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RANDOMLY MIXTURE OF WASTE PLASTICS CONVERSION INTO FUEL BY USING LEFTOVER RESIDUE

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Abstract- Randomly mixture of waste plastics conversion into liquid hydrocarbon fuel with thermal degradation process utilized leftover different percentage of residue. Mixture waste plastics content was high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP) and polystyrene (PS) and residue mixture content percentage was 5% and 10% for two different experiments under same parameter. Experimental processes were performed under laboratory fume hood without vacuum system and temperature range was used for each experiment 150-420ºC. In the laboratory scale process randomly mixture waste plastics sample was used for each experiment 1000 gm and added extra solid black residue percentage wise. Produced fuel was analyzed by Gas Chromatography and Mass Spectrometer (GC/MS) and obtained compound indicate that from randomly mixture waste plastics and extra 5% residue to fuel hydrocarbon range is C_3H_6 to $C_{35}H_{70}$ and 10% residue and randomly mixture waste plastics to fuel hydrocarbon compound range is C_3H_6 to $C_{35}H_{70}$. Produced fuel has aliphatic and aromatic group compounds and fuel could be use in the internal combustion engines, feed for feed stock refinery and electricity generation feed for power plants. Fuels sulfur content less than environmental protection agency (EPA) level.

Keywords- waste plastics, fuel, hydrocarbon, residue, thermal degradation, GC/MS, conversion

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Introduction

The disposal of waste plastics is an important environmental problem in developed countries. Most of these materials consist of several polymer types, which cannot be easily converted to hydrocarbons or any useful materials under normal conditions. Copyrolysis of coals with polymers is an attractive method to obtain valuable liquid and gas products. It was found that yields of tar or gas from copyrolysis are dramatically higher than those obtained by pyrolysis of coal alone [1-3]. The degradation mechanism of coal and polymer mixtures during the copyrolysis process, such as radicalic, ionic, etc., may be responsible for this variation. The hydrocarbon distributions are also affected by this mechanism. To investigate the effect of the experimental conditions on the amount of generated products in detail, a characterization of the pyrolysis liquid should be performed. In earlier works, characterization of such pyrolysis liquids was performed by using various spectroscopic techniques [4 -7].

The main route for the production of light olefins, the key chemical building blocks for the petrochemical industry, has long been the steam cracking of liquid and gaseous hydrocarbons. From a statistical point of view, hydrocarbon fractions lying in the range of light to heavy naphtha still are paramount feedstock used in the olefin plants over the world [8]. In the wake of reduced availability and concomitant rise in the price of naphtha, thermal cracking of heavier fractions, such as gas oil, has received attention by some researchers [9-12]. Economic considerations and difficulties with feedstock availability have inspired some authors to study pyrolysis or copyrolysis of used oils and waste plastics material [13-16]. Nevertheless, the direct use of heavy oil fractions, as either main raw feedstock into modern olefin plants or an alternative feed (by its own or co-fed) in existing plants of naphtha cracking is substantially hindered by limitations in the downstream equipment and recovery units. Of the principal shortcomings in application of, e.g., gas oil, are lower ethylene and propylene yields accompanied by a larger extent of less desirable byproduct, such as fuel oil, when compared to lower hydrocarbons [17].

The economic viability of waste plastics valorization processes is a subject that needs to be addressed in developed countries. Concerning the problems that delay their large-scale implementation, there are those inherent to the process of transforming plastics into monomers and fuels and to the complexity of adapting product conditioning steps to market requirements. Pyrolysis is a transformation technology with good perspectives for treating both polyolefins (2/3 of waste plastics) and remaining waste plastics and it has undergone important development. Pyrolysis is efficient for recovering monomers and obtaining fuels with a significant reduction in gases and volatile compounds compared to gasification, with a low emission of pollutants. The processes proposed for plastics waste pyrolysis are flexible and may treat both mixtures of plastics and mixtures of these with residual materials (such as wood and agro forest wastes and tire derived fuel) [18-20]. It may also operate auto thermally, under a controlled O_2 content [21]. The use of acid catalysts

in the pyrolysis reactor itself effectively decreases the temperature required for cracking and for modifying product distribution [22-24].

Materials

Waste plastics were collected from local city grocery store and restaurant. All waste plastics were comes with foreign material and foreign materials separated by manually. Waste plastics cleaned with soap and water then dried in to laboratory floor with fan air. Waste plastics cut into small pieces by manually using scissor then transfer into grinder machine for grounded and size was 4-5 mm. Grounded waste plastics was transfer into reactor chamber for liquefaction process. During waste plastics washing period waste water also generated and waste water was kept into separated container for treatment purpose.

Experimental Method

Randomly mixture waste plastics transfer into reactor chamber and reactor was set up under laboratory fume hood without vacuum system. Reactor and reactor cover was tighten properly for prevent any gas leakage from reactor. In this experiment randomly waste plastics sample was added 1000 gm and 5% extra black solid residue was added also. Without using any kind of catalyst or chemical experiment was performed properly and temperature range was used 150- 420ºC. Randomly mixture sample content was low and high density polyethylene (LDPE, HDPE), polypropylene (PP) and polystyrene (PS) and residue was added 5% for the experiment. Reactor set up with other device shown in to [Fig-1] and provided their information according to number wise such as 1= Reactor chamber, 2= Coil and insulator, 3= Condenser unit, 4=Temp. controller & display, 5=Electrical outlet, 6= 2'' ht. & 1'' dia. for gas pressure monitor, 7= 2'' ht. & 1'' dia. for glass monitor, 8= 2'' ht. & 1'' dia. for inside temperature monitor, 9=2'' ht. & 1'' dia. for thermocouple, 10= 2'' ht. & 1'' dia. for glass monitor, 11= Condenser Inner dia. 2'', 12= Collection tank, 13= Light gas collection neck, 14= Fuel product, 15= RCI purification system, 1= Gas cleaning device, 17= Light gas collection Teflon bag, 18= Final fuel collection tank. Randomly mixture waste plastics and 5% residue mixture to fuel production starting temperature 150ºC and heat applied until 420ºC. When temperature increased gradually from 150 to 300ºC that time observed that vapor was started to come out, because waste plastics first melted then turned into liquid slurry, then turned into vapor and vapor condensed into produced hydrocarbon liquid fuel. Mixture of waste plastics with residue to fuel production process residue was react as catalyst and left over residue has some percentage of carbon and hydrogen those carbon and hydrogen again convert into liquid hydrocarbon fuel. Residue has some metal content those metal contend also help to break down long chin polymer to short chain hydrocarbon.

