3	2924.69	C-CH_3	15	1075.15	
4	2731.20	C-CH_3	16	992.04	-CH=CH_2
5	2671.06	C-CH_3	17	964.98	-CH=CH-(trans)
6	2331.20		18	909.44	-CH=CH_2
7	2027.67		19	887.85	C=CH_2
8	1821.60	Non-Conjugated	20	768.10	
9	1722.59	Non-Conjugated	21	721.98	-CH=CH-(cis)
10	1641.71	Conjugated	22	674.34	-CH=CH-(cis)
11	1456.01	CH_3	23	634.22	
12	1377.88	CH_3	24	552.93	

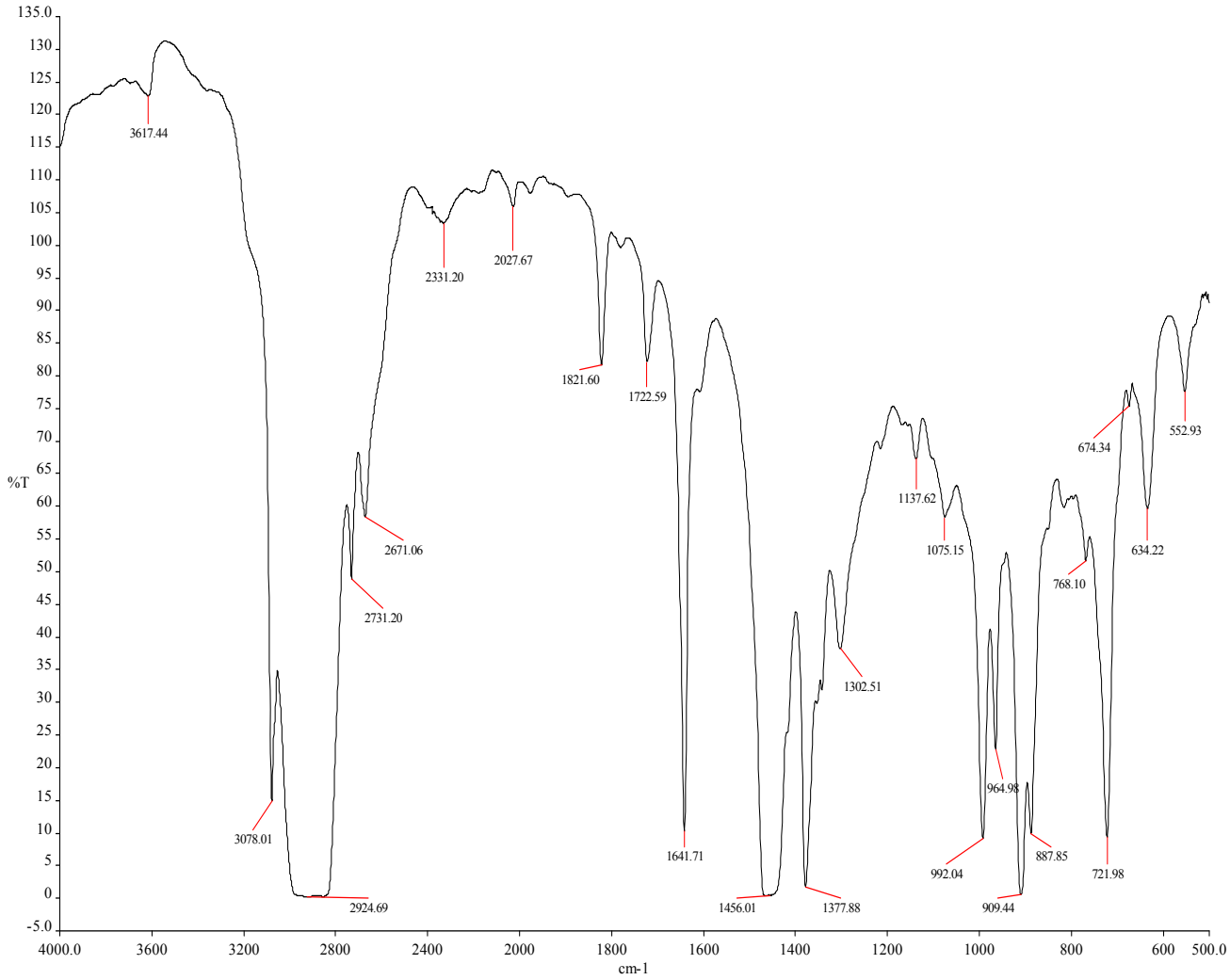

Figure 9: FT-IR spectrum of LDPE standard plastic to fuel

FTIR analysis of LDPE raw standard plastic to fuel (**fig. 9 and table12**) according to their wave number and spectrum band following types of functional groups are appeared in the analysis. In the spectrum field we noticed that higher wave number are emerged in the initial phase and middle index of the spectrum and in higher wave number small and bulky both functional groups are available and in low wave number double bond and single bond functional groups are available such as methane group, cis and trans alkene etc. Hereafter wave number 3617.44 cm^{-1} ,functional group is Free OH, wave number 3078.01 cm^{-1} , functional group is H Bonded NH, wave number 2924.69 cm^{-1}, functional group is C-CH_3, 2731.20 cm^{-1} functional group is C-CH_3, wave number 1821.60 cm^{-1}, functional group is Non-Conjugated, wave number 1722.59 cm^{-1} , functional group is Non-Conjugated, wave number 1641.71 cm^{-1}, functional group is Conjugated, wave number 1456.01 cm^{-1} and 1377.88 cm^{-1} functional group is CH_3, wave number 992.04 cm^{-1} functional group is -CH=CH_2, wave number 964.98 cm^{-1}, functional group is -CH=CH-(trans), wave number 887.85, functional group is C=CH_2, wave number 721.98 cm^{-1} , functional group is -CH=CH-(cis) and ultimately wave number 674.34 cm^{-1} , functional group is -CH=CH-(cis) as well. For several wave number energy values are calculated, using formula is E=hυ, Where h=Planks Constant, h =6.626x10^{-34} J, υ= Frequency in Hertz (sec^{-1}), Where υ=c/λ, c=Speed of light, where, c=3x10^{10} m/s, W=1/λ, where λ is wave length and W is wave number in cm^{-1}. Therefore the equation E=hυ, can substitute by the following equation, E=hcW.

