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Research article

Hydrocarbon Compounds Fuel Recover from LDPE/HDPE/PP/PS Waste Plastics Mixture Using Zinc Oxide Catalyst

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Abstract

Waste plastics mixture (low density polyethylene, high density polyethylene, polypropylene, and polystyrene) to fuel recover with 20% Zinc Oxide catalyst experiment was performed into laboratory batch scale. Waste plastics mixture was use for experiment 1000 gm (1kg) and catalyst was use 200 gm as a 20%. Waste plastics mixture was randomly and un- proportional. Experimental temperature was 200 – 400 ºC, and experimental purpose reactor was use steel reactor. Product fuel density is 0.77 gm/ml and fuel color is light yellow. Liquid fuel conversion rate was 71.68%, light gas was 15.51%, and solid black residue was 12.81%. Gas Chromatography and Mass Spectrometer (GC/MS) was use for liquid fuel analysis purpose and GC/MS chromatogram analysis result showed fuel has hydrocarbon range C_3 to C_{36} including aromatic group, alcoholic group, and oxygen content. Fuel is ignited and fuel can use internal combustion engines and petroleum refinery process as a feed.

Keywords: waste plastics, hydrocarbon, fuel, catalyst, Zinc Oxide, LDPE, HDPE, PP, PS

Introduction

In modern life, the application of polymers is common. This kind of material is present in packaging, the electrical industry, in toys, etc. The increase in application leads to a higher per capita consumption of virgin plastics. Thus, this increment rose 96.6 kg in 2002 and 98.1 kg in 2003 [1, 2]. Although significant amounts of thermoplastics are utilized in products with a long life span, the majority are used in short term applications. Because of this, the

quantity of thermoplastics found in waste is increasing correspondingly. High-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), and polyethylene terephtalate (PET) are the most extensively used plastics. The polyethylene plastics (HDPE and LDPE) are the major components of the total plastic content of municipal solid waste [3-6]. Plastics have a high calorific value (i.e., polyethylene 43 MJ/ kg, polypropylene 44 MJ/kg, polyvinyl chloride 20 MJ/kg), and their combustion can be an alternative to removing them [7]. This alternative must, however, be subjected to severe environmental controls in order to fulfill the legal restrictions concerning the emission of solid particles and gaseous effluents [7,8,9] Landfills have also been used for plastic disposal, but these can pose a danger through the environment product degradation and the subsequent pollutant generation [8, 9, 10].

The magnitude of the problem can be roughly estimated by examining several figures [11]. The total world production of plastic in 2005 was ~230 million tonnes, having overtaken the consumption of steel. In Western Europe, 47.5 million of tonnes were consumed in the same year and the equivalent amount of generated post-consumer waste accounted for 22 million tonnes. The main components of the household plastic waste streams include the following five families of plastics: polyethylene (low density polyethylene (LDPE), linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE)), polypropylene (PP), poly (vinyl chloride) (PVC), polystyrene (PS), and polyethylene-terephthalate (PET), which account entirely for 74% of all plastic wastes. Figure 1 shows the distribution of the different end-of-life treatments for plastic waste in Western Europe in 2005 [4]. Landfilling is still the main treatment (53%), although its share is dropping at a rate of 2% annually, which highlights the growing success of recycling/energy recovery options. Two types of recycling can be distinguished: mechanical recycling, which recovers the plastic material for similar or lower-quality applications for such plastics, and feedstock recycling, which turns the plastic waste by means of chemical reactions into chemical raw materials or fuels [12]. A significant amount of research has been conducted on the catalytic liquefaction of plastic. Excellent results have been obtained from liquefaction of individual polymers [polyethylene (PE), polypropylene (PPE), polystyrene (PS), etc.] and relatively clean mixed plastic using solid acid catalysts and metal-promoted solid acid catalysts [13-21]. For example, Venkatesh et al.20 and Shabtai et al.21 have obtained high yields of liquids that consist predominantly of isoalkanes in the gasoline boiling range from HDPE, PPE, and PS at relatively low temperatures (300 - 375 °C) using Pt-promoted ZrO2/ SO4 or ZrO2/WO3 catalysts. However, true post-consumer plastic (PCP) contains heteroatoms (principally chlorine, but also nitrogen and some sulfur), paper, dirt, and inorganic matter that can render such catalysts ineffective [22].