In this diagram showed waste plastics transfer into reactor chamber with 5% residue then heated up waste plastics and residue mixture produce vapors then vapor passed through condensation process and turn into liquid fuel. Liquid fuel was cleaned by RCI technology provided RCI fuel purification system to remove fuel sediment and other impurities and made it clean fuel. Light gas passed through from collection tank to cleaning device and wash out by alkali solution then transfer into Teflon bag by using small pump. Light gases are mixture of hydrocarbon such as methane, ethane, propane and butane. Its call natural gas and hydrocarbon range is C_1-C_4. In this experiment initial feed was 1000 gm and 5% residue including total weight 1050 gm. Produce fuel density is 0.80 g/ml. In mass balance calculation showed from randomly mixture waste plastics with 5% residue mixture to fuel converted 817.4 gm, light gas generated from initial feed to 144.3 gm and solid black residue generated 88.3 gm. In percentage calculation showed from initial feed and residue mixture to fuel yield percentage 77.85%, light gas 13.74% and leftover solid black residue 8.41%. From this experiment showed light gas percentage was increased and added left over residue some portion converted as gas because pervious added residue has some percentage of carbon and hydrogen mixture and carbon percentage is less than 45% and hydrogen percentage is less than 3%. In 10% solid black residue with randomly mixture of waste plastics experiment was performed same procedure and same temperature profile and produce fuel density 0.79 g. /ml. 10% leftover residue mixture experiment mass balance calculation indicate that [Table-1] fuel converted 821 gm from initial feed 1100 gm, light gas generated from total sample to 155.2 gm and leftover residue was 123.8 gm. In percentage calculation 100 gm residue with 1000 gm randomly mixture waste plastics to fuel yield percentage is 74.64%, light gas percentage is 14.10% and leftover residue percentage is 11.26%. Both experiments production result showed that added residue percentage wise light gas percentage was increased. Experimental run time was for 5% residue with randomly mixture waste plastics to fuel 5-6 hours and input electricity was 6.36 kWh. On the other hand 10% residue with randomly mixture waste plastics to fuel experiment run time was 5-6 hours and input electricity was 6.31kWh.

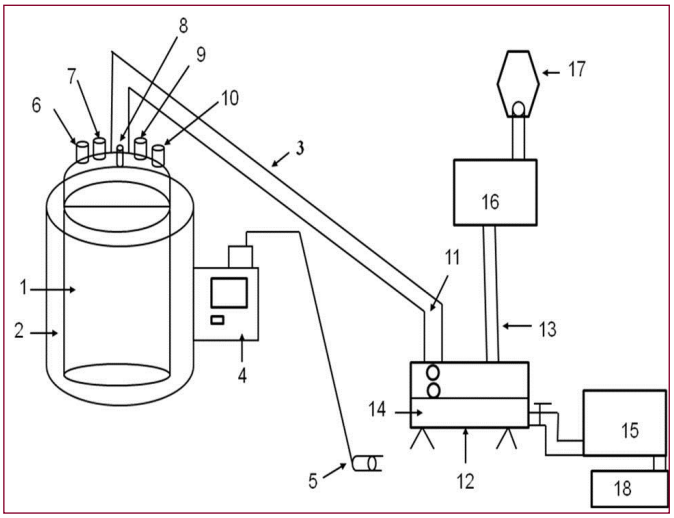

Fig. 1- Randomly mixture waste plastics to fuel production process with left over residue

Table 1- Randomly mixture of waste plastics to fuel production yield percentage chart

Name of Plastics	Plastics + residue weight (g.)	Extra Residue Adding %	Fuel weight (g.)	Fuel weight (vol.)	Sample as light gas (g.)	Residue weight (g.)	Electricity input kWh	Fuel yield %	Light Gas yield %	Residue yield %
Waste plastics mixture	1000+50	5	817.4	1020	144.3	88.3	6.36	77.85	13.74	8.41
Waste plastics mixture	1000+100	10	821	1038	155.2	123.8	6.31	74.64	14.1	11.26

Result and Discussion

Perkin Elmer GC-MS analysis of randomly waste mixed plastics with 5% residue to fuel instrument set up program is inspected properly such as Instrument Control Method, Channel Parameters, Autosampler Method, Carriers Parameters and Valve Configuration and Settings [Fig-2], [Table-2]. In Channel Parameter Data will be collected from Channel B, Delay Time: 0.00 min, Run Time: 44.50 min, Sampling Rate: 1.5625 pts/s. Auto sampler Method is Syringe Capacity: 5.0 µL, Injection Speed: Normal, Viscosity Delay: 0, Pre-injection Solvent Washes: 2, Post-injection Solvent Washes(A): 6, Injection Volume: 0.5 µL, Sample Pumps: 6, Wash/Waste Vial Set: 2, Pre-injection Sample Washes: 2. Carrier Parameters, Carrier A control: Press-PSIG, Carrier A setpoint: 0.0 PSIG. Carrier B control: PFlow-He, Column B length: 30.00, Vacuum Compensation: ON, Split Flow: 101.0 Ml/min, Initial Set point: 1.00 ml/min, Diameter: 250 µm and Initial Hold: 999.00 min. Valve Configuration Settings are Valve 1: SPLIT On, Valve 2: SPLIT On, Valve 3: None, Valve 4: None, Valve 5: None, Valve 6: None. Detector Parameters, Detector A None, Range: 1, Time Constant 200, Autozero ON, Polarity: None. In Detector B Detector: None, Range: 1, Time Constant: 200, Autozero: ON, Polarity: None. Heated Zones, Injector A: CAP, Set-point: OFF. Injector B: PSSI, Initial Set point: 280ºC, Initial Hold: 999.00 min. Detector A: 0ºC, Detector B: 0ºC, Auxiliary (NONE): 0ºC. Oven Program Cryogenics: Off, Initial Temp: 40ºC, Initial Hold: 1.00 min, Ramp 1: 10.0 0/min to 325ºC, hold for 15.00 min, Total Run Time 44.50 min, Maximum Temp: 330ºC, Equilibrium Time: 0.5 min, Timed Events: There are no timed events in the method. Carrier gas used Helium and Perkin Elmer Elite 5MS capillary column used for GC. Column length is 30 m, ID 0.25 mm and DF 0.5 um. Column temperature range is -60 to 350ºC.