According to their wave number several energy values are calculated such as for 2924.69 (cm^{-1}) calculated energy, $E=5.79x10^{-20}$ J, wave number 2731.20 (cm^{-1}), calculated energy, $E=5.42x10^{-20}$ J, wave number 1641.71 (cm^{-1}), calculated energy, $E=3.26x10^{-20}$ J, wave number 1456.01 (cm^{-1}), calculated energy, $E=2.90x10^{-20}$ J , wave number 1377.88 (cm^{-1}), calculated energy, $E=2.73x10^{-20}$ J, wave number 721.98 (cm^{-1}), calculated energy, $E=1.44x10^{-20}$ J, Similarly, wave number 674.34 (cm^{-1}) energy, $E =1.33x10^{-20}$ J respectively.

Table 13: LDPE waste plastic to fuel ASTM test result

Method Name	Test Name	Results	Units
ASTM D240	Gross Heat of Combustion	18681	BTU/lb
ASTM D240	Gross Heat of Combustion (Calculated)	123631	BTU/gal
ASTM D4052	API Gravity @ 60°F	46.5	°API
ASTM D86-07b	IBP Recovery	95.6	°C
ASTM D86-07b	5% Recovery	120.0	°C
ASTM D86-07b	10% Recovery	136.7	°C
ASTM D86-07b	20% Recovery	164.4	°C
ASTM D86-07b	30% Recovery	193.3	°C
ASTM D86-07b	40% Recovery	222.2	°C
ASTM D86-07b	50% Recovery	248.9	°C
ASTM D86-07b	60% Recovery	262.2	°C
ASTM D86-07b	70% Recovery	288.9	°C
ASTM D86-07b	80% Recovery	365.6	°C
ASTM D86-07b	90% Recovery	-	°C
ASTM D86-07b	95% Recovery	-	°C
ASTM D86-07b	FBP Recovery	371.1	°C
ASTM D86-07b	Recovery	82.0	Vol%
ASTM D86-07b	Residue	18.0	Vol%
ASTM D2500	Cloud point	-20.6	°C
ASTM D2500	Cloud Point	-5.1	°F
ASTM D97	Pour point	-24	°C
ASTM D97	Pour point	-11.2	°F
ASTM D2386	Freezing Point	16.0	°C
ASTM D2386	Freezing Point	61.0	°F
ASTM D2624	Temperature	24.0	°C
ASTM D2624	Electrical Conductivity	1.0	pS/M
ASTM D5453	Sulfur	<1.0	mg/kg
AST M D1500	ASTM Color	<5.0	
ASTM D4176	Appearance: Clean and Bright	-	
ASTM D4176	Free Water Content/Particles	No water	mg/kg
ASTM D4176	Haze Rating	6.0	
ASTM D4176	Special Observation	Darker than usual	
ASTM D4737	Cetane Index (Procedure A)	63.2	
ASTM D5708_MOD	Vanadium	<1.0	ppm
ASTM D5708_MOD	Nickel	<1.0	ppm
ASTM D5708_MOD	Iron	<1.0	ppm, or, mg/Kg
ASTM D482	Ash	<0.001	Wt%
ASTM D93	Procedure Used	A	
ASTM D93	Corrected Flash Point	Below room temperature	°C
ASTM D4530	Average Micro Method Carbon Residue 10% distillation	0.4	Wt%
ASTM D664	Procedure Used	A	