Thermal and catalytic cracking of common plastics such as PE and PP have already been studied extensively [23–31]. Although thermal degradation requires high temperature and gives a very broad product range, catalytic degradation provide control of both the product quality and distribution in polymer degradation as well as significantly lowering the degradation temperature. However, in case of waste plastic mixture, the quality of the fuel oil produced by cracking often does not meet the minimum specifications. Fuel oil can contain environmentally hazardous impurities such as sulfur and chlorine. These problems can be overcome by cracking in the presence of hydrogen. Hydrogenation process has excellent capabilities for handling troublesome hetero-atoms (i.e. Cl, N, O, S) present in the plastic waste. Another approach in the degradation of polymers is coprocessing. Co-processing waste plastics with coal provides another alternative for the production of fuels from waste plastics. Most of these studies involve the co-processing of single plastics with coal by using HZSM-5 and other acidic catalyst [32–39].

Materials and Method

A waste plastic was collected from local grocery store and collected waste plastics were shorted out and wash with soap and water. Waste plastics was cut into small pieces and keep into separated container for grinding. A grinder

machine was use for grinding purpose and size was 2-3 mm. Zinc Oxide catalyst was collected from VWR Company. High density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP), and polystyrene (PS) chemical structure showed in figure 1 for visual understanding.

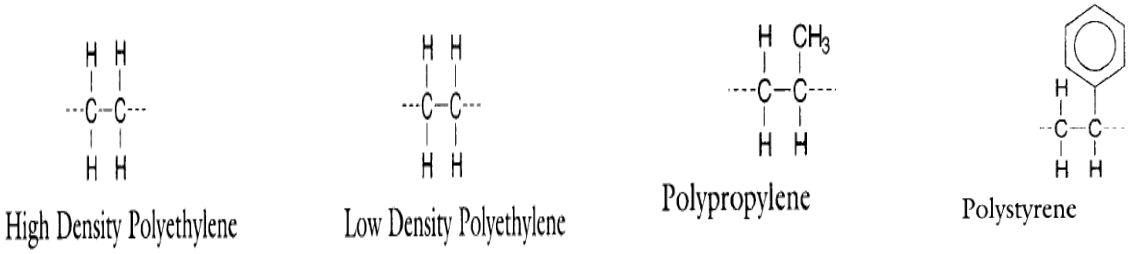

Figure 1: HDPE, LDPE, PP and PS Plastics Chemical Structure

Grounded waste plastics and ZnO was placed into steel reactor chamber manually. This experiment process was batch process and it was setup under laboratory fume hood in presence of oxygen. Experimental setup is show into figure 2 for visual understanding. For experiment setup purpose required equipment and accessories was steel reactor with temperature controller system, condensation unit, fuel collection container, fuel filter device, final fuel collection container, fuel sediment container, light gas cleaning liquid solution (NaOH, NaHCO3), clean water, small pump, Teflon Bag, residue collection container. All accessories and rector was setup properly to prevent gas loss into environment. This experiment main goal was conversion percentage rate determination using ZnO catalyst with mixture of waste plastics. Experimental start temperature was 200 ºC and finished temperature was 400 ºC. Low density waste plastic has long chain hydrocarbon compounds; high density waste plastic also has long chain hydrocarbon compounds, polypropylene waste plastic has long chain hydrocarbon compounds with methyl group, and polystyrene waste plastic has long chain hydrocarbon compounds with aromatic group. Mixture of waste plastics was breakdown with catalyst when heat was applied for liquefaction process and form into short chain hydrocarbon. When heat or temperature was applied from 200 ºC to until 400 ºC it create vapor and vapor travel through condensation unit and at the end liquid was collected as liquid fuel. During fuel production whole light gas was passed through alkali solution to remove contamination from light gas. After cleaning light gas was transferred into Teflon bag using small motor pump and light gas keep for future analysis purpose. Collected fuel was cleaned by using RCI fuel purification system with micron filter. Then liquid clean fuel transfer into separated container. Solid black residue was collected from reactor after cool down the reactor and made calculation for mass balance. Mass balance calculation showed 1000 gm waste sample to liquid fuel was 716.8 g (922 ml), light gas generated from 155.1 gm, and solid black residue was 128.1 gm. Total experiment run time was 4.30 hours and input electricity was 6.25 kWh. Solid black residue and light gas analysis under investigation, and ZnO catalyst recover under investigation.

