

None Coded Waste Plastics Conversion into Fuel

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Abstract

Waste plastics are major problem for environment all over the World. It's creating gas emission into the environment because waste plastic are non-biodegradable. Waste plastics can remain long period of time in the landfill. The thermal degradation process applied with none coded waste plastics with muffle furnace and reactor without using catalyst or chemical. None coded polymer has been selected for the experiment 100% by weight. The temperature used for thermal degradation for muffle furnace at 420 °C and for reactor temperature was 300-420 °C and experiment total experiment run time was 7-8 hours. The obtained products are liquid fuel 85%, light gas 9% and black carbon residue 6%. Various technique (Gas Chromatography and Mass Spectrometer, FT-IR) were used for produced fuel analysis. GC/MS analysis result is showing hydrocarbon compound ranges are C₃-C₂₈ and light gas are present C₁-C₄. Fuel analysis result showing different carbon range and these produced fuel are present short to long chain hydrocarbon such as alkane and alkene. Produce fuel could be use internal combustion engine or feed for feed stock refinery.

Keywords: waste plastic, liquid fuel, conversion, thermal process, hydrocarbon, none coded plastic

1. Introduction

Energy crisis and environmental degradation by polymer wastes have been imperative to find and propose technologies for recovery of raw materials and energy from non-conventional sources like organic wastes, plastic wastes, scrap tires, etc. A variety of methods and processes connected with global or national policies have been proposed worldwide. A new type of a tubular reactor with the molten metal bed is proposed for conversion of waste plastics to fuel like mixture of hydrocarbons. The results of the thermal degradation of polyolefins in the laboratory scale set-up based on this reactor are presented in the paper. The melting and cracking processes were carried out at the temperature 300–420 °C. The final product consisted of gaseous product 6% and liquid product 85% stream. Few amounts of residue products were produced that 6%. The light “gasoline” fraction of the liquid hydrocarbons mixture (C₄–C₁₁) made the liquid product. It may be used for fuel production or

electricity generation [1]. Since the continuous increase in polymer production and consumption leads to accumulation of large amounts of plastic wastes that pose serious environmental problems, the conversion of these wastes into a common fuel oil can be considered as their most promising recycling method. Some polymer materials e.g., polystyrene (PS), can be decomposed thermally in high yields to the monomers. However, this is not true for polyethylene (PE) or polypropylene (PP), which is among the most abundant polymeric waste materials, typically making up 60–70% of municipal solid waste.

However, most studies have mainly concentrated on the catalytic degradation of pure polymers. It would be desirable to convert these waste polyolefins into products of value other than the monomers, because they offset the collection and pyrolysis costs. It seems also that in the process of plastic pyrolysis, a particular kind of catalyst is effective for a particular kind of plastic. Unfortunately it can only be applied to pure plastics and is not recommended for mixed plastic wastes. A more difficult task is tertiary recycling of commingled post-consumer plastic waste since it consists of not only hydrocarbons but also nitrogen and sulfur containing mixed polymers as well as some modified materials. Study the products distribution from the degradation of mixture of post-commercial polymer wastes (LDPE/HDPE/PP/PS) and to especially develop a suitable reaction model for achieving post use polymer recycling [2]. In view of their versatility and relatively low cost, the consumption of plastic materials has been growing steadily, although the disposal of waste plastics constitutes a severe environmental problem due mainly to their chemical inertness. While a polymer recycling is a requirement to mitigate their impact on the environment [3], various tertiary recycling processes are attractive, since they produce valuable chemicals or fuels [4, 5]. Considering polyolefins, polyethylene and polypropylene have a massive production and consumption in a large number of applications. The tertiary recycling of polyolefins (particularly polyethylene) has been attempted under different approaches. The most used laboratory technique with some variations, is that of contacting the plastic with the catalyst in a closed environment, heating them together until reaction temperature, and allowing for a certain reaction-time; products are then

separated and analyzed (e.g. [6,7]). Some other researcher also fuel produced form waste plastics

with different method such as thermal cracking [8, 9], pyrolysis [10] and catalytic process [11, 12, 13].