ASTM D664	Acid Number	0.10	mgKOH/gm
ASTM D130	Copper Corrosion @ 50°C (122°F)/3 hrs.	1a	
ASTM D2709	Sediment and Water	<0.005	Vol%
ASTM D5291	Carbon Content	86.25	Wt%
ASTM D5291	Hydrogen Content	13.69	Wt%
ASTM D5291	Nitrogen Content	<0.75	Wt%

Low density polyethylene (LDPE) waste plastic to produced fuel was analysis (**table 13)** by 3rd party Intertek laboratory New Jersey, USA, and all test was performed ASTM test followed such as ASTM D240 Gross Heat of Combustion :18681 BTU/lb, ASTM D240 Gross Heat of Combustion, (Calculated): 123631 BTU/gal, ASTM D4052 API Gravity @ 60°F: 46.5 °API, ASTM D86-07b IBP Recovery: 95.6 °C, ASTM D86-07b 5% Recovery: 120.0 °C, ASTM D86-07b 10% Recovery: 136.7 °C, ASTM D86-07b 20% Recovery: 164.4 °C, ASTM D86-07b 30% Recovery: 193.3 °C, ASTM D86-07b 40% Recovery: 222.2 °C, ASTM D86-07b 50% Recovery: 248.9 °C, ASTM D86-07b 60% Recovery: 262.2 °C, ASTM D86-07b 70% Recovery: 288.9 °C, ASTM D86-07b 80% Recovery: 365.6 °C, ASTM D86-07b 90% Recovery: °C, ASTM D86-07b 95% Recovery: °C, ASTM D86-07b FBP Recovery: 371.1 °C, ASTM D86-07b Recovery: 82.0 Vol%, ASTM D86-07b Residue: 18.0 Vol%, ASTM D2500 Cloud point: -20.6 °C, ASTM D2500 Cloud Point : -5.1 °F, ASTM D97 Pour point: -24 °C, ASTM D97 Pour point: -11.2 °F, ASTM D2386 Freezing Point : 16.0 °C, ASTM D2386 Freezing Point: 61.0 °F, ASTM D2624 Temperature: 24.0 °C, ASTM D2624 Electrical Conductivity: 1.0 pS/M, ASTM D5453 Sulfur: <1.0 mg/kg, ASTM D1500 ASTM Color: <5.0, ASTM D4176 Appearance: Clean and Bright, ASTM D4176 Free Water Content/Particles: No water mg/kg, ASTM D4176 Haze Rating : 6.0, ASTM D4176 Special Observation: Darker than usual, ASTM D4737 Cetane Index (Procedure A): 63.2, ASTM D5708_MOD Vanadium: <1.0 ppm, ASTM D5708_MOD Nickel: <1.0 ppm, ASTM D5708_MOD Iron : <1.0 ppm, or, mg/Kg, ASTM D482 Ash: <0.001 Wt%, ASTM D93 Procedure Used _A ASTM D93 Corrected Flash Point : Below room temperature °C, ASTM D4530 Average Micro Method Carbon Residue 10% distillation: 0.4 Wt%, ASTM D664 Procedure Used_A ASTM D664 Acid Number: 0.10 mgKOH/gm, ASTM D130 Copper Corrosion @ 50°C (122°F)/3 hrs.: 1a , ASTM D2709 Sediment and Water: <0.005 Vol%, ASTM D5291 Carbon Content: 86.25 Wt%, ASTM D5291 Hydrogen Content : 13.69 Wt%, ASTM D5291 Nitrogen Content: <0.75 Wt%.

