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Research Article

Mixture of Waste Plastics to Fuel Production Process Using Catalyst Percentage Ratio Effect Study

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Abstract

Mixture of waste plastics (low density polyethylene, high density polyethylene, polypropylene and polystyrene) and ferric carbonate was use 5%, 10%, and 20% for fuel production liquefaction process. In the batch process experiment was perform under laboratory fume hood in atmospheric pressure without vacuum system. Each experiment initial sample was use 150 gm as a mixture waste plastics and catalyst was use ratio wise. Experimental temperature range was 200-420 ºC and glass reactor used. Product fuels density are 0.78 gm/ml (5% ferric carbonate), 0.77 gm/ml (10% ferric carbonate), and 0.77 gm/ml (20% ferric carbonate). Fuels were analysis by using gas chromatography and mass spectrometer (GC/MS) and obtain compounds range for 5% ferric carbonate C_3H_6 - $C_{28}H_{58}$, for 10% ferric carbonate compounds range C_3H_6 - $C_{28}H_{58}$, and 20 % ferric carbonate compounds range C_3H_6 -$C_{28}H_{58}$. Waste plastics mixture and ferric carbonate mixture to liquid fuel production conversion rate was 86% for 5% ferric carbonate, 86% for 10% ferric carbonate and 90% for 20% ferric carbonate added. Fuels color is light yellow and fuels can use internal combustion engines.

Keywords: waste plastics, catalyst, ferric carbonate, fuels, hydrocarbon, thermal, GC/MS

Introduction

Plastic products, such as polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), polyurethane and polyphenols, make up 83% of the production of plastics. In the U.S., 30 million tons of total plastic are produced each year, with only about 4% now being recycled [l]. Waste plastics roughly consisted of 50–60% of PE, 20–30% of PP, 10–20% of PS and, 10% of PVC [2]. Liquefaction of waste plastics has been attracting great attention as a key technology to solve environmental protection problems. It has been reported that thermal cracking or acid catalyzed cracking could produce liquid product from plastics, such as polypropylene or polyethylene. However, results to date have produced oils which are waxy and of a very bad quality and, thus, are useful for very limited purposes. The present authors have already reported a new coal-derived disposable catalyst developed for residual oils cracking to produce high quality distillates [3-4]. Nowadays there are three ways to utilize plastic waste: land filling, incineration with or without energy recovery and recycling. The largest amount of plastic wastes is disposed of by land filling (65-70%), and incineration (20-25%). Recycling is only about 10%. Moreover, the problem of wastes cannot be solved by land filling and incineration, because suitable and safe depots are expensive, and incineration stimulates the growing emission of harmful, greenhouse gases, e.g. NOx, SOx, COx, etc. Recycling can be divided into further important categories, such as mechanical recycling and chemical recycling. Chemical recycling is virtually a thermal method by which the long alkyl chains of polymers are broken into a mixture of lighter hydrocarbons. This is one of the prospective ways to utilize waste polymers [5-11].

Thermal recycling of waste polymers under different catalytic and thermal circumstances has been well investigated by researchers [12-17]. It was found that both the yields and chemical properties of products can be modified with catalysts. In batch reactions, catalysts can be added easily, but in a continuous system it might be problematical, because, e.g. the maintenance of fluid beds depends on the changing properties of wastes. A further problem is the handling of the deactivated catalysts, which have to be separated from the residue and reactivated. Hardman et al. [18] used silicates and sands for creating a fluidized bed. The minimum temperature of cracking could be reduced to 450-550 ºC and later to 430 ºC. Sharrath et al. [19] investigated the catalytic degradation of HDPE on a fluidized bed using HZSM-5 catalyst. Higher yields of gases and liquids and higher concentrations of branched hydrocarbons were found with increasing temperature and the presence of catalyst [20].

Experimental Process

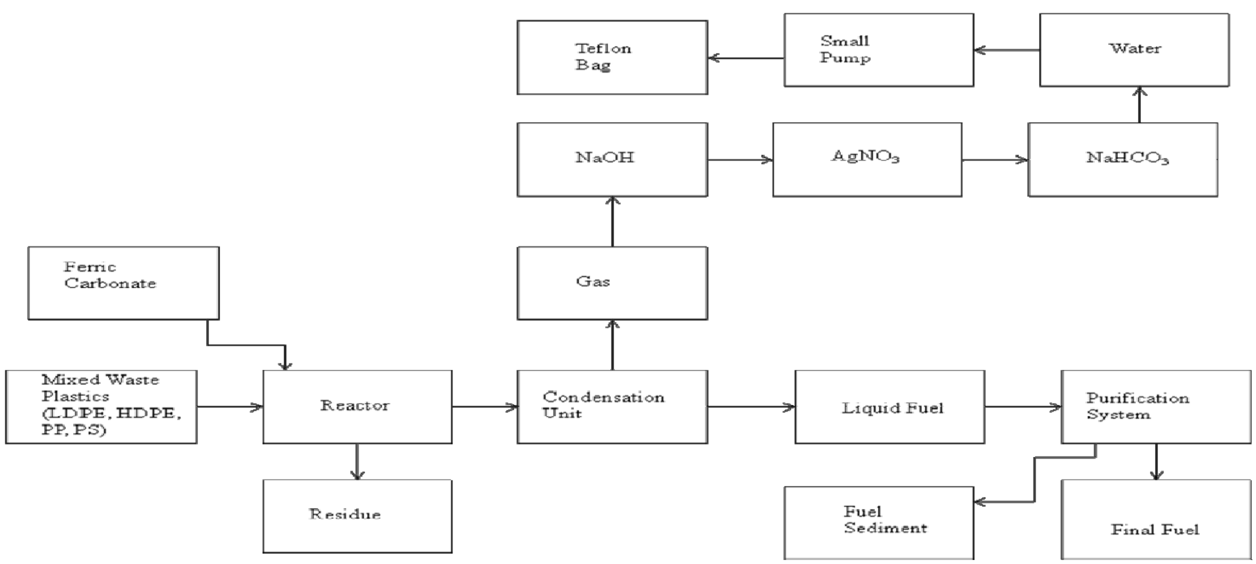

Figure 1: Mixed waste plastics and ferric carbonate catalyst mixture to fuel production process

Waste plastics mixture and ferric carbonate to fuels production process experiment was perform in batch process without vacuum system. LDPE, HDPE, PP and PS waste plastics was collected from local municipality and ferric carbonate was prepared by Natural State Research laboratory. For ferric carbonate preparation purpose was use ferric chloride and sodium bicarbonate and both chemicals were collected from VWR.COM Company. For experiment purpose sodium hydroxide, silver nitrate and sodium bicarbonate also collected same company. Three set up was placed under fume hood one by one with 5% ferric carbonate, 10% ferric carbonate, and 20% ferric carbonate with four types of waste plastics mixture (LDPE, HDPE, PP and PS). Every experiment initial raw materials was 150 gm and catalyst percentage was different. Each experiment temperature profile was same and temperature monitoring was same procedure. Temperature was controlled by variac meter and temperature range was 200-420 ºC. Each experiment procedure showed figure 1 and whole experiment was fully closed system but it was not vacuum. Experiment setup purposed accessories and equipment was glass reactor, heat mantle, heat controller, residue collection container, condensation unit, liquid fuel collection container, fuel purification device, final fuel collection container, fuel sediment collection container, liquid solution holding container, liquid solution such as sodium hydroxide, silver nitrate, sodium bicarbonate and water, small pump, Teflon bag. All equipments and accessories was connected one to another one properly. For 1st experiment was start with 105 gm of waste plastics and 5% ferric carbonate. 2nd experiment was start with 150 gm of waste plastics mixture and 10% ferric carbonate. 3rd experiment was start with 150 gm of waste plastics mixture and 20% ferric carbonate. All experimental initial raw materials were same and temperatures ware same but catalyst percentage was different. This type of experiment main goal was conversion rate determine and compounds range determination. 5% ferric carbonate and waste plastics mixture to liquid fuel production conversion rate was 86%, light gas was 7.2%, and residue was 6.74%. In mass balance calculation showed for 5% ferric carbonate and waste plastics mixture to liquid fuel weight 129.1 gm, light gas generated 10.8 gm, and left over solid black residue was 10.1 gm. For 10% ferric carbonate catalyst and 150 gm waste plastics mixture to liquid fuel production conversion rate was 86.2%, light gas was generate 7.4%, and solid black residue was 6.4%. In mass balance calculation showed 150 gm waste plastics and 10 % ferric carbonate to liquid fuel weight 129.3 gm, light gas generated 11.1 gm, and solid residue was 9.6 gm. For 20% ferric carbonate and 150 gm waste plastics mixture to liquid fuel conversion rate was 90.2%, light gas was generate 8.74, and solid black residue was 1.06%. In mass balance calculation showed from 150 gm sample with 20% ferric carbonate to liquid fuel was 135.3 gm, light gas was generated 13.1 gm, and solid black residue was 1.6 gm. From each experiment to generated light gas was passed through liquid solution sodium hydroxide, then silver nitrate, then sodium bicarbonate and water. Light gas was collected in to Teflon bag using small pump for future analysis purpose. Light gases are combination of methane, ethane, propane and butane. Light gas was clean by alkali wash. Table 1 showed catalyst ratio wise experiment result such as sample weight for each experiment, added catalyst percentage, total experiment time for each experiment, fuel volume, fuel weight, density, liquid conversion percentage, each experiment required electricity, and total cost for one gallon production. From all experiment conversion rate showed 20% ferric carbonate is higher than 5%, and 10% ferric carbonate. Waste plastics and 20% ferric carbonate added to fuel 90.2% conversion and increase light gas percentage. On the other hand 5% and 10% ferric carbonate and waste plastic to fuel production process almost are same conversion rate. Collected residue was keep into separate container for future analysis purpose. In residue percentage showed higher 5% ferric carbonate to fuel production then 10%, and 20%. Low percentage residue leftover was 20% ferric carbonate added with waste plastic to fuel production process.