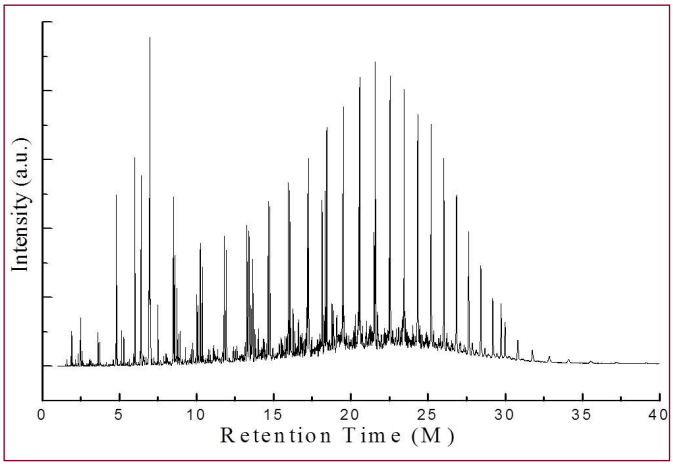

Fig. 2- GC/MS chromatogram of waste plastics and 5% residue mixture to fuel

Table 2- GC/MS chromatogram of waste plastics and 5% residue mixture to fuel compound list

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	1.50	41	Cyclopropane	C3H6	42	45.7	18854
2	1.60	41	1-Propene, 2-methyl-	C4H8	56	26.8	18910
3	1.64	41	2-Butene, (E)-	C4H8	56	18.5	105
4	1.67	41	Cyclobutane	C4H8	56	20.6	62181
5	1.88	42	Cyclopropane, ethyl-	C5H10	70	23.3	114410
6	1.91	43	Pentane	C5H12	72	85.7	114462
7	1.95	55	Cyclopropane, 1,2-dimethyl-, cis-	C5H10	70	15.3	19070
8	1.99	55	2-Pentene, (E)-	C5H10	70	25.3	231217
9	2.25	67	Cyclopentene	C5H8	68	16.8	19032
10	2.32	43	Pentane, 2-methyl-	C6H14	86	39.3	61279
11	2.50	41	Cyclopropane, 1-ethyl-2-methyl-, cis-	C6H12	84	15.9	113658
12	2.57	41	Hexane	C6H14	86	71.0	61280
13	2.64	41	2-Butene, 2,3-dimethyl-	C6H12	84	15.4	289588
14	2.90	56	Cyclopentane, methyl-	C6H12	84	61.6	114428
15	2.96	67	1,3-Pentadiene, 2-methyl-, (E)-	C6H10	82	12.7	113652
16	3.00	79	4-Methyl-2-pentyne	C6H10	82	12.2	231299
17	3.06	56	1-Pentene, 2,4-dimethyl-	C7H14	98	48.3	114435
18	3.14	67	Isopropenylcyclopropane	C6H10	82	8.32	118860
19	3.26	78	Benzene	C6H6	78	62.8	114388
20	3.41	43	Hexane, 3-methyl-	C7H16	100	43.2	113081
21	3.52	67	Cyclohexene	C6H10	82	22.8	114431
22	3.56	56	1-Hexene, 2-methyl-	C7H14	98	18.0	114433
23	3.62	41	Cyclopentane, 1,2-dimethyl-, cis-	C7H14	98	24.4	114027
24	3.73	43	Heptane	C7H16	100	46.1	61276
25	3.77	81	1,3-Pentadiene, 2,4-dimethyl-	C7H12	96	9.10	114450
26	3.83	55	2-Heptene	C7H14	98	27.8	113119
27	3.95	81	2,4-Hexadiene, 3-methyl-	C7H12	96	5.36	837
28	4.30	41	Cyclopentane, ethyl-	C7H14	98	26.8	940
29	4.39	81	7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl-	C8H12O2	140	17.3	118349
30	4.55	81	Cyclobutane, (1-methylethylidene)-	C7H12	96	10.0	150272
31	4.60	41	3-Decyn-2-ol	C10H18O	154	8.03	53449
32	4.77	43	Heptane, 4-methyl-	C8H18	114	59.1	113916
33	4.81	91	Toluene	C7H8	92	57.5	291301
34	4.86	81	Cyclohexene, 3-methyl-	C7H12	96	7.81	236066
35	5.15	41	1-Octene	C8H16	112	18.3	1604

Table 2- Continue...