Table 14: LDPE standard plastic to fuel ASTM test result

Method Name	Test Name	Results	Units
ASTM D240	Gross Heat of Combustion	19551	BTU/lb
ASTM D240	Gross Heat of Combustion (Calculated)	128606	BTU/gal
ASTM D4052	API Gravity @ 60°F	47.6	°API
ASTM D86-07b	IBP Recovery	86.7	°C
ASTM D86-07b	5% Recovery	104.4	°C
ASTM D86-07b	10% Recovery	120.0	°C
ASTM D86-07b	20% Recovery	151.1	°C
ASTM D86-07b	30% Recovery	188.9	°C
ASTM D86-07b	40% Recovery	223.3	°C
ASTM D86-07b	50% Recovery	246.7	°C
ASTM D86-07b	60% Recovery	271.1	°C
ASTM D86-07b	70% Recovery	297.8	°C
ASTM D86-07b	80% Recovery	-	°C
ASTM D86-07b	90% Recovery	-	°C
ASTM D86-07b	95% Recovery	-	°C

ASTM D86-07b	FBP Recovery	364.4	°C
ASTM D86-07b	Recovery	75.0	Vol%
ASTM D86-07b	Residue	25.0	Vol%
ASTM D2500	Cloud point	-16.6	°C
ASTM D2500	Cloud Point	2.1	°F
ASTM D97	Pour point	-18.0	°C
ASTM D97	Pour point	-0.4	°F
ASTM D2386	Freezing Point	13.0	°C
ASTM D2386	Freezing Point	55.0	°F
ASTM D2624	Temperature	24.0	°C
ASTM D2624	Electrical Conductivity	<1	pS/M
ASTM D5453	Sulfur	1.0	mg/kg
ASTM D1500	ASTM Color	<4.0	
ASTM D4176	Appearance: Clean and Bright	Fail	
ASTM D4176	Free Water Content/Particles		mg/kg
ASTM D4176	Haze Rating		
ASTM D4176	Special Observation	Darker than usual	
ASTM D4737	Cetane Index (Procedure A)	64.7	
ASTM D5708_MOD	Vanadium	<1.0	ppm
ASTM D5708_MOD	Nickel	<1.0	ppm
ASTM D5708_MOD	Iron	<1.0	ppm OR, mg/Kg
ASTM D482	Ash	<1.0	Wt%
ASTM D93	Procedure Used	A	
ASTM D93	Corrected Flash Point	Below room temperature	°C
ASTM D4530	Average Micro Method Carbon Residue 10% distillation	0.2	Wt%
ASTM D664	Procedure Used	A	
ASTM D664	Acid Number	<0.10	mgKOH/gm
ASTM D130	Copper Corrosion @ 50°C (122°F)/3 hrs.	1a	
ASTM D2709	Sediment and Water	<0.005	Vol%
ASTM D5291	Carbon Content	86.45	Wt%
ASTM D5291	Hydrogen Content	13.51	Wt%
ASTM D5291	Nitrogen Content	<0.75	Wt%