Table 1: Mixed waste plastics with 5%, 10%, and 20% ferric carbonate mixture to fuel production percentage

Sample Weight (gm)	Ferric Carbonate Catalyst %	Total Experimental Time	Fuel Density (g/ml)	Fuel Volume (ml)	Fuel Weight (gm)	Residue Weight (gm)	Liquid Conversion in (%)	Electricity Consumption (kWh)	Production Cost /Gallon ($)
150	20%	3 hrs 41 min	0.77	174	135.3	1.6	90.2%	0.985	2.36
150	10%	4 hrs 19 min	0.77	167	129.3	9.6	86.2%	0.925	2.54
150	5%	4 hrs 7 min	0.78	165	129.1	10.1	86.06 %	0.905	2.29

Results and Discussions

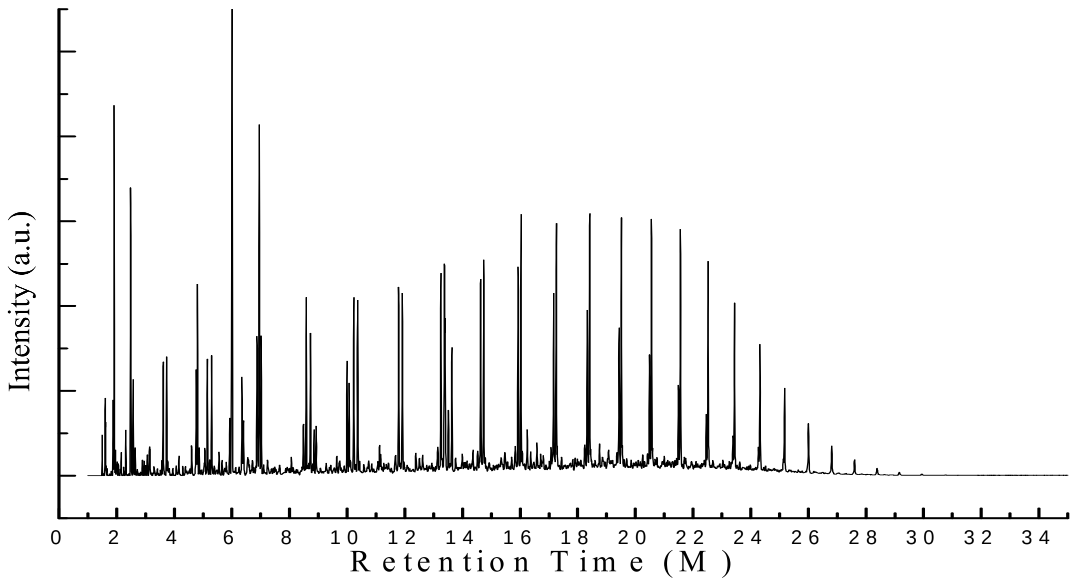

Figure 2: GC/MS chromatogram of mixed waste plastics and 5% ferric carbonate mixture to fuel

Table 2: GC/MS chromatogram compound list of mixed waste plastics and 5% ferric carbonate mixture to fuel

Number of Peak	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	1.49	41	Cyclopropane	C_3H_6	42	42.5	18854
2	1.56	43	Isobutane	C_4H_{10}	58	74.1	121
3	1.60	41	2-Butene	C_4H_8	56	24.5	61292
4	1.61	43	Butane	C_4H_{10}	58	72.6	123
5	1.63	41	2-Butene, (E)-	C_4H_8	56	25.5	105
6	1.87	42	Cyclopropane, ethyl-	C_5H_{10}	70	17.8	114410
7	1.91	43	Pentane	C_5H_{12}	72	81.6	229281
8	1.95	55	2-Pentene	C_5H_{10}	70	17.4	19079
9	2.01	55	2-Pentene, (E)-	C_5H_{10}	70	18.3	291780
10	2.05	67	1,3-Pentadiene	C_5H_8	68	20.3	291890
11	2.24	67	Bicyclo[2.1.0]pentane	C_5H_8	68	21.4	192491
12	2.32	43	Pentane, 2-methyl-	C_6H_{14}	86	49.2	61279
13	2.44	57	Pentane, 3-methyl-	C_6H_{14}	86	46.5	19375
14	2.48	56	1-Pentene, 2-methyl-	C_6H_{12}	84	33.5	495
15	2.57	57	Hexane	C_6H_{14}	86	85.7	61280
16	2.64	69	2-Butene, 2,3-dimethyl-	C_6H_{12}	84	15.9	289588
17	2.72	67	Cyclobutene, 3,3-dimethyl-	C_6H_{10}	82	12.0	62288
18	2.78	41	Pentane, 3-methylene-	C_6H_{12}	84	29.9	19323

19	2.89	56	Cyclopentane, methyl-	C_6H_{12}	84	66.0	114428
20	2.96	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	11.3	113646
21	3.06	56	1-Pentene, 2,4-dimethyl-	C_7H_{14}	98	68.9	114435
22	3.14	67	Cyclopentene, 1-methyl-	C_6H_{10}	82	14.7	107747
23	3.30	41	1-Pentanol, 2-ethyl-	$C_7H_{16}O$	116	24.2	114889
24	3.52	67	Cyclohexene	C_6H_{10}	82	28.7	61209
25	3.56	3.56	1-Hexene, 2-methyl-	C_7H_{14}	98	28.8	114433
26	3.62	56	1-Heptene	C_7H_{14}	98	40.4	107734
27	3.74	43	Heptane	C_7H_{16}	100	80.2	61276
28	3.77	81	1,3-Pentadiene, 2,4-dimethyl-	C_7H_{12}	96	18.4	114450
29	3.83	55	2-Heptene, (E)-	C_7H_{14}	98	20.8	932
30	4.07	81	Cyclohexene, 3-methyl-	C_7H_{12}	96	16.0	139433
31	4.16	83	Cyclohexane, methyl-	C_7H_{14}	98	67.1	118503
32	4.30	69	Cyclopentane, ethyl-	C_7H_{14}	98	39.0	940
33	4.39	55	1-Cyclohexene-1-methanol	$C_7H_{12}O$	112	20.2	210235
34	4.44	81	Cyclohexane, methylene-	C_7H_{12}	96	11.1	19641
35	4.51	56	2,4-Dimethyl-1-hexene	C_8H_{16}	112	35.8	113443
36	4.55	81	Cyclopentene, 4,4-dimethyl-	C_7H_{12}	96	15.1	38642
37	4.60	67	1-Heptene, 4-methyl-	C_8H_{16}	112	6.69	113433
38	4.76	43	Heptane, 4-methyl-	C_8H_{18}	114	65.3	113916
39	4.81	91	Toluene	C_7H_8	92	56.2	291301
40	4.86	81	Cyclohexene, 3-methyl-	C_7H_{12}	96	9.61	236066
41	5.06	56	1-Heptene, 2-methyl-	C_8H_{16}	112	52.7	113675
42	5.15	55	1-Octene	C_8H_{16}	112	26.4	1604
43	5.23	95	1,4-Pentadiene, 2,3,3-trimethyl-	C_8H_{14}	110	18.0	154036
44	5.29	43	Octane	C_8H_{18}	114	46.2	61242
45	5.39	55	Cyclohexane, 1,2-dimethyl-, cis-	C_8H_{16}	112	13.9	113985
46	5.55	83	2,2-Dimethyl-3-heptene trans	C_9H_{18}	126	11.2	113496
47	5.92	69	Cyclohexane, 1,3,5-trimethyl-	C_9H_{18}	126	29.8	114702
48	6.01	43	2,4-Dimethyl-1-heptene	C_9H_{18}	126	60.8	113516
49	6.24	43	3-Decyn-2-ol	$C_{10}H_{18}O$	154	10.7	53449
50	6.35	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C_9H_{18}	126	35.7	2480
51	6.40	91	Ethylbenzene	C_8H_{10}	106	66.2	114918
52	6.55	91	Cyclohexanol, 1-ethynyl-, carbamate	$C_9H_{13}NO_2$	167	44.8	313023
53	6.60	67	2-Methylbicyclo[3.2.1]octane	C_9H_{16}	124	4.29	215280
54	6.87	56	1-Nonene	C_9H_{18}	126	20.2	107756
55	6.95	104	Styrene	C_8H_8	104	41.4	291542