2. Experimental Process

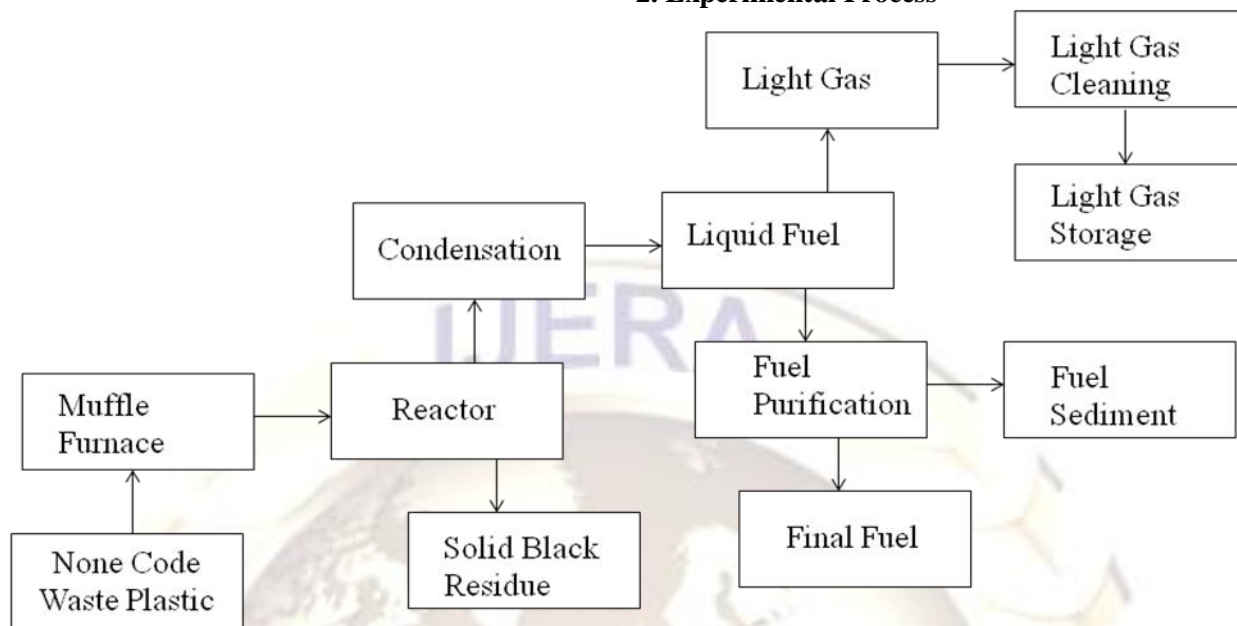


Figure 1: None coded waste plastic to fuel production process

None coded waste plastics provided by Natural State Research Inc owner Dr. Karin Kaufman from her house residence. After received, waste plastic separated and sort out all foreign materials such as food particle, paper, dust, cloth, glass, metal etc. Waste plastic wash with liquid soap (7th generation company provider) and after wash spread the entire sample into laboratory floor for air dry. Once plastics dried out and cut into small pieces by manually. Small pieces waste plastic put into crucible for 1st stage liquefaction process using muffle furnace. Before liquefaction process raw sample were analysis by using Gas Chromatography and Mass Spectrometer (GC/MS) with Pyroprobe (CDS), FT-IR (Spectrum 100), TGA (Pyris-1) and EA-2400 respectively. GC/MS used to identify in none coded waste plastic what types of compounds are present, FT-IR used to identify what types functional group present in the none coded waste plastic and also determine functional group band energy, TGA equipment was used for onset temperature measurement for liquefaction temperature determine and that temperature need for waste plastic liquefaction purposes, and at the end elemental analyzer were used (EA-2400) for raw sample carbon, hydrogen and nitrogen percentage measured. None coded waste plastics to fuel production process first able used muffle furnace that model is F 6000 from Barnstead International Company. Grounded none coded waste plastic inserted into ceramic crucible and top of the crucible one cover were set up as well. In the experiment none coded waste plastic was use as initial feed and weight was 400 gm. Ceramic crucible temperature tolerable capacity is up