LDPE standard plastic to fuel (**table 14**) test was performed from 3rd party Intertek laboratory in New Jersey, USA and all ASTM test method followed such as ASTM D240 Gross Heat of Combustion: 19551 BTU/lb, ASTM D240 Gross Heat of Combustion (Calculated): 128606 BTU/gal, ASTM D4052 API Gravity @ 60°F: 47.6 °API, ASTM D86-07b IBP Recovery: 86.7 °C, ASTM D86-07b 5% Recovery: 104.4 °C, ASTM D86-07b 10% Recovery: 120.0 °C, ASTM D86-07b 20% Recovery :151.1 °C, ASTM D86-07b 30% Recovery: 188.9 °C, ASTM D86-07b 40% Recovery: 223.3 °C, ASTM D86-07b 50% Recovery: 246.7 °C, ASTM D86-07b 60% Recovery: 271.1 °C, ASTM D86-07b 70% Recovery: 297.8 °C, ASTM D86-07b 80% Recovery: °C, ASTM D86-07b 90% Recovery: °C, ASTM D86-07b 95% Recovery: °C, ASTM D86-07b FBP Recovery: 364.4 °C, ASTM D86-07b Recovery: 75.0 Vol%, ASTM D86-07b Residue: 25.0 Vol%, ASTM D2500b Cloud point: -16.6 °C, ASTM D2500 Cloud Point: 2.1°F, ASTM D97 Pour point: -18.0 °C, ASTM D97 Pour point: -0.4 °F, ASTM D2386 Freezing Point: 13.0 °C, ASTM D2386 Freezing Point: 55.0 °F, ASTM D2624 Temperature: 24.0 °C, ASTM D2624 Electrical Conductivity : <1 pS/M, ASTM D5453 Sulfur: 1.0mg/kg, ASTM D1500 ASTM Color: <4.0, ASTM D4176 Appearance Clean and Bright: Fail, ASTM D4176 Free Water Content/Particles: 0 mg/kg, ASTM D4176Haze Rating: nil, ASTM D4176 Special Observation: Darker than usual, ASTM D4737 Cetane Index (Procedure A): 64.7, ASTM D5708_MOD Vanadium: <1.0 ppm , ASTM D5708_MOD Nickel: <1.0 ppm, ASTM D5708_MOD Iron: <1.0 ppm

OR, mg/Kg, ASTM D482 Ash: <1.0 Wt%, ASTM D93 Procedure Used _A ASTM D93 Corrected Flash Point: Below room temperature °C, ASTM D4530 Average Micro Method Carbon Residue 10% distillation: 0.2 Wt%, ASTM D664 Procedure Used _A ASTM D664 Acid Number: <0.10 mgKOH/gm, ASTM D130 Copper Corrosion @ 50°C (122°F)/3 hrs.:1a, ASTM D2709 Sediment and Water: <0.005 Vol%, ASTM D5291 Carbon Content: 86.45Wt%, ASTM D5291 Hydrogen Content:13.51 Wt%, ASTM D5291 Nitrogen Content : <0.75 Wt%.

3.4. Solid Residue Analysis

Table 15: LDPE waste plastic and LDPE standard plastic to residue analysis result by ICP

Test Method Name	Trace Metal Name	LDPE Waste Plastic to Residue (ppm)	LDPE Standard Plastic to Residue (ppm)
ASTM D1976	Silver	<1.0	<1.0
	Aluminum	7806	799.9
	Arsenic	23.6	<1.0
	Boron	24.3	14.9
	Barium	11.4	74.8
	Beryllium	<1.0	<1.0
	Calcium	1041	2879
	Cadmium	<1.0	<1.0
	Chromium	29.2	51.0
	Copper	82.4	38.7
	Iron	4280	2112
	Potassium	106.7	<1.0
	Lithium	<1.0	<1.0
	Magnesium	221.6	125.0
	Manganese	17.8	24.4
	Sodium	1201	152.9
	Nickel	148.7	246.7
	Lead	10.8	<1.0
	Antimony	<1.0	<1.0
	Selenium	<1.0	<1.0
	Silicon	77.0	33.8
	Tin	274.3	152.7
	Titanium	191.1	736.5
	Vanadium	17.0	<1.0
	Zinc	1617	84.5