56	7.02	43	Nonane	C_9H_{20}	128	32.9	228006
57	7.24	55	3-Octyne, 2-methyl-	C_9H_{16}	124	4.76	62452
58	7.66	55	2,4-Pentadien-1-ol, 3-propyl-, (2Z)-	$C_8H_{14}O$	126	13.1	142179
59	8.06	57	Nonane, 4-methyl-	$C_{10}H_{22}$	142	19.7	3834
60	8.12	43	Cyclopentanol, 1-(1-methylene-2-propenyl)-	$C_9H_{14}O$	138	19.9	152742
61	8.49	118	α-Methylstyrene	C_9H_{10}	118	40.5	229186
62	8.58	55	1-Decene	$C_{10}H_{20}$	140	13.6	107686
63	8.67	69	1-Octene, 2,6-dimethyl-	$C_{10}H_{20}$	140	6.25	150583
64	8.73	57	Decane	$C_{10}H_{22}$	142	37.6	291484
65	8.80	55	2-Decene, (Z)-	$C_{10}H_{20}$	140	11.6	140
66	8.85	43	Octane, 3,5-dimethyl-	$C_{10}H_{22}$	142	9.03	114062
67	8.92	71	Nonane, 2,6-dimethyl-	$C_{11}H_{24}$	156	11.1	61438
68	9.64	83	2-Undecanethiol, 2-methyl-	$C_{12}H_{26}S$	202	6.04	9094
69	9.99	69	3-Tetradecene, (E)-	$C_{14}H_{28}$	196	3.51	142623
70	10.06	69	1-Octanol, 3,7-dimethyl-	$C_{10}H_{22}O$	158	3.63	232406
71	10.12	56	3-Decene, 2-methyl-, (Z)-	$C_{11}H_{22}$	154	6.48	61010
72	10.23	55	1-Undecene	$C_{11}H_{22}$	154	6.08	34717
73	10.30	55	3-Decen-1-ol, (Z)-	$C_{10}H_{20}O$	156	4.37	53357
74	10.37	57	Undecane	$C_{11}H_{24}$	156	30.4	114185
75	10.43	55	3-Undecene, (Z)-	$C_{11}H_{22}$	154	12.8	142598
76	10.58	55	2,4-Pentadien-1-ol, 3-pentyl-, (2Z)-	$C_{10}H_{18}O$	154	11.9	142197
77	11.12	69	(2,4,6-Trimethylcyclohexyl) methanol	$C_{10}H_{20}O$	156	14.0	113757
78	11.68	56	5-Undecene, 2-methyl-, (Z)-	$C_{12}H_{24}$	168	6.06	61877
79	11.78	55	1-Dodecene	$C_{12}H_{24}$	168	9.43	107688
80	11.91	57	Dodecane	$C_{12}H_{26}$	170	33.6	291499
81	13.15	56	2-Tridecene, (Z)-	$C_{13}H_{26}$	182	4.01	142613
82	13.25	41	1-Tridecene	$C_{13}H_{26}$	182	9.55	107768
83	13.37	57	Tridecane	$C_{13}H_{28}$	184	23.4	107767
84	13.40	69	2-Isopropyl-5-methyl-1-heptanol	$C_{11}H_{24}O$	172	3.57	245029
85	13.63	69	2-Isopropyl-5-methyl-1-heptanol	$C_{11}H_{24}O$	172	4.43	245029
86	13.76	92	Benzene, heptyl-	$C_{13}H_{20}$	176	51.1	118464
87	13.99	69	1-Nonadecanol	$C_{19}H_{40}O$	284	3.37	13666
88	14.64	55	1-Tetradecene	$C_{14}H_{28}$	196	5.37	34720
89	14.74	57	Tetradecane	$C_{14}H_{30}$	198	39.7	113925
90	15.83	55	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	10.9	245485
91	15.93	55	1-Pentadecene	$C_{15}H_{30}$	210	8.84	69726
92	16.03	57	Pentadecane	$C_{15}H_{32}$	212	25.3	107761
93	16.07	55	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	8.39	131101

94	17.17	55	1-Hexadecene	$C_{16}H_{32}$	224	7.92	69727
95	17.25	57	Hexadecane	$C_{16}H_{34}$	226	42.1	114191
96	17.29	55	1-Hexadecene	$C_{16}H_{32}$	224	3.77	34722
97	18.24	55	E-2-Octadecadecen-1-ol	$C_{18}H_{36}O$	268	10.4	131102
98	18.33	55	1-Hexadecanol	$C_{16}H_{34}O$	242	5.97	313200
99	18.42	57	Heptadecane	$C_{17}H_{36}$	240	22.5	107308
100	19.44	55	E-15-Heptadecenal	$C_{17}H_{32}O$	252	7.85	130979
101	19.51	57	Octadecane	$C_{18}H_{38}$	254	16.5	57273
102	19.70	55	1-Decanol, 2-hexyl-	$C_{16}H_{34}O$	242	5.21	114709
103	20.49	55	9-Nonadecene	$C_{19}H_{38}$	266	11.2	113627
104	20.56	57	Nonadecane	$C_{19}H_{40}$	268	29.6	114098
105	21.49	55	3-Eicosene, (E)-	$C_{20}H_{40}$	280	7.67	62838
106	21.56	57	Eicosane	$C_{20}H_{42}$	282	29.9	290513
107	21.70	57	1-Docosanol	$C_{22}H_{46}O$	326	6.37	23377
108	22.46	55	10-Heneicosene (c,t)	$C_{21}H_{42}$	294	8.90	113073
109	22.52	57	Heneicosane	$C_{21}H_{44}$	296	28.4	107569
110	23.38	55	1-Docosene	$C_{22}H_{44}$	308	16.0	113878
111	23.44	57	Heneicosane	$C_{21}H_{44}$	296	11.8	107569
112	24.27	55	1-Docosene	$C_{22}H_{44}$	308	11.4	113878
113	24.33	57	Heneicosane	$C_{21}H_{44}$	296	12.6	107569
114	25.18	57	Tetracosane	$C_{24}H_{50}$	338	14.7	248196
115	26.01	57	Heneicosane	$C_{21}H_{44}$	296	8.90	107569
116	26.81	57	Octacosane	$C_{28}H_{58}$	394	7.80	149865
117	27.60	57	Heneicosane	$C_{21}H_{44}$	296	8.69	107569
118	28.39	57	Nonadecane	$C_{19}H_{40}$	268	9.51	114098

Waste plastics mixture and 5% ferric carbonate to liquid fuel was analysis by GC/MS (figure 2 and table 1). GC/MS solvent used carbon disulfide (C_2S) for syringe cleaning and capillary column was use for sample analysis. Analysis result showed product fuel has hydrocarbon compounds including aromatics group, oxygen content, nitrogen content and alcoholic group. PS plastic has aromatic group with hydrocarbon, PP has methyl group with hydrocarbon and polyethylene has long chain hydrocarbon group compounds including alkane, alkene and alkyl. 5% ferric carbonate added with waste plastics mixture to fuel hydrocarbon compounds chain showed C_3H_6 to $C_{28}H_{58}$ with different retention time (t) and different trace mass (m/z). All compounds was detected based on retention time (m), trace mass (m/z), compounds formula, molecular weight, probability percentage and NIST library number. Form analysis compounds table (table1) some compounds details are given below with rention time (m) and trace mass (m/z) such as Butane (C_4H_{10}) (t=1.612, m/z=43), Pentane (C_5H_{12}) (t=1.91, m/z=43), 2-methyl-Pentane (C_6H_{14}) (t=2.32, m/z=43), Hexane (C_6H_{14}) (t=2.57, m/z=57), methyl-Cyclopentane (C_6H_{12}) (t=2.89, m/z=56), Heptane (C_7H_{16}) (t3.74, m/z=43), methyl-Cyclohexane (C_7H_{14}) (t=4.16, m/z=43), 4-methyl-Heptane (C_8H_{18}) (t=4.76, m/z=43), Octane (C_8H_{18}) (t=5.29, m/z=43), 2,4-Dimethyl-1-heptene (C_9H_{18}) (t=6.01, m/z=43), α-Methylstyrene (C_9H_{10}) (t=8.45, m/z=118), Undecane ($C_{11}H_{24}$) (t=10.37, m/z=57), Dodecane ($C_{12}H_{26}$) (t=11.91, m/z=57), Tetradecane ($C_{14}H_{30}$) (t=14.74, m/z=57), Hexadecane ($C_{16}H_{34}$) (t=17.25, m/z=57), Nonadecane ($C_{19}H_{40}$) (t=20.56, m/z=57), Tetracosane ($C_{24}H_{50}$) (t=25.18, m/z=57) and above all compounds are high probability percentage compounds. Oxygen content and alcoholic compounds are 2-ethyl-1-Pentanol, 1-Cyclohexene-1-methanol, 3-Decyn-2-ol, (2Z)-