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
36	5.29	43	Octane	C8H18	114	25.9	229407
37	5.39	55	3-Octene, (Z)-	C8H16	112	15.2	113895
38	5.55	83	Cyclopentane, 1,1,3,4-tetramethyl-, cis-	C9H18	126	18.7	34789
39	5.65	43	Hexane, 3-ethyl-	C8H18	114	14.8	113940
40	5.92	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C9H18	126	25.3	2480
41	6.01	43	2,4-Dimethyl-1-heptene	C9H18	126	50.2	113516
42	6.42	91	Ethylbenzene	C8H10	106	39.7	114918
43	6.56	91	Cyclohexanol, 1-ethynyl-, carbamate	C9H13NO2	167	36.3	313023
44	6.72	67	Cyclohexene, 3,3,5-trimethyl-	C9H16	124	20.6	114765
45	6.98	104	Styrene	C8H8	104	31.4	291542
46	7.02	43	Nonane	C9H20	128	28.4	228006
47	7.50	105	Benzene, 1-ethyl-2-methyl-	C9H12	120	19.6	114029
48	7.66	55	Cyclopentane, butyl-	C9H18	126	13.7	114172
49	7.88	117	Benzene, 2-propenyl-	C9H10	118	14.3	114744
50	8.02	91	Benzene, propyl-	C9H12	120	71.9	113930
51	8.07	57	Octane, 2,3-dimethyl-	C10H22	142	11.7	114135
52	8.13	105	Benzene, 1-ethyl-3-methyl-	C9H12	120	20.6	228743
53	8.51	117	α-Methylstyrene	C9H10	118	37.7	30236
54	8.59	41	1-Decene	C10H20	140	26.1	118883
55	8.73	43	Decane	C10H22	142	47.5	114147
56	8.86	71	Decane, 4-methyl-	C11H24	156	11.1	5261
57	8.93	43	Nonane, 2,6-dimethyl-	C11H24	156	10.7	61438
58	8.99	105	1-Decen-4-yne, 2-nitro-	C10H15NO2	181	7.48	186798
59	9.08	41	2-Decyn-1-ol	C10H18O	154	6.52	53366
60	9.27	117	Benzene, 2-propenyl-	C9H10	118	16.9	114744
61	9.39	55	2,4-Pentadien-1-ol, 3-pentyl-, (2Z)-	C10H18O	154	23.6	142197
62	9.44	69	3-Undecene, (E)-	C11H22	154	13.4	60565
63	9.54	91	Benzene, 3-butenyl-	C10H12	132	7.43	53479
64	9.65	43	2-Undecanethiol, 2-methyl-	C12H26S	202	4.31	9094
65	9.75	91	1,2,3,4,5,8-Hexahydronaphthalene	C10H14	134	13.1	113559
66	9.80	41	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, [1R-(1α,2β,5α)]-	C10H20O	156	7.43	114560
67	9.91	41	7-Hexadecenal, (Z)-	C16H30O	238	7.31	293051
68	10.01	69	3-Tetradecene, (E)-	C14H28	196	4.11	142623
69	10.07	43	2-Undecanethiol, 2-methyl-	C12H26S	202	4.20	9094
70	10.13	56	3-Undecene, (Z)-	C11H22	154	6.56	142598
71	10.24	41	1-Undecene	C11H22	154	6.81	5022
72	10.38	43	Undecane	C11H24	156	49.3	114185
73	10.44	55	5-Undecene, (E)-	C11H22	154	8.70	114227
74	10.71	69	1b,5,5,6a-Tetramethyl-octahydro-1-oxa-cyclopropa[a]inden-6-one	C13H20O2	208	12.2	194131
75	10.86	41	2-Undecanethiol, 2-methyl-	C12H26S	202	3.86	9094
76	10.93	41	1,12-Tridecadiene	C13H24	180	7.93	7380
77	11.08	91	Benzene, (3-methyl-3-butenyl)-	C11H14	146	37.4	27671
78	11.13	69	1,12-Tridecadiene	C13H24	180	9.30	7380
79	11.17	69	2-Isopropenyl-5-methylhex-4-enal	C10H16O	152	6.47	191046
80	11.24	41	Benzene, (3-ethenyl-5,5-dimethylhexyl)-	C16H24	216	6.76	64052
81	11.29	43	Undecane, 4-methyl-	C12H26	170	8.45	6604
82	11.36	91	Benzene, (3-methylbutyl)-	C11H16	148	32.6	114000
83	11.44	69	Cyclopropanemethanol, 2-methyl-2-(4-methyl-3-pentenyl)-	C11H20O	168	8.82	185050
84	11.80	41	3-Dodecene, (E)-	C12H24	168	7.78	113960
85	11.92	57	Dodecane	C12H26	170	17.4	291499
86	12.39	43	Decane, 2,3,5,8-tetramethyl-	C14H30	198	6.28	149589
87	12.63	43	2-Hexyl-1-octanol	C14H30O	214	3.57	113807
88	12.77	41	Benzene, (3-ethenyl-5,5-dimethylhexyl)-	C16H24	216	6.36	64052
89	13.15	41	3-Trifluoroacetoxypentadecane	C17H31F3O2	324	4.28	245478
90	13.26	41	2-Tridecene, (E)-	C13H26	182	7.73	142614
91	13.39	43	Tridecane	C13H28	184	10.4	114282
92	13.41	43	1-Nonene, 4,6,8-trimethyl-	C12H24	168	2.59	6413
93	13.52	43	3-Eicosene, (E)-	C20H40	280	2.40	62838
94	13.63	43	Isotridecanol-	C13H28O	200	2.97	298499
95	13.77	92	Benzene, heptyl-	C13H20	176	45.0	118464

Table 2- Continue...

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
96	13.83	142	Bicyclo[4.4.1]undeca-1,3,5,7,9-pentaene	C11H10	142	53.1	190616
97	14.38	55	1b,5,5,6a-Tetramethyl-octahydro-1-oxa-cyclopropa[a]inden-6-one	C13H20O2	208	10.4	194131
98	14.64	41	1-Hexadecene	C16H32	224	5.07	118882
99	14.75	43	Tetradecane	C14H30	198	33.2	113925
100	14.80	41	7-Tetradecene	C14H28	196	6.41	70643
101	15.48	43	Octadecane, 6-methyl-	C19H40	268	5.84	35803
102	15.84	41	1-Nonadecanol	C19H40O	284	5.74	13666
103	15.94	41	1-Pentadecene	C15H30	210	6.01	69726
104	16.04	43	Hexadecane	C16H34	226	17.6	114191
105	16.82	41	1-Docosanol	C22H46O	326	6.05	23377
106	17.09	41	Z-10-Pentadecen-1-ol	C15H30O	226	4.76	245485
107	17.17	41	1-Hexadecene	C16H32	224	5.69	118882
108	17.27	43	Hexadecane	C16H34	226	32.3	114191
109	17.45	41	1-Dodecanol, 3,7,11-trimethyl-	C15H32O	228	4.63	22776
110	18.14	91	Benzene, 1,1'-(1,3-propanediyl)bis-	C15H16	196	88.0	133399
111	18.34	41	1-Nonadecene	C19H38	266	4.55	113626
112	18.43	43	Heptadecane	C17H36	240	15.0	107308
113	18.88	91	Benzeneacetic acid, 4-tetradecyl ester	C22H36O2	332	9.88	282026
114	19.08	43	1-Docosanol	C22H46O	326	4.96	23377
115	19.45	55	1-Nonadecene	C19H38	266	6.20	113626
116	19.52	43	Octadecane	C18H38	254	19.4	57273
117	20.51	43	1-Docosene	C22H44	308	5.81	113878
118	20.58	43	Nonadecane	C19H40	268	12.3	114098
119	21.02	43	1-Hexadecanol, 2-methyl-	C17H36O	256	6.04	36540
120	21.21	43	Heptadecane, 9-octyl-	C25H52	352	8.87	15951
121	21.29	43	Ethanol, 2-(octadecyloxy)-	C20H42O2	314	6.73	36195
122	21.51	43	1-Docosene	C22H44	308	8.98	113878
123	21.58	43	Eicosane	C20H42	282	19.6	290513
124	21.71	204	Naphthalene, 2-phenyl-	C16H12	204	15.3	101249
125	22.48	43	1-Docosene	C22H44	308	9.39	113878
126	22.54	43	Heneicosane	C21H44	296	16.1	107569
127	23.46	57	Eicosane	C20H42	282	15.6	290513
128	24.01	43	Octadecane, 3-ethyl-5-(2-ethylbutyl)-	C26H54	366	12.9	16319
129	24.29	55	1-Eicosanol	C20H42O	298	6.10	113075
130	24.35	57	Heneicosane	C21H44	296	14.8	107569
131	25.15	43	1-Docosanol	C22H46O	326	10.3	23377
132	25.20	57	Heneicosane	C21H44	296	11.5	107569
133	26.03	57	Heneicosane	C21H44	296	12.9	107569
134	26.22	92	Benzene, (3-octylundecyl)-	C25H44	344	24.4	15748
135	26.84	57	Heneicosane	C21H44	296	9.04	107569
136	27.08	57	17-Pentatriacontene	C35H70	490	13.4	233160
137	27.64	57	Heneicosane	C21H44	296	6.31	107569
138	28.42	57	Octacosane	C28H58	394	7.77	149865
139	29.20	57	Heptacosane	C27H56	380	7.00	79427
140	29.73	306	1,1':3',1"-Terphenyl, 5'-phenyl-	C24H18	306	43.9	57402
141	29.98	57	Heptacosane	C27H56	380	12.6	79427
142	30.82	57	Heptacosane	C27H56	380	11.6	79427
143	31.76	57	Heptacosane	C27H56	380	12.7	79427