LDPE waste plastic and LDPE standard plastic to fuel production period some residue was left over that residue was combination of metal and metal was analysis by ICP and ASTM method was ASTM D1976 and **table 15** showed metal content result for LDPE waste plastic to residue such as Silver <1.0 ppm, Aluminum 7806 ppm, Arsenic 23.6 ppm, Boron 24.3ppm, 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, Magnesium 221.6 ppm, Manganese 17.8 ppm, Sodium 1201 ppm, Nickel 148.7 ppm, Lead 10.8 ppm, Antimony <1.0 ppm, Selenium <1.0 ppm, Silicon 77.0 ppm, Tin 274.3 ppm, Titanium 191.1 ppm, Vanadium 17.0 ppm, Zinc 1617 ppm level was present into LDPE waste plastic to residue. On the other hand pure standard LDPE plastic to residue also metal content present such as Silver <1.0 ppm, Aluminum 799.9 ppm, Arsenic <1.0 ppm, Boron 14.9 ppm, Barium 74.8 ppm, Beryllium <1.0 ppm, Calcium 2879 ppm, Cadmium <1.0 ppm, Chromium 51.0 ppm, Copper 38.7 ppm, Iron 2112 ppm, Potassium <1.0 ppm, Lithium <1.0 ppm, Magnesium 125.0 ppm, Manganese 24.4 ppm, Sodium 152.9 ppm, Nickel 246.7 ppm, Lead <1.0 ppm, Antimony <1.0 ppm, Selenium <1.0 ppm, Silicon 33.8 ppm, Tin 152.7

ppm, Titanium736.5 ppm, Vanadium <1.0 ppm, Zinc 84.5 ppm level present respectively. LDPE waste plastic and LDPE standard plastic metal content was vary because LDPE waste plastic was come from consumer level and LDPE plastic was made for consumer and it was made with different types of additives and additives percentage is almost 3-4% and those additives come out as solid black residue. On the other hand pure standard LDPE plastic made for analysis or made for plastic manufacturing company making plastic with adding dye or chemical for that reason additives percentage is less then manufactured consumer plastic. During waste plastic to fuel production or standard plastic to fuel production metal content was not come out that much what ever come it was negligible because all metal content melting point temperature more than higher from waste plastic to fuel production temperature. Metal content was help to break down long chain hydrocarbon to short chain hydrocarbon because metal content react as catalyst because all types of catalyst are made by metal.

Table 16: LDPE waste plastic and LDPE standard plastic to residue C, H and N % by EA-2400

Test Method Name	Plastics Name	Carbon (C) %	Hydrogen (H) %	Nitrogen (N)%
ASTM D5291.a	LDPE Waste Plastic to Residue	81.81	2.15	<0.30
	LDPE Standard Plastic to Residue	68.72	2.15	<0.30

LDPE waste plastic and LDPE standard plastic to residue was analysis by Elemental Analyzer 2400 in CHN mode with followed ASTM method ASTM D529_a. In **table 16** analysis result indicate that LDPE waste plastic to residue carbon percentage is 81.81%, hydrogen percentage is 2.15% and nitrogen percentage is less then <0.30%. On the other hand standard pure LDPE plastic to residue analysis result indicate that carbon percentage is 68.72 %, hydrogen percentage is 2.15% and nitrogen percentage is <0.30%. LDPE waste plastic additives percentage is higher than LDPE standard plastic. Residue analysis result showed also Btu value more than 5000/lb and this residue could be use as substantial coal or road carpeting and road carpeting. Both residue was heated up to more than 800 ºC and check there physical properties and found it did not burn it and make more hard like stone. During heating period we notice that some black smoke came out. Residue was combination of different category of metal which was used during plastic manufacturing period for their different shape or hardness and softness. All metal was come out as a residue after plastic to fuel production finished.

4. Conclusion

LDPE waste plastic and LDPE standard plastic to fuel production process was applied with thermal degradation without catalyst in present of oxygen under laboratory fume hood. Both experiments were performed same parameter and same condition. In laboratory batch scale process LDPE waste plastic and LDPE standard plastic to fuel production temperature were uses in same feature. Collected fuel was analyzed by NSR laboratory and 3rd party analysis for fuel properties determination. In this analysis ASTM result indicate that LDPE waste plastic to fuel BTU value is 123631/gallon and on the other hand LDPE standard plastic to fuel BTU value is 128606/ gallon. LDPE standard plastic to fuel GC/MS analysis result showed hydrocarbon range is C_3-C_{28} on the other hand LDPE waste plastic to fuel GC/MS analysis result indicate that hydrocarbon range is C_3-C_{44}. By using this technology could be solve environmental problems as well as energy problems and the thermal process can able to convert all LDPE waste plastic into liquid hydrocarbon fuel for internal combustion engines. Produced fuel could be use as a feed stock refinery or feed for electricity generation power plant. By using the technologies could be reduce some foreign oil dependency and boost up energy sector for near future.

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