3-propyl-2,4-Pentadien-1-ol, 1-(1-methylene-2-propenyl)-Cyclopentanol, 3,7-dimethyl-1-Octanol, (Z)- 3-Decen-1-ol, (2Z)-3-pentyl-2,4-Pentadien-1-ol, 2-Isopropyl-5-methyl-1-heptanol, 1-Nonadecanol, Z-10-Pentadecen-1-ol, E-2-Hexadecacen-1-ol, E-2-Octadecadecen-1-ol, E-15-Heptadecenal, 2-hexyl-1-Decanol, 1-Docosanol. Nitrogen content compounds are carbamate 1-ethynyl-cyclohexanol. Product fuel has some aromatic group compounds and compounds are Toluene, Ethylbenzene, Styrene, heptyl-Benzene, and so on. Most of the compounds are straight chain compounds or long chain compounds. Aromatic compounds appeared from polystyrene waste plastic because polystyrene waste plastic has benzene group with hydrocarbon. 5% ferric carbonates add with 4types mixture of waste plastics to fuel product was light yellow and fuel is ignited.

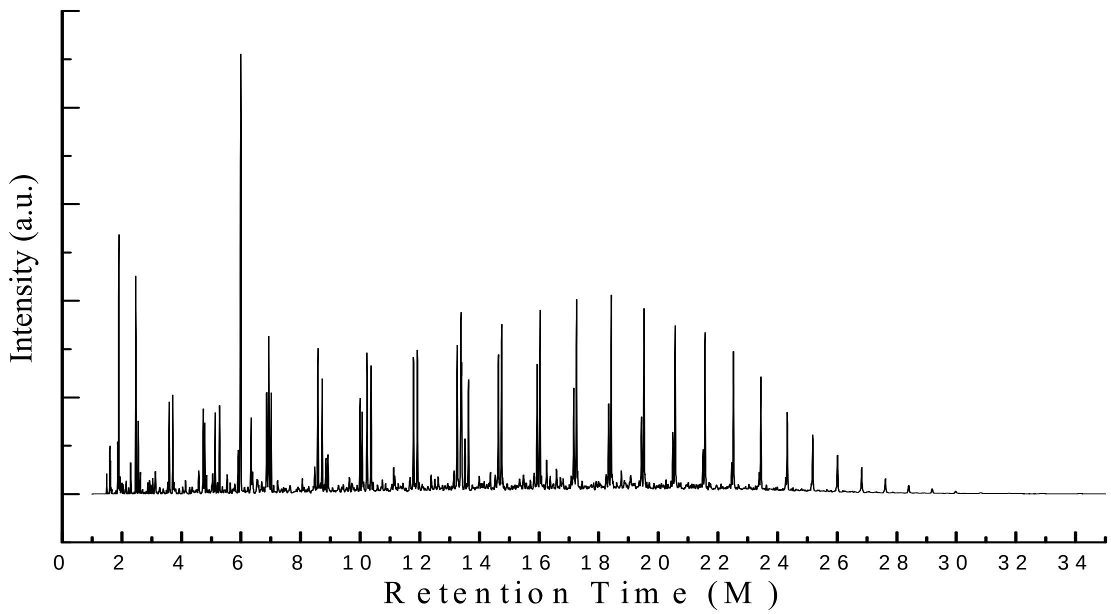

Figure 3: GC/MS chromatogram of mixed waste plastics and 10% ferric carbonate mixture to fuel

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2	1.60	41	1-Propene, 2-methyl-	C_4H_8	56	27.1	61293
3	1.63	41	1-Propene, 2-methyl-	C_4H_8	56	25.2	61293
4	1.67	41	2-Butene, (E)-	C_4H_8	56	26.3	105
5	1.86	42	Cyclopropane, ethyl-	C_5H_{10}	70	20.9	114410
6	1.90	43	Pentane	C_5H_{12}	72	85.8	229281
7	1.94	55	Cyclopropane, 1,2-dimethyl-, cis-	C_5H_{10}	70	16.0	19070
8	2.04	67	1,4-Pentadiene	C_5H_8	68	20.3	114494
9	2.23	67	Bicyclo[2.1.0]pentane	C_5H_8	68	11.7	192491

10	2.30	43	Pentane, 2-methyl-	C_6H_{14}	86	62.2	61279
11	2.46	56	1-Pentene, 2-methyl-	C_6H_{12}	84	34.7	61283
12	2.55	57	Hexane	C_6H_{14}	86	84.6	61280
13	2.62	69	2-Butene, 2,3-dimethyl-	C_6H_{12}	84	15.2	289588
14	2.87	56	Cyclopentane, methyl-	C_6H_{12}	84	61.3	114428
15	2.93	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	12.4	113646
16	2.98	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	18.7	113646
17	3.04	56	1-Pentene, 2,4-dimethyl-	C_7H_{14}	98	65.0	114435
18	3.13	81	2,4-Dimethyl 1,4-pentadiene	C_7H_{12}	96	39.3	114468
19	3.18	41	(Z)-Hex-2-ene, 5-methyl-	C_7H_{14}	98	11.4	113669
20	3.24	78	Benzene	C_6H_6	78	67.4	114388
21	3.27	41	1-Pentanol, 2-ethyl-	$C_7H_{16}O$	116	29.1	114889
22	3.39	43	Hexane, 3-methyl-	C_7H_{16}	100	65.1	113081
23	3.50	67	Cyclohexene	C_6H_{10}	82	26.6	61209
24	3.54	56	1-Hexene, 2-methyl-	C_7H_{14}	98	39.7	114433
25	3.59	56	1-Heptene	C_7H_{14}	98	40.5	107734
26	3.71	43	Heptane	C_7H_{16}	100	77.4	61276
27	3.75	81	1,3-Pentadiene, 2,4-dimethyl-	C_7H_{12}	96	15.9	114450
28	3.92	81	Cyclopropane, trimethylmethylene-	C_7H_{12}	96	13.4	63085
29	4.04	81	Cyclopentane, 1-methyl-2-methylene-	C_7H_{12}	96	16.5	62523
30	4.14	55	Cyclohexane, methyl-	C_7H_{14}	98	69.7	118503
31	4.28	69	Cyclopentane, ethyl-	C_7H_{14}	98	53.6	231044
32	4.36	79	1-Cyclohexene-1-methanol	$C_7H_{12}O$	112	22.2	210235
33	4.41	67	Norbornane	C_7H_{12}	96	18.2	114371
34	4.49	56	2,4-Dimethyl-1-hexene	C_8H_{16}	112	48.2	113443
35	4.53	81	Cyclobutane, (1-methylethylidene)-	C_7H_{12}	96	11.4	150272
36	4.58	67	1-Heptene, 4-methyl-	C_8H_{16}	112	17.9	113433
37	4.73	43	Heptane, 4-methyl-	C_8H_{18}	114	69.7	113916
38	4.78	91	Toluene	C_7H_8	92	44.5	291301
39	4.84	81	Cyclohexene, 1-methyl-	C_7H_{12}	96	9.43	139432
40	4.93	70	1,6-Heptadiene, 2,3,6-trimethyl-	$C_{10}H_{18}$	138	24.1	61690
41	5.05	56	1-Heptene, 2-methyl-	C_8H_{16}	112	53.7	113675
42	5.13	55	1-Octene	C_8H_{16}	112	27.6	1604
43	5.21	95	1,4-Pentadiene, 2,3,3-trimethyl-	C_8H_{14}	110	20.2	154036
44	5.28	43	Octane	C_8H_{18}	114	42.4	229407
45	5.37	55	3-Octene, (Z)-	C_8H_{16}	112	11.7	113895
46	5.47	55	Cyclohexane, 1,4-dimethyl-, cis-	C_8H_{16}	112	18.0	113914
47	5.53	83	2,2-Dimethyl-3-heptene	C_9H_{18}	126	10.6	113496