In the initial preface of the analysis retention time 1.50, trace mass 41, compound is Cyclopropane (C3H6), retention time at 1.60, trace mass 41, compound is 1-Propene-2-Methyl (C4H8), retention time 1.64, trace mass 41, compound is 2-Butene, (E)- (C5H10), retention time 1.90, trace mass 43, compound is Pentane (C5H12), retention time 2.30, trace mass 43, compound is Pentane-2-Methyl-(C6H14), retention time 2.47, trace mass 41, 3-Hexene, (E)-, (C6H12), retention time 2.25 and trace mass 67, compound is Cyclopentene (C5H8), retention time 2.90 and trace mass 56, compound is Cyclopentane, methyl-(C6H12), retention time 3.06, trace mass 56, compound is 1-Pentene, 2, 4-dimethyl-(C7H14), retention time 3.14, trace mass 67, compound is Isopropenylcyclopropane (C7H12), retention time 3.56, trace mass 56, compound name is 1-Hexene, 2 -methyl- (C7H14), retention time 3.73, trace mass 43, compound is Heptane, retention time 4.75, trace mass 70, compound is Heptane, 4-methyl- (C8H18), retention time 4.81, trace mass 91, compound is Toluene, (C7H8), retention time 5.15, trace mass 41, compound is 1-Octene, retention time 5.29, trace mass 43, compound is Oc-

tane, retention time 5.55, trace mass 83, compound is Cyclopentane, 1, 1, 3, 4-tetramethyl-, cis-(C9H18), retention time 5.65, trace mass 43, compound is Hexane, 3-ethyl-(C8H18), retention time 6.01, trace mass 43, compound is 2, 4-Dimethyl-1-heptene (C9H18), retention time 6.42, trace mass 91, compound is Ethyl benzene (C9H10), retention time 6.56, trace mass 91, compound is Cyclohexanol, 1-ethylnyl-, ($C_9H_{13}NO_2$) etc. In low retention time and low trace mass small structure compounds are derived and high retention time high and high trace mass large and bulky structure compounds are appeared. In the middle of analysis high retention time and high trace mass are seen such as retention time 7.50 and trace mass 105, compound is Benzene, 1-ethyl-2-methyl-(C9H12), retention time 7.88, trace mass 117, compound is Benzene, Propenyl-(C9H10), retention time 8.02, trace mass 91, compound is Benzene, propyl-(C9H12), retention time 8.51, trace mass 117, compound is α-Methylstyrene- (C9H10), benzene derivatives compound are available because in the raw randomly mixed waste plastics has structure of the PS-6 styrene as well. Retention time 8.59, trace mass 41, compound is 1-Decene (C10H20), retention time 9.27 and trace mass 117, compound is Benzene, 2-propenyl-(C9H10), retention time 10.01, trace mass 69, compound is 3-Tetradecene, (E)- (C14H28) and retention time 10.38, trace mass 43, compound is Undecane (C11H24) accordingly. Eventually we noticed in high retention time and low trace mass some higher carbon number compound are appeared such as retention time 12.39, trace mass 43, compound is Decane, 2, 3, 5, 8-tetramethyl (C14H30), retention time 15.94, trace mass 41, compound is 1-Pentadecene (C15H30), retention time 19.45 and trace mass 55, compound is 1-Nonadecene (C19H38), retention time 20.58, trace mass 43.compound is Nonadecane (C19H40), retention time 21.51, trace mass 41 compound is 1-Docosene (C22H44), retention time 25.15 and trace mass 43, compound is -Dcosanol (C26H46O) etc. On the other hand in some field high retention time and high trace mass also larger hydrocarbon compound are noticed such as retention time 27.64 and trace mass 57, compound is Heneicosane (C21H44), retention time 28.42 and trace mass 57, compound is Octacosane (C28H58), retention time 29.73 and trace mass 306, compound is 1, 1': 3', 1"-Tetraphenyl, 5'-Phenyl- (C24H18), at retention time 27.08 and trace mass 57 highest carbon compound is 17-Pentatriacontene (C35H70) and ultimately retention time 31.76 and trace mass 57 compound is Heptacosane (C27H56) respectively.