to 1200 °C and muffle furnace temperature can be raise up to 1400 °C. Under Labconco fume hood whole experiment was placed. In the crucible one portion of plastic parts was taken and crucible another part was covered then put in the muffle furnace inside and furnace door were closed accordingly. Then furnace temperature programs are setup and muffle furnace temperature range selected up to 420 °C. Muffle furnace started from room (25 °C) temperature and ramping rate was used 20 °C per minute. Hold for final temperature at 30 minute. After 30 minute hold, sample temperature cooling down per minute 10 °C. When temperature goes down 300-290 °C muffle furnace door was open and liquid none coded waste plastic slurry was transferred into reactor chamber (**Figure 1**). During the muffle furnace process produced some light gases and light gas percentage was 3% from total waste plastic. Muffle furnace experiment expedited in presence of oxygen without vacuumed system. Subsequently reactor started and heated up liquid slurry 300- 420 °C for converting liquid slurry to vapor, vapor travel through condenser unit without water cooling system and at the end turns into liquid fuel and collected as well. During liquid fuel production period certain amount of light hydrocarbon gases generated and this gas was passed through alkali wash (light gas cleaning system) for removing contamination. It's same as natural gas and stored the gas as well and able to reuse that gas for sample heating sources in the reactor by using small pump. Produced fuel was purifying by RCI purification system, its removing water contain and fuel sediment. Obtained fuel density is 0.77 gm/ml. By using this technology fuel

yield percentage is 85%, residue yield percentage is 6% and light gas yield percentage is 6%. The experiment was performed without any catalyst or extra chemical and none coded waste plastics were

used and experiment run time was including muffle furnace and reactor 7-8 hours.