			trans				
48	5.91	69	Cyclohexane, 1,3,5-trimethyl-	C_9H_{18}	126	34.5	114702
49	5.99	70	2,4-Dimethyl-1-heptene	C_9H_{18}	126	59.7	113516
50	6.23	41	3-Decyn-2-ol	$C_{10}H_{18}O$	154	10.0	53449
51	6.34	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C_9H_{18}	126	38.9	2480
52	6.39	91	Ethylbenzene	C_8H_{10}	106	65.0	114918
53	6.54	81	Cyclohexanol, 1-ethynyl-, carbamate	$C_9H_{13}NO_2$	167	41.2	313023
54	6.70	67	cis-1,4-Dimethyl-2-methylenecyclohexane	C_9H_{16}	124	15.0	113533
55	6.86	43	1-Nonene	C_9H_{18}	126	18.1	107756
56	6.93	104	Styrene	C_8H_8	104	42.6	291542
57	7.01	57	Nonane	C_9H_{20}	128	29.8	228006
58	7.09	55	4-Nonene	C_9H_{18}	126	12.8	113904
59	7.42	95	Ethylidenecycloheptane	C_9H_{16}	124	8.65	113500
60	7.64	55	2,4-Pentadien-1-ol, 3-propyl-, (2Z)-	$C_8H_{14}O$	126	20.3	142179
61	7.86	67	Cyclopentene, 1-butyl-	C_9H_{16}	124	25.1	113491
62	8.06	57	Nonane, 4-methyl-	$C_{10}H_{22}$	142	22.3	3834
63	8.47	56	Azetidine, 3-methyl-3-phenyl-	$C_{10}H_{13}N$	147	62.3	4393
64	8.58	56	1-Decene	$C_{10}H_{20}$	140	13.0	107686
65	8.67	69	1-Octene, 2,6-dimethyl-	$C_{10}H_{20}$	140	7.25	150583
66	8.73	57	Decane	$C_{10}H_{22}$	142	36.8	291484
67	8.80	55	cis-3-Decene	$C_{10}H_{20}$	140	12.0	113558
68	8.85	71	Nonane, 2,6-dimethyl-	$C_{11}H_{24}$	156	9.64	61438
69	9.07	55	6-Octenal, 3,7-dimethyl-	$C_{10}H_{18}O$	154	8.97	57666
70	9.43	56	3-Decene, 2-methyl-, (Z)-	$C_{11}H_{22}$	154	5.96	61010
71	9.63	83	2-Undecanethiol, 2-methyl-	$C_{12}H_{26}S$	202	6.24	9094
72	9.99	69	Cyclooctane, 1,4-dimethyl-, trans-	$C_{10}H_{20}$	140	3.70	61408
73	10.06	69	1-Octanol, 2,7-dimethyl-	$C_{10}H_{22}O$	158	4.27	5475
74	10.11	56	3-Decene, 2-methyl-, (Z)-	$C_{11}H_{22}$	154	6.68	61010
75	10.23	55	1-Undecene	$C_{11}H_{22}$	154	6.10	232523
76	10.36	57	Undecane	$C_{11}H_{24}$	156	31.8	114185
77	10.43	55	5-Undecene, (E)-	$C_{11}H_{22}$	154	9.90	114227
78	11.12	69	(2,4,6-Trimethylcyclohexyl) methanol	$C_{10}H_{20}O$	156	14.7	113757
79	11.16	69	2-Isopropenyl-5-methylhex-4-enal	$C_{10}H_{16}O$	152	7.54	191046
80	11.28	43	Undecane, 4-methyl-	$C_{12}H_{26}$	170	17.5	6604
81	11.43	69	1-Isopropyl-1,4,5-trimethylcyclohexane	$C_{12}H_{24}$	168	15.9	113584
82	11.68	56	5-Undecene, 2-methyl-,	$C_{12}H_{24}$	168	5.94	61877

			(Z)-				
83	11.78	55	1-Dodecene	$C_{12}H_{24}$	168	11.4	107688
84	11.91	57	Dodecane	$C_{12}H_{26}$	170	33.3	291499
85	11.97	55	3-Dodecene, (E)-	$C_{12}H_{24}$	168	10.9	113960
86	12.08	69	Ethanone, 1-(1,2,2,3-tetramethylcyclopentyl)-, (1R-cis)-	$C_{11}H_{20}O$	168	6.81	186082
87	12.38	43	Dodecane, 2,6,10-trimethyl-	$C_{15}H_{32}$	212	8.07	68892
88	13.14	56	1-Tridecene	$C_{13}H_{26}$	182	3.94	232738
89	13.25	55	1-Tridecene	$C_{13}H_{26}$	182	15.8	107768
90	13.38	57	Tridecane	$C_{13}H_{28}$	184	19.1	107767
91	13.51	69	Isotridecanol-	$C_{13}H_{28}O$	200	3.42	298499
92	13.63	69	2-Isopropyl-5-methyl-1-heptanol	$C_{11}H_{24}O$	172	3.65	245029
93	14.53	56	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	5.54	245485
94	14.64	55	1-Tetradecene	$C_{14}H_{28}$	196	5.39	69725
95	14.74	57	Tetradecane	$C_{14}H_{30}$	198	38.4	113925
96	14.78	55	3-Tetradecene, (E)-	$C_{14}H_{28}$	196	5.87	139981
97	14.93	55	7-Tetradecene	$C_{14}H_{28}$	196	4.65	70643
98	15.70	71	7-Hexadecenal, (Z)-	$C_{16}H_{30}O$	238	10.6	293051
99	15.93	55	1-Pentadecene	$C_{15}H_{30}$	210	9.91	69726
100	16.03	57	Pentadecane	$C_{15}H_{32}$	212	29.1	107761
101	16.07	55	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	6.72	131101
102	16.59	69	1-Decanol, 2-hexyl-	$C_{16}H_{34}O$	242	5.66	114709
103	17.17	55	1-Hexadecene	$C_{16}H_{32}$	224	9.75	69727
104	17.26	57	Hexadecane	$C_{16}H_{34}$	226	39.2	114191
105	17.29	55	1-Hexadecene	$C_{16}H_{32}$	224	4.89	34722
106	17.44	55	Cyclohexadecane	$C_{16}H_{32}$	224	3.59	258206
107	18.34	55	E-14-Hexadecenal	$C_{16}H_{30}O$	238	7.98	130980
108	18.42	57	Heptadecane	$C_{17}H_{36}$	240	36.6	107308
109	18.76	69	Trichloroacetic acid, hexadecyl ester	$C_{18}H_{33}Cl_3O_2$	386	6.57	280518
110	19.44	55	E-15-Heptadecenal	$C_{17}H_{32}O$	252	7.71	130979
111	19.52	57	Octadecane	$C_{18}H_{38}$	254	18.3	57273
112	19.70	55	1-Decanol, 2-hexyl-	$C_{16}H_{34}O$	242	4.90	114709
113	20.49	55	9-Nonadecene	$C_{19}H_{38}$	266	9.34	113627
114	20.57	57	Nonadecane	$C_{19}H_{40}$	268	28.9	114098
115	20.75	55	9-Nonadecene	$C_{19}H_{38}$	266	5.15	113627
116	21.50	55	3-Eicosene, (E)-	$C_{20}H_{40}$	280	7.03	62838
117	21.57	57	Eicosane	$C_{20}H_{42}$	282	18.9	290513
118	21.70	55	1-Eicosene	$C_{20}H_{40}$	280	5.09	13488
119	22.46	55	10-Heneicosene (c,t)	$C_{21}H_{42}$	294	9.02	113073
120	22.52	57	Heneicosane	$C_{21}H_{44}$	296	29.0	107569
121	23.39	55	1-Docosene	$C_{22}H_{44}$	308	14.0	113878
122	23.44	57	Heneicosane	$C_{21}H_{44}$	296	15.2	107569

123	23.62	55	1-Docosene	$C_{22}H_{44}$	308	12.5	113878
124	24.28	55	1-Docosene	$C_{22}H_{44}$	308	10.7	113878
125	24.33	57	Heneicosane	$C_{21}H_{44}$	296	11.8	107569
126	24.52	55	1-Eicosanol	$C_{20}H_{42}O$	298	6.90	113075
127	25.18	57	Tetracosane	$C_{24}H_{50}$	338	16.6	248196
128	26.01	57	Octacosane	$C_{28}H_{58}$	394	7.73	149865
129	26.82	57	Octacosane	$C_{28}H_{58}$	394	8.35	134306
130	27.62	57	Heptacosane	$C_{27}H_{56}$	380	11.5	79427
131	28.40	57	Nonadecane	$C_{19}H_{40}$	268	7.32	114098