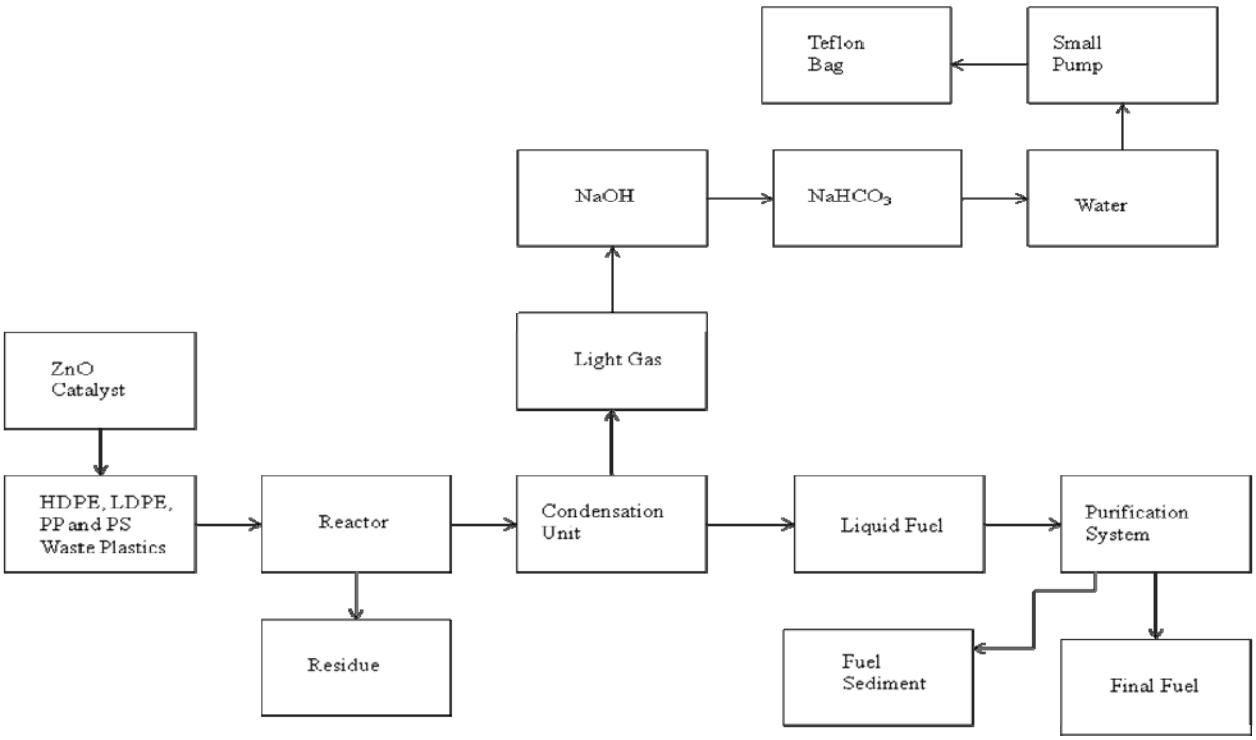

Figure 2: Mixture of LDPE/HDPE/PP/PS waste plastic to fuel production process

Result and Discussion

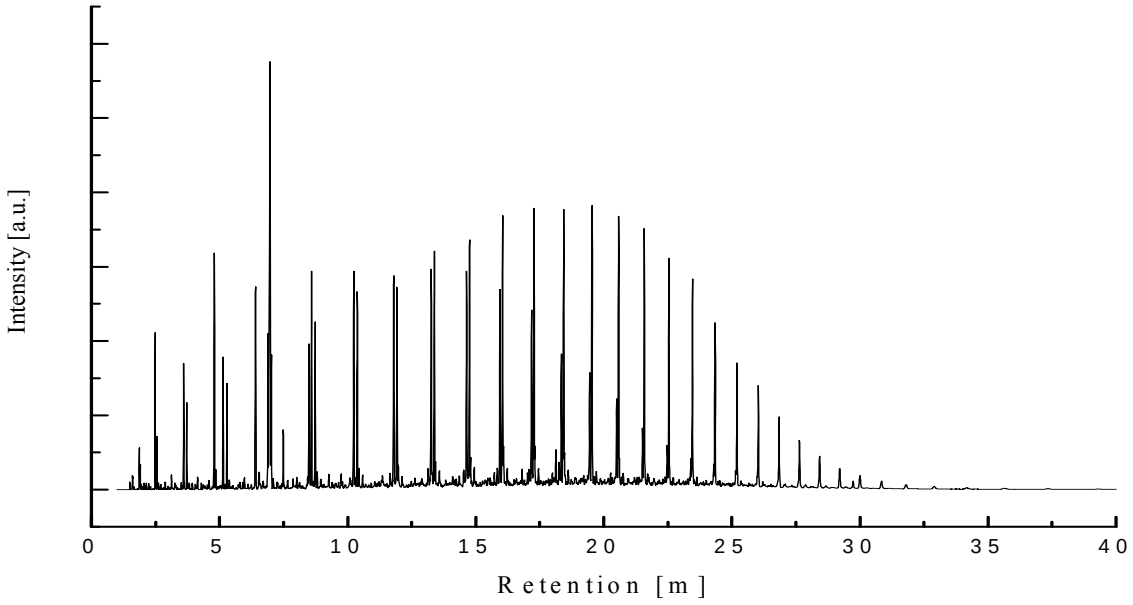

Figure 3: GC/MS chromatogram of mixture of LDPE/HDPE/PP/PS waste plastic to fuel

Table 1: GC/MS chromatogram compounds list of mixture of LDPE/HDPE/PP/PS waste plastic 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	43.6	18854
2	1.60	41	2-Butene, (E)-	C_4H_8	56	23.9	105
3	1.61	43	Butane	C_4H_{10}	58	62.4	18940
4	1.63	41	2-Butene	C_4H_8	56	33.3	61292
5	1.67	41	2-Butene, (E)-	C_4H_8	56	33.9	105
6	1.75	55	Cyclopropane, 1,1-dimethyl-	C_5H_{10}	70	21.4	34618
7	1.87	42	Cyclopropane, ethyl-	C_5H_{10}	70	25.1	114410
8	1.91	43	Pentane	C_5H_{12}	72	86.7	61286