3. Results and Discussion

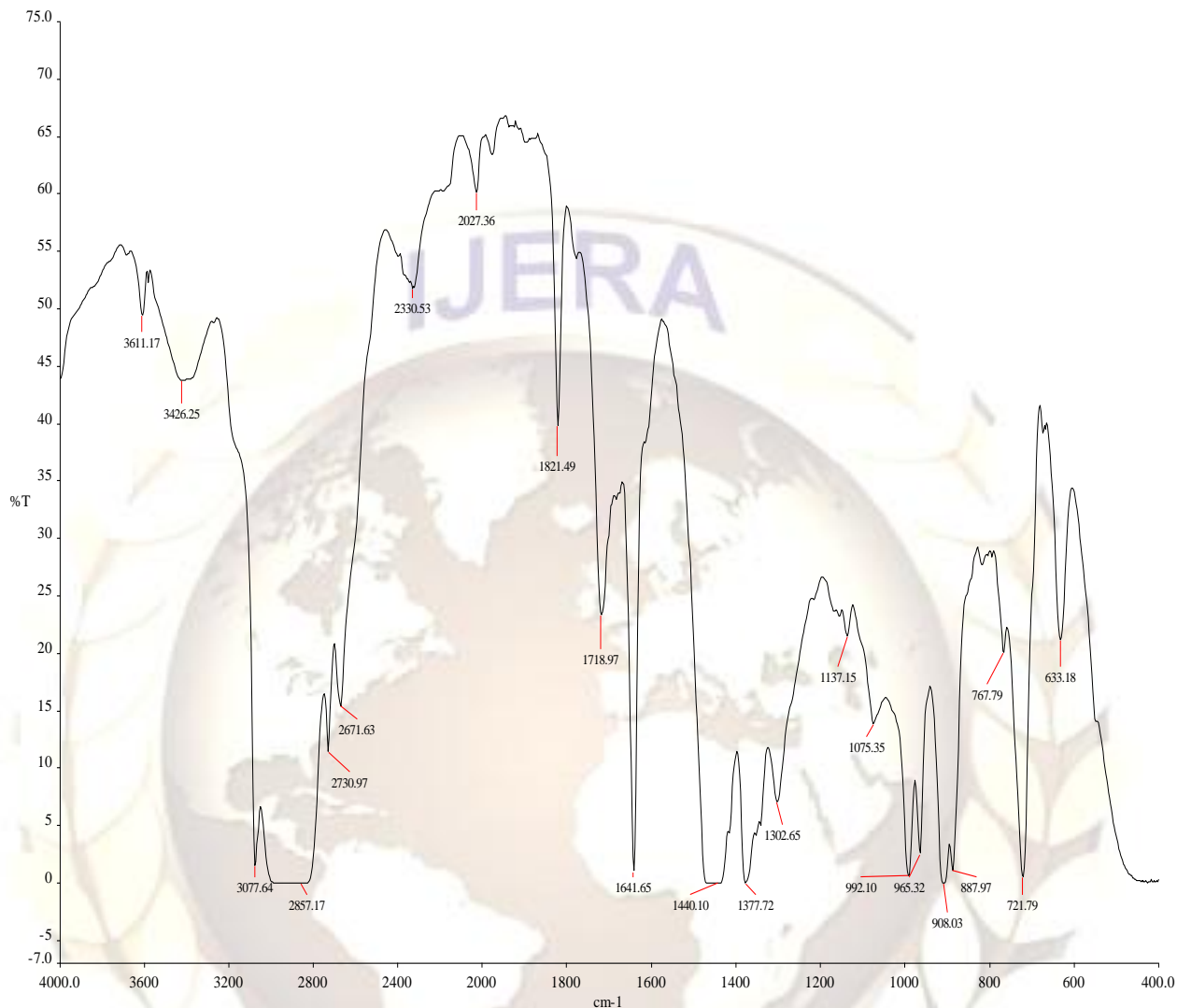


Figure 2: FT-IR spectra of none coded waste plastics to fuel

FT-IR (Fourier Transform Infra-red Spectroscopy) analysis of none coded waste plastic to fuel (**figure 2**) noticed following types of functional group appeared such as at wave number 3611.17 cm^{-1} , compound is Free OH, wave number 3426.25 cm^{-1} , compound is intermolecular H bonds, wave number 3077.64 cm^{-1} , compound is H bonded NH, wave number 2857.17 cm^{-1} , 2730.97 cm^{-1} , 2671.63 cm^{-1} compound is C-CH₃ accordingly. Descending wave number such as 1821.49 cm^{-1} , 1718.97 cm^{-1} compound is Non-Conjugated, wave number 1641.65 cm^{-1} , compound is conjugated, wave number 1440.10 cm^{-1} and 1377.72 cm^{-1} compound is CH₃, wave number 992.10 cm^{-1} compound is -CH=CH₂, wave number 965.32 cm^{-1} , compound is -CH=CH-(trans), wave number 908.03 cm^{-1} compound is -CH=CH₂, wave number 887.97 cm^{-1} ,

compound is C=CH₂ and ultimately wave number 721.79 cm^{-1} , compound is -CH=CH-(cis) respectively.

From FT-IR analysis (Spectrum 100 Perkin Elmer) obtained functional group (see **figure 2**) has also band energy. Energy value are calculated using energy formula that is $E=hcw$, where E=energy, h=plank constant, w =frequency number/wave number. Functional group C-CH₃, calculated energy value is $5.67 \times 10^{-20}\text{ J}$, functional group CH₃, energy value is $2.86 \times 10^{-20}\text{ J}$, functional group H bonded NH, energy value is $6.11 \times 10^{-20}\text{ J}$, functional group Non-Conjugated, calculated energy value is $3.61 \times 10^{-20}\text{ J}$, functional group -CH=CH₂, energy value is $1.97 \times 10^{-20}\text{ J}$, functional group C=CH₂, energy value is $1.76 \times 10^{-20}\text{ J}$, functional group -CH=CH-(cis), energy value is $1.97 \times 10^{-20}\text{ J}$ and ultimately functional group C=CH₂, calculated energy value is $1.76 \times 10^{-20}\text{ J}$.