Waste plastics mixture and 10% ferric carbonate mixture to fuel was analysis by GC/MS and chromatogram showed figure 3 and compounds showed table 3. Same procedure was applied for 10% ferric carbonate and waste plastics mixture to fuel analysis by GC/MS. Product fuel analysis result showed starting compound is Cyclopropane (C_3H_6) and a highest carbon number long chain compound is Octacosane ($C_{28}H_{58}$). Above mentioned table 3 all compounds are filtered from Perkin Elmer NIST library. Product fuel has hydrocarbon compounds with aromatics group, oxygen content compounds, alcoholic compounds, nitrogen content compounds. 5% ferric carbonate added fuel and 10% ferric carbonate added fuel compounds are not same. Compounds structure and number of compounds little difference, because 10% ferric carbonate added waste plastics long chain break little more than 5% ferric carbonate added to fuel. All compounds was traced from 10% ferric carbonate added fuel based on compounds retention time (t), compounds trace mass (m/z), molecular weight, compounds probability percentage and etc. starting compounds Cyclopropane (C_3H_6) (t=1.49, m/z=41) compound probability percentage is 35.4%, Pentane (C_5H_{12}) (t=1.90, m/z=43) compound probability percentage is 85.8%, Hexane (C_6H_{14}) (t=2.55, m/z=57) compound probability percentage is 84.6%, 2,4-dimethyl-1-Pentene (C_7H_{14}) (t=3.04, m/z=56) compound probability percentage is 65.0%, 3-methyl- Hexane (C_7H_{16}) (t=3.39, m/z=43) compound probability percentage is 65.1%, methyl-cyclohexane (C_7H_{14}) (t=4.14, m/z=55) compound probability percentage is 69.7%, 4-methyl-Heptane (C_8H_{18}) (t=4.73, m/z=43) compound probability percentage is 69.7%, 2-methyl-1-Heptene (C_8H_{16}) (t=5.05, m/z=56) compound probability percentage is 53.7%, 2,4-Dimethyl-1-heptene (C_9H_{18}) (t=5.99, m/z=70) compound probability percentage is 59.7%, Ethylbenzene (C_8H_{10}) (t=6.39, m/z=91) compound probability percentage is 65.0%, Styrene (C_8H_8) (t=6.93, m/z=104), compound probability percentage is 42.6%, 3-methyl-3-phenyl- Azetidine ($C_{10}H_{13}N$) (t=8.47, m/z=56) compound probability percentage is 62.3%, Decane ($C_{10}H_{22}$) (t=8.73, m/z=57) compound probability percentage is 36.8%, Undecane ($C_{11}H_{24}$), (t=10.43, m/z=55) compound probability percentage is 31.8%, Dodecane ($C_{12}H_{26}$) (t=11.91, m/z=57) compound probability percentage is 33.3%, Tridecane ($C_{13}H_{28}$) (t=13.38, m/z=57) compound probability percentage is 19.1%, Tetradecane ($C_{14}H_{30}$) (t=14.74, m/z=57) compound probability percentage is 38.4%, Pentadecane ($C_{15}H_{32}$) (t=16.03, m/z=57) compound probability percentage is %, Heptadecane ($C_{17}H_{36}$) (t=18.42, m/z=57) compound probability percentage is 36.6%, Nonadecane ($C_{19}H_{40}$) (t=20.57, m/z=57) compound probability percentage is 28.9%, Heneicosane ($C_{21}H_{44}$) (t=22.52, m/z=57) compound probability percentage is 29.0%, Tetracosane ($C_{24}H_{50}$) (t=25.18, m/z=57) compound probability percentage is 16.6%, Octacosane ($C_{28}H_{58}$) (t=27.62, m/z=57) compound probability percentage is 8.35% so on. Above all compounds traced based one higher percentage of GC/MS probability. Alcoholic compounds are appeared because fuel production process was not vacuumed and it was in presence of oxygen. Aromatic group compounds are present into fuel such as Benzene, Toluene, Ethylbenzene, and Styrene. Alcoholic compounds are 2-ethyl-1-Pentanol, 1-Cyclohexene-1-methanol, 3-Decyn-2-ol, (2Z)-3-propyl-2,4-Pentadien-1-ol, 3,7-dimethyl-6-Octenal, 2,7-dimethyl-1-Octanol, 2-Isopropyl-5-methyl-1-heptanol, Z-10-Pentadecen-1-ol, (Z)- 7-Hexadecenal, E-14-Hexadecenal, 2-hexyl-1-Decanol and so on. In analysis result showed one compound found hexadecyl ester Trichloroacetic acid ($C_{18}H_{33}Cl_3O_2$) it appeared from waste plastics additives because plastics has different kind of additives such as reinforcing fiber, fillers, coupling agent, plasticizers, colorants, stabilizers (halogen stabilizers, antioxidants, ultraviolet absorbers and biological preservatives), processing aids (lubricants, and flow control), flame retardants, peroxide and antistatic agent and etc. All additive melting points higher than experimental temperature and it will not affect when fuel will use for combustion engine, because in GC/MS analysis showed peak intensity so small. In product fuel most of the compounds showed straight chain and branch chain compounds.

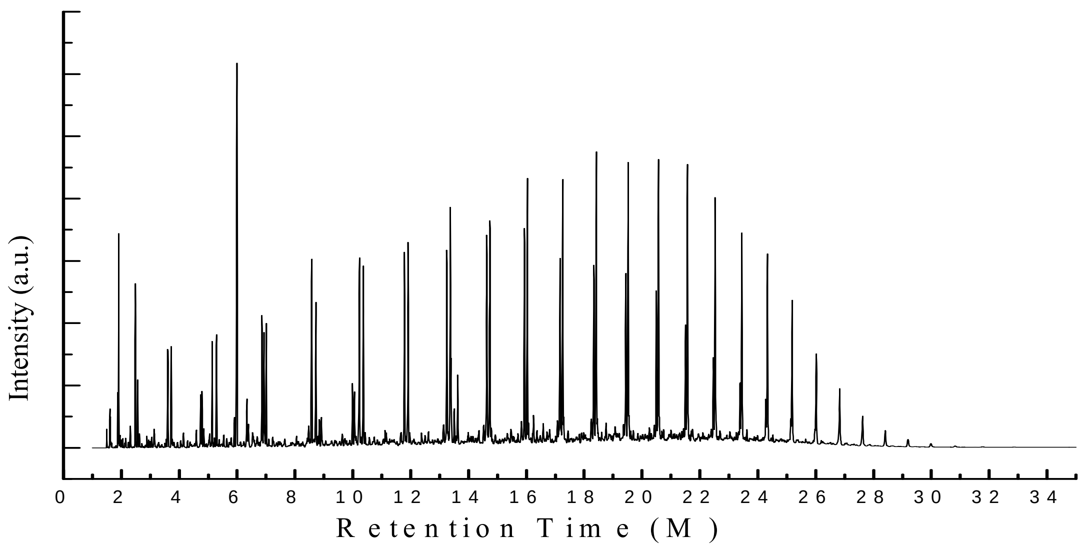

Figure 4: GC/MS chromatogram of mixed waste plastics and 20% ferric carbonate mixture to fuel

Table 4: GC/MS chromatogram compound list of mixed waste plastics and 20% ferric carbonate mixture to fuel

Number of Peak	Retention Time (min.)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	1.49	41	Cyclopropane	C_3H_6	42	33.3	18854
2	1.60	41	1-Propene, 2-methyl-	C_4H_8	56	26.9	61293
3	1.61	43	Butane	C_4H_{10}	58	73.5	18940
4	1.63	41	2-Butene	C_4H_8	56	29.9	61292
5	1.67	41	2-Butene, (E)-	C_4H_8	56	26.3	105
6	1.81	43	Butane, 2-methyl-	C_5H_{12}	72	78.2	61287
7	1.87	42	1-Pentene	C_5H_{10}	70	20.2	19081
8	1.91	43	Pentane	C_5H_{12}	72	82.6	61286
9	1.95	55	2-Pentene	C_5H_{10}	70	16.1	19079
10	2.01	55	2-Pentene, (E)-	C_5H_{10}	70	16.9	291780