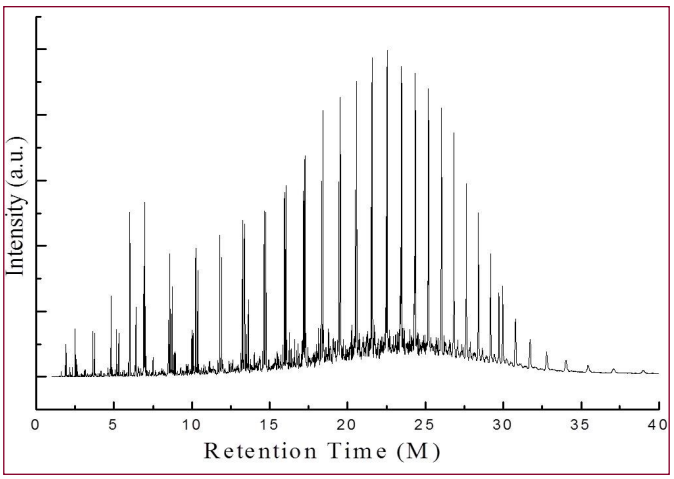

Fig. 3- GC/MS chromatogram of waste plastics and 10% residue mixture to fuel

From Perkin Elmer GC-MS analysis of randomly mixed waste plastics with 10% residue to fuel [Fig-3] and [Table-3] at the initial preface of the analysis retention time 1.50, trace mass 41, compound is Cyclopropane (C3H6), retention time at 1.60 and trace mass 41, compound is 2-Butene, (E)- (C4H8), retention time 1.63 and trace mass 41, compound is 2-Butene, (C5H10), retention time 1.91 and trace mass 43, compound is Pentane (C5H12), retention time 2.32 and trace mass 43, compound is Pentane-2-Methyl-(C6H14), retention time 2.50 and trace mass 41, 1-Hexene (C6H12), retention time 2.79 and trace mass 69, compound is 2-Pentene, 3-methyl-, (E)-, (C6H12), retention time 3.01 and trace mass 67, compound is 2, 4-Hexadiene, (Z, Z)-, (C6H10), retention time 3.08, trace mass 56, compound is 1-Pentene, 2, 4-dimethyl-(C7H14), retention time 3.15 and trace mass 67, compound is Cyclopentane, 3-methyl (C6H10), retention time 3.58 and trace mass 56, compound name is 1-Hexene, 2-methyl- (C7H14), retention time 3.74 and trace mass 43, compound is Heptane (C7H16), retention time 4.77 and trace mass 43, compound is Heptane, 4-methyl- (C8H18), retention time 4.81, trace mass 91, compound is Toluene, (C7H8), retention time 5.16 and trace mass 41, compound is 2-Octene, (Z), retention time 5.31 and trace mass 43, compound is Octane, retention time 5.56 and trace mass 43, compound is Cyclopentane, 1, 1, 3, 4-tetramethyl-, cis-, (C9H18), retention time 5.66 and trace mass 43, compound is Hexane, 3-ethyl-(C8H18), retention time 6.01 and trace mass 43, compound is 2, 4-Dimethyl-1-heptene (C9H18), retention time 6.42, trace mass 91, compound is Ethyl benzene (C9H10), retention time 6.56, trace mass 91, compound is Cyclohexanol, 1-ethylnyl-, (C9H13NO2) etc. In low retention time and low trace mass small structure compounds are derived and high retention time high and high trace mass large and bulky structure compounds are appeared. In the middle of analysis high retention time and high trace mass are seen such as retention time 7.50 and trace mass 105, compound is Benzene, 1-ethyl-2-methyl-(C9H12), retention time 7.88, trace mass 67, compound is Cyclopentene, 1-butyl--(C9H16), retention time 8.02, trace mass 91, compound is Benzene, propyl-(C9H12), retention time 8.50 and trace mass 118, compound is α-Methylstyrene- (C9H10), benzene derivatives compound are available because in the raw randomly mixed waste plastics has structure of the PS-6 styrene as well. Retention time 8.59, trace mass 41, compound is 1-Decene (C10H20), retention time 9.27 and trace mass 117, compound is Benzene, 2-propenyl- (C9H10), retention time 10.01 and trace mass 41, compound is 1-Octene, 3, 7-dimethyl - (C10H28) and retention time 10.38 and trace mass 43, compound is Undecane (C11H24) accordingly. Eventually we noticed in high retention time and low trace mass some higher carbon number compound are appeared such as retention time 12.39, trace mass 43, compound is Decane, 2, 3, 5, 8-tetramethyl (C14H30), retention time 15.94, trace mass 41, compound is 1-Pentadecene (C15H30), retention time 19.45 and trace mass 41, compound is 1-Nonadecene (C19H38), retention time 20.58, trace mass 57 compound is Nonadecane (C19H40), retention time 21.51, trace mass 41 compound is Octadecane (C18H38), retention time 25.20 and trace mass 85, compound is Hexacosane (C26H54) etc. On the other hand in some field high retention time and high trace mass also larger hydrocarbon compound are noticed such as retention time 27.62 and trace mass 57, compound is Hexacosane (C21H44), retention time 28.41 and trace mass 57, compound is Eicosane, 2-methyl- (C21H44), retention time 29.96 and trace mass 57, compound is Heneicosane, 11-(1-ethylpropyl) - (C26H54) and ultimately retention time 34.03 and trace mass 57 compound is Heptacosane (C27H56) respectively.

Table 3- GC/MS chromatogram of waste plastics and 10% residue mixture to fuel compound list