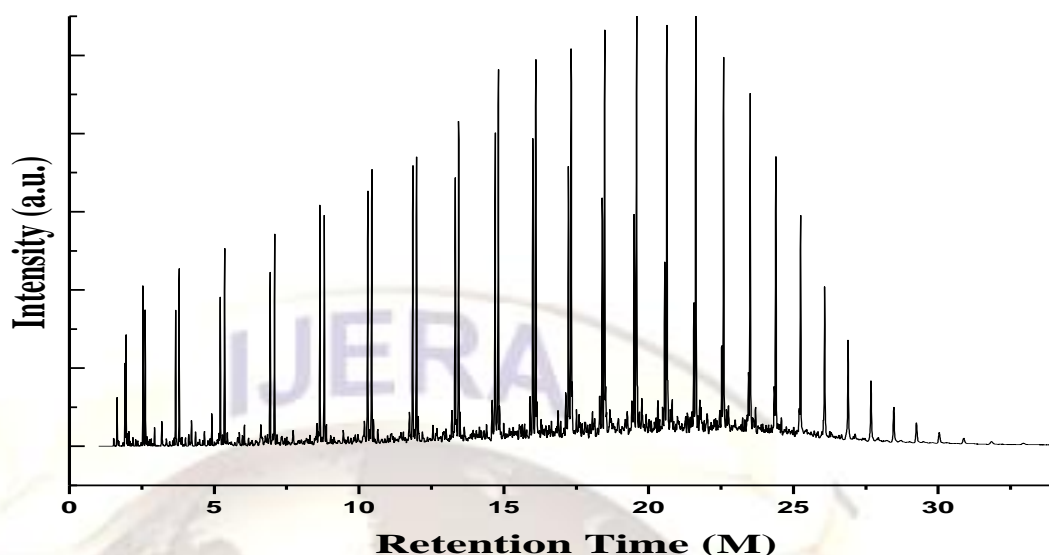


Figure 3: GC/MS chromatogram of none coded waste plastics to fuel

Table 1: None coded waste plastics to fuel GC/MS chromatogram compound list

Peak Number	Retention Time (min)	Trace Mass (m/z)	Compound Name	Compound Formula	Molecular Weight	CAS Number
1	1.53	39	Propane	C ₃ H ₈	44	74-98-6
2	1.65	43	Butane	C ₄ H ₁₀	58	106-97-8
3	1.91	42	Cyclopropane, ethyl-	C ₅ H ₁₀	70	1191-96-4
4	1.95	43	Pentane	C ₅ H ₁₂	72	109-66-0
5	2.54	41	1-Hexene	C ₆ H ₁₂	84	592-41-6
6	2.62	41	Hexane	C ₆ H ₁₄	86	110-54-3
7	3.19	67	Cyclopentene, 1-methyl-	C ₆ H ₁₀	82	693-89-0
8	3.66	41	1-Heptene	C ₇ H ₁₄	98	592-76-7
9	3.79	43	Heptane	C ₇ H ₁₆	100	142-82-5
10	4.22	83	Cyclohexane, methyl-	C ₇ H ₁₄	98	108-87-2
11	4.92	81	Cyclohexene, 1-methyl-	C ₇ H ₁₂	96	591-49-1
12	5.21	41	1-Octene	C ₈ H ₁₆	112	111-66-0
13	5.36	43	Octane	C ₈ H ₁₈	114	111-65-9
14	6.04	83	Cyclohexane, ethyl-	C ₈ H ₁₆	112	1678-91-7
15	6.61	81	Cyclohexene, 1,2-dimethyl-	C ₈ H ₁₄	110	1674-10-8
16	6.93	41	1-Nonene	C ₉ H ₁₈	126	124-11-8
17	7.08	43	Nonane	C ₉ H ₂₀	128	111-84-2
18	8.55	70	Nonane, 3-methylene-	C ₁₀ H ₂₀	140	51655-64-2
19	8.65	41	1-Decene	C ₁₀ H ₂₀	140	872-05-9
20	8.80	57	Decane	C ₁₀ H ₂₂	142	124-18-5
21	9.45	55	Cyclodecane	C ₁₀ H ₂₀	140	293-96-9
22	10.19	70	4-Undecene, (Z)-	C ₁₁ H ₂₂	154	821-98-7
23	10.30	41	1-Undecene	C ₁₁ H ₂₂	154	821-95-4
24	10.44	57	Undecane	C ₁₁ H ₂₄	156	1120-21-4
25	11.74	70	5-Undecene, 9-methyl-, (Z)-	C ₁₂ H ₂₄	168	74630-65-2
26	11.86	41	1-Dodecene	C ₁₂ H ₂₄	168	112-41-4