11	2.05	67	1,3-Pentadiene	C_5H_8	68	22.1	291890
12	2.24	67	Bicyclo[2.1.0]pentane	C_5H_8	68	18.5	192491
13	2.31	43	Pentane, 2-methyl-	C_6H_{14}	86	40.8	61279
14	2.48	56	1-Hexene	C_6H_{12}	84	25.0	227613
15	2.56	57	Hexane	C_6H_{14}	86	86.5	61280
16	2.63	69	2-Butene, 2,3-dimethyl-	C_6H_{12}	84	17.4	289588
17	2.70	67	Cyclobutene, 3,3-dimethyl-	C_6H_{10}	82	9.97	62288
18	2.82	67	3-Hexyne	C_6H_{10}	82	8.93	19282
19	2.88	56	Cyclopentane, methyl-	C_6H_{12}	84	62.5	114428
20	2.94	67	2,4-Hexadiene, (E,Z)-	C_6H_{10}	82	9.56	113650
21	2.99	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	18.4	113646
22	3.05	56	1-Pentene, 2,4-dimethyl-	C_7H_{14}	98	64.8	114435
23	3.13	67	Cyclopentene, 1-methyl-	C_6H_{10}	82	13.7	107747
24	3.28	41	Cyclohexane	C_6H_{12}	84	16.4	228008
25	3.40	43	Hexane, 3-methyl-	C_7H_{16}	100	64.5	113081
26	3.50	67	Cyclohexene	C_6H_{10}	82	35.6	114431
27	3.55	56	1-Hexene, 2-methyl-	C_7H_{14}	98	35.4	114433
28	3.60	41	1-Heptene	C_7H_{14}	98	37.8	107734
29	3.72	43	Heptane	C_7H_{16}	100	74.7	61276
30	3.76	81	1,3-Pentadiene, 2,4-dimethyl-	C_7H_{12}	96	12.3	114450
31	3.82	55	2-Heptene	C_7H_{14}	98	41.1	160628
32	3.94	81	Cyclopropane, trimethylmethylene-	C_7H_{12}	96	17.5	63085
33	4.05	81	Cyclohexene, 3-methyl-	C_7H_{12}	96	14.2	139433
34	4.15	55	Cyclohexane, methyl-	C_7H_{14}	98	66.8	118503
35	4.29	69	Cyclopentane, ethyl-	C_7H_{14}	98	38.5	231044
36	4.37	79	1-Cyclohexene-1-methanol	$C_7H_{12}O$	112	8.59	210235
37	4.59	67	Cyclopentane, ethylidene-	C_7H_{12}	96	8.11	151340
38	4.74	43	Heptane, 4-methyl-	C_8H_{18}	114	66.4	113916
39	4.79	91	Toluene	C_7H_8	92	43.7	291301
40	4.85	81	Cyclohexene, 1-methyl-	C_7H_{12}	96	9.62	139432
41	4.90	79	1,3,5-Hexatriene, 3-methyl-, (E)-	C_7H_{10}	94	11.1	61094
42	4.94	67	1,6-Heptadiene, 2,3,6-trimethyl-	$C_{10}H_{18}$	138	5.35	61690
43	5.05	56	1-Heptene, 2-methyl-	C_8H_{16}	112	51.9	113675
44	5.13	41	1-Octene	C_8H_{16}	112	30.1	1604
45	5.21	95	Cyclopropane, (2,2-dimethylpropylidene)-	C_8H_{14}	110	10.5	60981
46	5.29	43	Octane	C_8H_{18}	114	52.0	229407
47	5.38	55	3-Octene, (Z)-	C_8H_{16}	112	17.1	113895
48	5.54	69	2,2-Dimethyl-3-heptene trans	C_9H_{18}	126	20.2	113496
49	5.91	69	Cyclohexane, 1,3,5-trimethyl-	C_9H_{18}	126	29.0	114702

50	5.99	43	2,4-Dimethyl-1-heptene	C_9H_{18}	126	60.6	113516
51	6.12	67	3-Octyne	C_8H_{14}	110	6.94	118185
52	6.24	41	3-Decyn-2-ol	$C_{10}H_{18}O$	154	9.79	53449
53	6.34	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C_9H_{18}	126	34.3	2480
54	6.39	91	Ethylbenzene	C_8H_{10}	106	65.7	114918
55	6.54	81	Cyclohexanol, 1-ethynyl-, carbamate	$C_9H_{13}NO_2$	167	31.5	313023
56	6.60	67	3,4-Octadiene, 7-methyl-	C_9H_{16}	124	3.98	54090
57	6.70	67	cis-1,4-Dimethyl-2-methylenecyclohexane	C_9H_{16}	124	7.66	113533
58	6.86	56	1-Nonene	C_9H_{18}	126	21.9	107756
59	6.93	104	Bicyclo[4.2.0]octa-1,3,5-triene	C_8H_8	104	37.8	154588
60	7.01	57	Nonane	C_9H_{20}	128	32.6	228006
61	7.09	55	4-Nonene	C_9H_{18}	126	17.1	113904
62	7.23	55	Ethylidenecyclooctane	$C_{10}H_{18}$	138	3.90	99204
63	7.36	55	2,4-Undecadien-1-ol	$C_{11}H_{20}O$	168	8.54	136410
64	7.48	105	Benzene, (1-methylethyl)-	C_9H_{12}	120	13.2	249348
65	7.52	67	1-Cyclohexyl-1-pentyne	$C_{11}H_{18}$	150	16.2	114866
66	7.59	81	Cyclohexane, (1-methylethylidene)-	C_9H_{16}	124	15.1	192449
67	7.64	55	2,4-Pentadien-1-ol, 3-propyl-, (2Z)-	$C_8H_{14}O$	126	15.3	142179
68	7.86	67	Cyclopentene, 1-butyl-	C_9H_{16}	124	49.2	113491
69	7.91	57	2-Nonenal, (E)-	$C_9H_{16}O$	140	5.77	53571
70	8.01	91	1,3,5-Cycloheptatriene, 7-ethyl-	C_9H_{12}	120	43.7	157650
71	8.05	57	Octane, 2,3-dimethyl-	$C_{10}H_{22}$	142	17.7	114135
72	8.12	105	Benzene, 1-ethyl-3-methyl-	C_9H_{12}	120	15.9	228743
73	8.17	105	3-Decyn-2-ol	$C_{10}H_{18}O$	154	7.40	53449
74	8.23	56	2-Decen-1-ol	$C_{10}H_{20}O$	156	17.0	136260
75	8.27	105	2H-Indeno[1,2-b]oxirene, octahydro-, (1aα,1bβ,5aα,6aα)-	$C_9H_{14}O$	138	8.40	46570
76	8.43	55	1,9-Decadiene	$C_{10}H_{18}$	138	7.66	118291
77	8.47	118	Azetidine, 3-methyl-3-phenyl-	$C_{10}H_{13}N$	147	42.3	4393
78	8.58	55	1-Decene	$C_{10}H_{20}$	140	18.4	107686
79	8.73	57	Decane	$C_{10}H_{22}$	142	39.4	291484
80	8.80	55	cis-3-Decene	$C_{10}H_{20}$	140	15.2	113558
81	8.84	43	Nonane, 2,6-dimethyl-	$C_{11}H_{24}$	156	10.2	61438
82	8.91	71	Nonane, 2,6-dimethyl-	$C_{11}H_{24}$	156	11.4	61438
83	9.63	83	2,4-Pentadien-1-ol, 3-pentyl-, (2Z)-	$C_{10}H_{18}O$	154	8.77	142197
84	9.99	69	3-Tetradecene, (E)-	$C_{14}H_{28}$	196	4.22	142623
85	10.06	69	1-Octanol, 3,7-dimethyl-	$C_{10}H_{22}O$	158	4.38	232406