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
1	1.50	41	Cyclopropane	C3H6	42	21.8	18854
2	1.60	41	2-Butene, (E)-	C4H8	56	24.7	105
3	1.61	43	Butane	C4H10	58	58.0	18940
4	1.63	41	2-Butene	C4H8	56	16.9	61292
5	1.87	42	Cyclopropane, ethyl-	C5H10	70	21.0	114410
6	1.91	43	Pentane	C5H12	72	86.3	114462
7	1.95	55	Cyclopropane, 1,2-dimethyl-, cis-	C5H10	70	19.4	19070
8	2.07	67	1,4-Pentadiene	C5H8	68	16.3	209
9	2.26	67	Cyclopentene	C5H8	68	12.5	19032
10	2.32	43	Pentane, 2-methyl-	C6H14	86	58.3	61279
11	2.50	41	1-Hexene	C6H12	84	20.0	500
12	2.58	57	Hexane	C6H14	86	74.5	61280
13	2.65	69	2-Pentene, 4-methyl-, (Z)-	C6H12	84	15.8	19318
14	2.73	67	1,3-Butadiene, 2-ethyl-	C6H10	82	15.9	118159
15	2.79	69	2-Pentene, 3-methyl-, (E)-	C6H12	84	18.3	19321
16	2.90	56	Cyclopentane, methyl-	C6H12	84	66.1	114428
17	2.96	67	1,3-Pentadiene, 2-methyl-, (E)-	C6H10	82	12.2	113652
18	3.01	67	2,4-Hexadiene, (Z,Z)-	C6H10	82	10.4	113646
19	3.08	56	1-Pentene, 2,4-dimethyl-	C7H14	98	53.2	114435
20	3.15	67	Cyclopentene, 3-methyl-	C6H10	82	10.5	114408
21	3.21	41	3-Heptene	C7H14	98	6.35	113117
22	3.28	78	Benzene	C6H6	78	64.5	114388
23	3.31	41	1-Hexene, 3,4-dimethyl-	C8H16	112	12.9	113920
24	3.38	79	1,3-Cyclohexadiene	C6H8	80	16.0	19246
25	3.42	43	Hexane, 3-methyl-	C7H16	100	61.8	113081
26	3.58	56	1-Hexene, 2-methyl-	C7H14	98	27.0	114433
27	3.62	41	Cyclopentane, 1,2-dimethyl-, cis-	C7H14	98	18.5	114027
28	3.74	43	Heptane	C7H16	100	46.5	61276
29	3.78	81	1,4-Hexadiene, 4-methyl-	C7H12	96	12.8	113135
30	4.17	83	Cyclohexane, methyl-	C7H14	98	61.7	118503
31	4.31	69	Cyclopentane, ethyl-	C7H14	98	30.0	940
32	4.39	79	1-Cyclohexene-1-methanol	C7H12O	112	10.9	52048
33	4.56	81	Cyclobutane, (1-methylethylidene)-	C7H12	96	11.3	150272
34	4.61	67	3-Decyn-2-ol	C10H18O	154	8.65	53449
35	4.77	43	Heptane, 4-methyl-	C8H18	114	68.0	113916
36	4.81	91	Toluene	C7H8	92	60.4	291301
37	4.87	81	Cyclohexene, 3-methyl-	C7H12	96	8.44	236066
38	5.07	56	1-Heptene, 2-methyl-	C8H16	112	50.4	113675
39	5.16	41	2-Octene, (Z)-	C8H16	112	15.1	113889
40	5.24	95	2-Octyn-1-ol	C8H14O	126	13.4	113247
41	5.31	43	Octane	C8H18	114	25.3	229407
42	5.40	55	3-Octene, (Z)-	C8H16	112	19.6	113895
43	5.56	69	Cyclopentane, 1,1,3,4-tetramethyl-, cis-	C9H18	126	14.2	34789
44	5.66	43	Hexane, 3-ethyl-	C8H18	114	13.4	113940
45	5.93	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C9H18	126	18.7	2480
46	6.01	43	2,4-Dimethyl-1-heptene	C9H18	126	56.5	113516
47	6.36	69	Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)-	C9H18	126	34.0	2480
48	6.42	91	Ethylbenzene	C8H10	106	65.0	114918
49	6.56	81	Cyclohexanol, 1-ethynyl-, carbamate	C9H13NO2	167	31.2	313023
50	6.88	41	1-Nonene	C9H18	126	11.1	107756
51	6.96	104	1,3,5,7-Cyclooctatetraene	C8H8	104	42.9	113230
52	7.03	43	Nonane	C9H20	128	20.3	249212
53	7.25	55	2-Octyn-1-ol	C8H14O	126	4.43	113247
54	7.44	67	Ethylidenecycloheptane	C9H16	124	7.57	113500
55	7.50	105	Benzene, (1-methylethyl)-	C9H12	120	33.5	228742
56	7.66	55	Cyclopentane, butyl-	C9H18	126	9.29	114172
57	7.84	41	2-Nonyn-1-ol	C9H16O	140	9.77	53365
58	7.88	67	Cyclopentene, 1-butyl-	C9H16	124	6.39	113491
59	7.92	41	2,4-Undecadien-1-ol	C11H20O	168	12.9	136410
60	8.02	91	Benzene, propyl-	C9H12	120	55.1	113930
61	8.07	57	Octane, 2,3-dimethyl-	C10H22	142	16.3	114135
62	8.50	118	α-Methylstyrene	C9H10	118	38.2	30236
63	8.59	41	1-Decene	C10H20	140	24.1	118883
64	8.74	43	Decane	C10H22	142	52.5	114147
65	8.81	55	2-Decene, (Z)-	C10H20	140	14.4	114151

Table 3- Continue...