27	11.98	57	Dodecane	C ₁₂ H ₂₆	170	112-40-3
28	13.21	70	5-Tridecene, (E)-	C ₁₃ H ₂₆	182	23051-84-5
29	13.32	41	1-Tridecene	C ₁₃ H ₂₆	182	2437-56-1
30	13.44	57	Tridecane	C ₁₃ H ₂₈	184	629-50-5
31	14.40	57	Tridecane, 3-methyl-	C ₁₄ H ₃₀	198	6418-41-3
32	14.70	41	1-Tetradecene	C ₁₄ H ₂₈	196	1120-36-1
33	14.82	57	Tetradecane	C ₁₄ H ₃₀	198	629-59-4
34	15.00	55	7-Tetradecene	C ₁₄ H ₂₈	196	10374-74-0
35	15.90	41	Z-10-Pentadecen-1-ol	C ₁₅ H ₃₀ O	226	N/A
36	16.00	55	1-Pentadecene	C ₁₅ H ₃₀	210	13360-61-7
37	16.10	57	Pentadecane	C ₁₅ H ₃₂	212	629-62-9
38	17.14	70	Cyclohexadecane	C ₁₆ H ₃₂	224	295-65-8
39	17.23	55	1-Hexadecene	C ₁₆ H ₃₂	224	629-73-2
40	17.33	43	Hexadecane	C ₁₆ H ₃₄	226	544-76-3
41	18.40	55	E-14-Hexadecenal	C ₁₆ H ₃₀ O	238	330207-53-9
42	18.49	41	Heptadecane	C ₁₇ H ₃₆	240	629-78-7
43	19.50	55	E-15-Heptadecenal	C ₁₇ H ₃₂ O	252	N/A
44	19.59	57	Octadecane	C ₁₈ H ₃₈	254	593-45-3
45	20.56	55	1-Nonadecene	C ₁₉ H ₃₈	266	18435-45-5
46	20.63	43	Eicosane	C ₂₀ H ₄₂	282	112-95-8
47	21.56	55	1-Docosene	C ₂₂ H ₄₄	308	1599-67-3
48	22.59	57	Heneicosane	C ₂₁ H ₄₄	296	629-94-7
49	25.25	57	Tetracosane	C ₂₄ H ₅₀	338	646-31-1
50	26.07	57	Octacosane	C ₂₈ H ₅₈	394	630-02-4
51	27.68	57	Heptacosane	C ₂₇ H ₅₆	380	593-49-7

GC-MS analysis of none coded waste plastic to fuel (figure 3 and table 1) in accordance with the various retention time and trace masses 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 C₃ to C₂₈. Based on the retention time and trace mass following hydrocarbon compounds as follows such as at the initial phase of the analysis at retention time 1.53 and trace mass 39, compound is Propene, (C₃H₈), retention time 1.65 and trace mass 43, compound is Butane, (C₃H₈), retention time 1.91 and trace mass 42, compound is Cyclopropane,ethyl- (C₅H₁₀), retention time 1.95 and trace mass 43, compound is Pentane (C₅H₁₂), retention time 2.54 and trace mass 41, compound is 1-Hexene, (C₆H₁₂), retention time 2.62 and trace mass 41, compound is Hexane (C₆H₁₄), retention time 3.19 and trace mass 67, compound is Cyclopentane,1-methyl- (C₆H₁₀), retention time 3.66 and trace mass 41, compound name is 1-Hentene, (C₇H₁₄), retention time 3.79 and trace mass 43, compound name is Heptane (C₇H₁₆), retention time 4.22 and trace mass 83, compound is Cyclohexane, methyl- (C₇H₁₄), retention time 4.92