86	10.23	55	Cyclopropane, 1-heptyl-2-methyl-	$C_{11}H_{22}$	154	6.92	62622
87	10.29	55	3-Decen-1-ol, (Z)-	$C_{10}H_{20}O$	156	5.35	53357
88	10.36	57	Undecane	$C_{11}H_{24}$	156	32.8	107774
89	10.42	55	3-Undecene, (Z)-	$C_{11}H_{22}$	154	12.9	142598
90	11.06	55	7-Tetradecene	$C_{14}H_{28}$	196	7.97	70643
91	11.12	69	(2,4,6-Trimethylcyclohexyl) methanol	$C_{10}H_{20}O$	156	14.8	113757
92	11.16	69	2-Isopropenyl-5-methylhex-4-enal	$C_{10}H_{16}O$	152	5.96	191046
93	17.27	43	2,3-Dimethyldecane	$C_{12}H_{26}$	170	9.26	113027
94	11.67	56	3-Undecene, 2-methyl-, (Z)-	$C_{12}H_{24}$	168	5.42	61842
95	11.78	55	1-Dodecene	$C_{12}H_{24}$	168	12.3	107688
96	11.91	57	Dodecane	$C_{12}H_{26}$	170	36.8	291499
97	11.96	55	3-Dodecene, (E)-	$C_{12}H_{24}$	168	15.6	70642
98	13.14	56	4-Tridecene, (Z)-	$C_{13}H_{26}$	182	5.20	142617
99	13.25	55	1-Tridecene	$C_{13}H_{26}$	182	18.1	107768
100	13.37	57	Tridecane	$C_{13}H_{28}$	184	19.3	107767
101	13.63	69	Isotridecanol-	$C_{13}H_{28}O$	200	4.05	298499
102	14.52	55	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	11.4	245485
103	14.63	55	3-Tetradecene, (Z)-	$C_{14}H_{28}$	196	6.27	62806
104	14.74	57	Tetradecane	$C_{14}H_{30}$	198	38.6	113925
105	14.78	55	7-Tetradecene	$C_{14}H_{28}$	196	8.13	70643
106	15.93	55	1-Pentadecene	$C_{15}H_{30}$	210	11.3	69726
107	16.03	57	Pentadecane	$C_{15}H_{32}$	212	34.3	107761
108	16.07	55	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	8.28	131101
109	17.16	55	1-Hexadecene	$C_{16}H_{32}$	224	11.2	69727
110	17.25	57	Hexadecane	$C_{16}H_{34}$	226	43.5	114191
111	18.24	55	E-2-Octadecadecen-1-ol	$C_{18}H_{36}O$	268	12.4	131102
112	18.33	55	E-14-Hexadecenal	$C_{16}H_{30}O$	238	8.98	130980
113	18.42	57	Heptadecane	$C_{17}H_{36}$	240	34.1	107308
114	19.44	55	E-15-Heptadecenal	$C_{17}H_{32}O$	252	9.27	130979
115	19.52	57	Octadecane	$C_{18}H_{38}$	254	18.2	57273
116	19.70	55	1-Eicosanol	$C_{20}H_{42}O$	298	4.55	113075
117	20.49	55	9-Nonadecene	$C_{19}H_{38}$	266	9.77	113627
118	20.57	57	Nonadecane	$C_{19}H_{40}$	268	31.0	114098
119	21.50	55	5-Eicosene, (E)-	$C_{20}H_{40}$	280	7.11	62816
120	21.57	57	Eicosane	$C_{20}H_{42}$	282	17.7	290513
121	22.46	55	1-Heneicosyl formate	$C_{22}H_{44}O_2$	340	7.90	72853
122	22.53	57	Heneicosane	$C_{21}H_{44}$	296	29.2	107569
123	23.39	55	1-Docosene	$C_{22}H_{44}$	308	17.7	113878
124	23.44	57	Heneicosane	$C_{21}H_{44}$	296	12.8	107569
125	24.28	55	1-Docosene	$C_{22}H_{44}$	308	10.4	113878
126	24.33	57	Heneicosane	$C_{21}H_{44}$	296	12.4	107569

127	25.14	55	1-Docosene	$C_{22}H_{44}$	308	10.3	113878
128	25.19	57	Tetracosane	$C_{24}H_{50}$	338	19.5	248196
129	26.01	57	Heneicosane	$C_{21}H_{44}$	296	7.12	107569
130	26.83	57	Octacosane	$C_{28}H_{58}$	394	8.49	134306
131	27.62	57	Octacosane	$C_{28}H_{58}$	394	11.7	134306
132	28.41	57	Octacosane	$C_{28}H_{58}$	394	13.4	149865
133	29.19	57	Nonadecane	$C_{19}H_{40}$	268	8.67	114098
134	29.98	57	Nonadecane	$C_{19}H_{40}$	268	9.58	114098

Mixture of waste plastics with 20% ferric carbonate to fuel product was analysis by GC/MS to compare with 5% and 10% ferric carbonate added to fuel. 20% ferric carbonate and waste plastics mixture to fuel chromatogram showed figure 4 and compounds data table showed table 4. 20% ferric carbonate with waste plastic to fuel analysis was followed same procedure like 5% and 10% ferric carbonate added to fuel analysis. In analysis result showed some compounds structures are different from 5% and 10% ferric carbonate added fuel. 20% ferric carbonate and waste plastic to fuel analysis result showed long chain polymer breakdown more and form short chain hydrocarbon compounds. Catalyst percentage increase showed good result and conversion rate is higher than low percentage adding catalyst. Analysis result showed most of the compounds are branch chain and long chain hydrocarbon including aromatic, oxygen content, nitrogen content. An aliphatic compound has alkane, alkene, and alkyl group compounds. Product fuel carbon chain showed C_3 to C_{28} same as 5% and 10% ferric carbonate added fuel. Inside compounds structure are different all of those experimental fuels. Adding catalyst percentage waste plastics to fuel production process was differ because less percentage of catalyst breakdowns little less the higher percentage catalyst. In our experimental procedure showed higher percentage catalyst adding waste plastic to fuel conversion percentage higher then lower percentage catalyst. 20% ferric carbonates added to fuel compounds are Cyclopropane (C_3H_6) (t=1.49, m/z=41) compound probability percentage is 33.3%, 2-methyl-Butane (C_5H_{12}) (t=1.81, m/z=43) compound probability percentage is 78.2%, 2-methyl-Pentane (C_6H_{14}) (t=2.31, m/z=43) compound probability percentage is 40.8 %, 2, 4-dimethyl-1-Pentene (C_7H_{14}) (t=3.05, m/z=56) compound probability percentage is 64.8%, 3-methyl- Hexane (C_7H_{16}) (t=3.40, m/z=43) compound probability percentage is 64.5%, 2-Heptene (C_7H_{14}) (t=3.82, m/z=55) compound probability percentage is 41.1%, ethyl-Cyclopentane (C_7H_{14}) (t=4.29, m/z=69) compound probability percentage is 38.5%, 4-methyl-Heptane (C_8H_{18}) (t=4.74, m/z=43) compound probability percentage is 66.4%, 2-methyl-1-Heptene (C_8H_{16}) (t=5.05, m/z=56) compound probability percentage is 51.9%, 2,4-Dimethyl-1-heptene (C_9H_{18}) (t=5.99, m/z=43) compound probability percentage is 60.6%, (1α,3α,5β)-1,3,5-trimethyl-Cyclohexane (C_9H_{18}) (t=6.34, m/z=69) compound probability percentage is 34.3%, Nonane (C_9H_{20}) (t=7.01, m/z=57) compound probability percentage is 32.6 %, 1-butyl-Cyclopentene (C_9H_{16}) (t=7.86, m/z=67) compound probability percentage is 49.2%, 1-ethyl-3-methyl- Benzene (C_9H_{12}) (t=8.12, m/z=105) compound probability percentage is 15.9%, Decane ($C_{10}H_{22}$) (t=8.73, m/z=57) compound probability percentage is 39.4%, (2Z)-3-pentyl-2,4-Pentadien-1-ol ($C_{10}H_{18}O$) (t=9.63, m/z=83) compound probability percentage is 8.77%, 2,3-Dimethyldecane ($C_{12}H_{26}$) (t=17.27, m/z=43) compound probability percentage is 9.26%, Dodecane ($C_{12}H_{26}$) (t=11.91, m/z=57) compound probability percentage is 36.8%, Tridecane ($C_{13}H_{28}$) (t=13.37, m/z=57) compound probability percentage is 19.3 %, Tetradecane ($C_{14}H_{30}$) (t=14.74, m/z=57) compound probability percentage is 38.6%, Pentadecane ($C_{15}H_{32}$) (t=16.03, m/z=57) compound probability percentage is 34.3%, Hexadecane ($C_{16}H_{34}$) (t=17.25, m/z=57) compound probability percentage is 43.5%, Heptadecane ($C_{17}H_{36}$) (t=18.42, m/z=57) compound probability percentage is 34.1%, Nonadecane ($C_{19}H_{40}$) (t=20.57, m/z=57) compound probability percentage is 31.0%, Heneicosane ($C_{21}H_{44}$) (t=22.53, m/z=57) compound probability percentage is 29.2%, 1-Docosene ($C_{22}H_{44}$) (t=24.28, m/z=55) compound probability percentage is 10.4%, Tetracosane ($C_{24}H_{50}$) (t=25.19, m/z=57) compound probability percentage is 19.5%, Octacosane ($C_{28}H_{58}$) (t=28.41, m/z=57) compound probability percentage is 13.4% and so on.

Conclusion

Ferric carbonate catalyst and waste plastic mixture to fuel production reports showed that higher percentage catalyst adding fuel conversion rate is increasing. GC/MS analysis results showed that compounds structure also differs from each to another one. But every experimental fuel carbon chain length is similar and inside compounds are different. 20% ferric carbonate added fuel quality better than 10% and 5% ferric carbonate added fuels. All fuels hydrocarbon compounds chain range showed C_3-C_{28} including aromatics group. Left over residue and light gas analysis is under consideration. 20% ferric carbonate and waste plastics mixture to fuel production conversation rate more than 90% and 5%, 10% ferric carbonate added to fuel production conversion rate less than 90%. High percentage catalyst added increase the light gas production percentage and produce light gas can be use for heat source when large scale production start. In this experiment showed less percentage catalyst added fuel conversion little less. On the other hand high percentage catalyst added to fuel production cost will be increase because catalyst has to buy from market and it adding extra cost also during production period. One hand higher percentage catalyst added increase fuel production conversion rate other hand its can be increase production cost also. By using this technology can converts all kinds of waste plastics into fuel or fuel energy less than dollar a gallon when big commercial plant will start.

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