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
66	8.86	43	Decane, 4-methyl-	C11H24	156	11.8	113875
67	9.27	117	Benzene, 2-propenyl-	C9H10	118	13.0	114744
68	9.39	41	2,4-Pentadien-1-ol, 3-pentyl-, (2Z)-	C10H18O	154	14.2	142197
69	9.44	69	6-Octenal, 3,7-dimethyl-	C10H18O	154	5.35	57666
70	9.65	41	2-Undecanethiol, 2-methyl-	C12H26S	202	4.93	9094
71	9.75	91	2-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)-	C10H16O	152	27.6	114684
72	9.80	41	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, [1R-(1α,2β,5α)]-	C10H20O	156	8.95	114560
73	10.01	41	1-Octene, 3,7-dimethyl-	C10H20	140	3.69	3653
74	10.08	41	5-Ethyl-1-nonene	C11H22	154	2.96	114896
75	10.13	41	3-Undecene, (Z)-	C11H22	154	6.24	142598
76	10.24	41	1-Undecene	C11H22	154	6.43	5022
77	10.30	41	Z-10-Pentadecen-1-ol	C15H30O	226	6.26	245485
78	10.38	43	Undecane	C11H24	156	47.6	114185
79	10.44	55	5-Undecene, (E)-	C11H22	154	8.70	114227
80	10.76	43	Ethanone, 1-(1,2,2,3-tetramethylcyclopentyl)-, (1R-cis)-	C11H20O	168	4.10	186082
81	11.08	91	1,10-Dichlorodecane	C10H20Cl2	210	7.57	155022
82	11.13	69	1,12-Tridecadiene	C13H24	180	5.05	7380
83	11.17	41	1b,5,5,6a-Tetramethyl-octahydro-1-oxa-cyclopropa[a]inden-6-one	C13H20O2	208	4.20	194131
84	11.36	91	Benzene, (3-methylbutyl)-	C11H16	148	8.85	114000
85	11.68	41	3-Dodecene, (E)-	C12H24	168	5.78	113960
86	11.80	41	3-Dodecene, (E)-	C12H24	168	10.2	113960
87	11.92	43	Dodecane	C12H26	170	19.2	291499
88	12.39	43	Decane, 2,3,5,8-tetramethyl-	C14H30	198	4.20	149589
89	13.15	41	Z-10-Pentadecen-1-ol	C15H30O	226	8.11	245485
90	13.26	41	2-Tridecene, (E)-	C13H26	182	9.23	142614
91	13.38	41	Tridecane	C13H28	184	16.2	114282
92	13.51	43	4-Trifluoroacetoxytridecane	C15H27F3O2	296	2.73	245473
93	13.64	43	1-Nonadecene	C19H38	266	2.51	113626
94	13.77	92	Benzene, heptyl-	C13H20	176	35.2	118464
95	14.00	41	1-Tetracosanol	C24H50O	354	3.17	16001
96	14.24	41	Tetradecane, 2,6,10-trimethyl-	C17H36	240	7.39	11556
97	14.64	41	7-Tetradecene, (E)-	C14H28	196	4.48	142631
98	14.75	43	Tetradecane	C14H30	198	19.3	113925
99	14.79	41	7-Tetradecene	C14H28	196	9.90	70643
100	15.48	43	1-Decanol, 2-hexyl-	C16H34O	242	4.87	113815
101	15.56	43	Octadecane, 6-methyl-	C19H40	268	4.07	35803
102	15.94	41	1-Pentadecene	C15H30	210	5.31	69726
103	16.04	57	Hexadecane	C16H34	226	18.8	114191
104	16.72	41	2-Piperidinone, N-[4-bromo-n-butyl]-	C9H16BrNO	233	5.20	251632
105	16.81	41	1-Tetracosanol	C24H50O	354	7.37	16001
106	17.17	55	1-Hexadecene	C16H32	224	7.16	118882
107	17.27	57	Nonadecane	C19H40	268	11.8	114098
108	17.30	41	1-Hexadecene	C16H32	224	2.76	118882
109	17.45	41	1-Docosanol	C22H46O	326	2.84	23377
110	18.13	92	Benzene, 1,1'-(1,3-propanediyl)bis-	C15H16	196	80.0	34894
111	18.26	41	E-2-Octadecadecen-1-ol	C18H36O	268	6.67	131102
112	18.34	41	1-Heptadecanol	C17H36O	256	6.94	113250
113	18.42	43	Octadecane	C18H38	254	10.1	57273
114	18.46	41	10-Heneicosene (c,t)	C21H42	294	5.15	113073
115	19.08	43	1-Docosanol	C22H46O	326	6.08	23377
116	19.45	41	1-Nonadecene	C19H38	266	7.29	113626
117	19.52	85	Octadecane	C18H38	254	13.1	57273
118	20.51	55	9-Nonadecene	C19H38	266	7.55	113627
119	20.58	57	Octadecane	C18H38	254	8.64	57273
120	21.51	43	1-Docosene	C22H44	308	11.3	113878
121	21.57	57	Eicosane	C20H42	282	9.03	290513
122	22.48	55	1-Docosene	C22H44	308	13.4	113878
123	22.54	85	Octadecane	C18H38	254	6.86	57273
124	23.40	43	1-Docosene	C22H44	308	11.4	113878
125	23.46	57	Octadecane	C18H38	254	8.17	57273
126	24.00	43	Ethanol, 2-(octadecyloxy)-	C20H42O2	314	7.02	36195
127	24.29	55	1-Docosene	C22H44	308	9.42	113878
128	24.35	57	Octadecane	C18H38	254	6.62	57273
129	25.20	85	Hexacosane	C26H54	366	5.44	107147
130	25.80	57	17-Pentatriacontene	C35H70	490	9.65	233160

Table 3- Continue...

Peak Number	Retention Time (M)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	Probability %	NIST Library Number
131	26.03	57	Eicosane	C20H42	282	4.72	290513
132	26.84	85	Octadecane	C18H38	254	5.96	57273
133	27.62	57	Hexacosane	C26H54	366	6.21	107147
134	28.41	57	Eicosane, 2-methyl-	C21H44	296	5.43	113884
135	29.19	57	Heptacosane	C27H56	380	5.80	150574
136	29.72	306	1,1':3',1''-Terphenyl, 5'-phenyl-	C24H18	306	40.1	57402
137	29.96	57	Heneicosane, 11-(1-ethylpropyl)-	C26H54	366	4.78	16318
138	30.79	57	Heptacosane	C27H56	380	6.63	79427
139	31.72	57	Heptacosane	C27H56	380	11.5	79427
140	32.79	57	Heptacosane	C27H56	380	7.66	79427
141	34.03	57	Heptacosane	C27H56	380	16.7	79427

Conclusion

Randomly mixture of waste plastics and leftover residue mixture to fuel production process was performed in laboratory scale batch process. 5% and 10% residue were use for two experiments and experimental parameters were same condition. Two experiments was performed individual with randomly mixture waste plastics including low and high density polyethylene, polypropylene and polystyrene mixture and 5% residue was added for first experiment and 2nd experiment 10% residue was added with same waste plastics. Both experimental fuel yield percentage was close one to another and light gas percentage was also close one to another but left over residue was different. Because 1st experiment was added residue 5% and 2nd experiment added residue was 10%. Residue again converted certain percentage with randomly mixture waste plastics to fuel production process. Added residue was certain percentage carbon and hydrogen those carbon and hydrogen again converted fuel and light gas with mixture of waste plastics. Residue and waste plastics mixture to fuel production after that was collected solid black residue again. Because full residue cannot be converted as fuel with waste plastics because residue has also metal content those metal portions come out as residue. In the both experiment gas percentage was increased also residue percentage was increased because initial raw waste plastics was 1000 gm and residue was 50 gm as 5% and total sample was 1050 gm. 5% residue and randomly mixture waste plastics to fuel and light gas yield percentage 91.59% and residue percentage 8.41%. 10% residue and randomly mixture waste plastics to fuel and light gas yield percentage 88.74% and residue percentage 11.26%. 10% residue or 100 gm residue and randomly waste plastics 1000 gm or total 1100 gm was initial feed for 2nd experiment. By using this technology randomly mixture waste plastics and certain percentage residue can converted fuel and fuel could be use all internal combustion engine, feed for feed stock refinery and electricity generation feed for power plants.

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Conflicts of Interest: None declared.

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