and trace mass 81, compound is Cyclohexane,1-methyl (C₇H₁₂), retention time 5.21 and trace mass 41, compound is 1-Octene, (C₈H₁₆), retention time 5.36 and trace mass 43, compound is Octane, (C₈H₁₈), retention time 6.04 and trace mass 83 compound is Cyclohexane,ethyl- (C₈H₁₆), retention time 7.08 and trace mass 43, compound is Nonane (C₉H₂₀), retention time 8.55 and trace mass 70, compound is Nonane, 3-methylene- (C₁₀H₂₀), retention time 9.45 and trace mass 55, compound is Cyclodecane (C₁₀H₂₀). Also at retention time 10.19 and trace mass 70, compound is 4-Undecene, (Z) - (C₁₁H₂₂), retention time 10.44 and trace mass 57, and compound is 1-Undecane (C₁₁H₂₄) etc. In the middle phases of the analysis index results in accordance with the retention time and trace masses various kinds of compounds are detected such as at retention time 11.74 and trace mass 70, compound is 5-Undecene,9-methyl-,(Z)- (C₁₂H₂₄). Retention time 11.98 and trace mass 57, compound is Dodecane (C₁₂H₂₆). Retention time 13.44 and trace mass 57, compound is Tridecane (C₁₃H₂₆), retention time 14.70 and trace mass 41, compound is 1-Tetradecene (C₁₄H₂₈), retention time 15.90 and trace mass 41, compound is Z-10-Pentadecene-1-ol, (C₁₅H₃₂O), at

retention time 16.10 and trace mass 57, compound is Pentadecane ($C_{15}H_{32}$), retention time 17.33 and trace mass 43, compound is Hexadecane ($C_{16}H_{34}$) etc. In the ultimate phase of the analysis index several compound are detected as according to their retention time and trace masses such as retention time 18.40 and trace mass 55, compound is E-4-Hexadecenal ($C_{15}H_{32}O$), retention time 19.50 and trace mass 57, compound is Octadecane ($C_{18}H_{38}$), retention time 20.63 and trace mass 43, compound is Eicosane ($C_{20}H_{42}$), retention time 22.59 and trace mass 57, compound is Heneicosane ($C_{21}H_{44}$), retention time 25.25 and trace mass 57, compound is Trtracosane ($C_{24}H_{50}$), retention time 26.07 and trace mass 57, compound is Octacosane ($C_{28}H_{58}$) and eventually retention time 27.68 and trace mass 57, compound is Heptacosane ($C_{27}H_{56}$). Aromatic benzene compounds are formed because when raw polystyrene are made benzene are added into the reactants. Some oxygenated compounds are formed because in the glass reactor chamber much amount of steams are produced and also experiment executed in the presence of air moisture.

4. Conclusion

None coded waste plastic to liquid fuel production process experiment done without catalyst and two step processes was applied in this experiment. Muffle furnace temperature was 420 °C and reactor process temperature range were also 300- 420 °C for slurry boiling to produce vapor and vapor condense to liquid fuel. Produce fuel was analysis by GC/MS and liquid fuel hydrocarbon compound range is C_3H_8 to $C_{28}H_{58}$. FT-IR analysis results indicate that liquid fuel functional group band energy represent to calorific value. Produce fuel density is 0.77 g/ml and light gases are mixture of hydrocarbon such as methane, ethane, propane and butane. In this experiment light gas percentage increased and liquid fuel production percentage little decreased because the experiment performed in two step process. Light gas could be use as heat source for none coded waste plastic to fuel production period and it's reduce production cost as well. By using the technology none coded waste plastic problems can be resolved with environmental problem accordingly. Produce fuel can be use for internal combustion engines as well as feed stock refinery process, electricity generation and reduce certain percentages of foreign oil dependency.

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