9	1.94	55	2-Pentene	C_5H_{10}	70	14.2	19079
10	1.98	55	2-Pentene, (E)-	C_5H_{10}	70	18.5	291780
11	2.05	67	1,3-Pentadiene	C_5H_8	68	21.0	291890
12	2.12	67	1,3-Pentadiene, (E)-	C_5H_8	68	15.4	212
13	2.24	67	Bicyclo[2.1.0]pentane	C_5H_8	68	21.4	192491
14	2.48	56	1-Hexene	C_6H_{12}	84	37.7	227613
15	2.56	57	Hexane	C_6H_{14}	86	87.2	61280
16	2.62	55	3-Hexene, (E)-	C_6H_{12}	84	23.1	19325
17	2.76	41	Pentane, 3-methylene-	C_6H_{12}	84	34.4	19323
18	2.82	67	2,4-Hexadiene, (Z,Z)-	C_6H_{10}	82	7.45	113646
19	2.88	56	Cyclopentane, methyl-	C_6H_{12}	84	63.5	114428
20	2.94	67	3-Hexyne	C_6H_{10}	82	22.9	19282
21	2.99	79	1,3-Cyclohexadiene	C_6H_8	80	13.6	118700
22	3.04	79	1,3-Cyclopentadiene, 1-methyl-	C_6H_8	80	22.1	164279
23	3.12	67	Cyclopentene, 1-methyl-	C_6H_{10}	82	15.1	107747
24	3.18	56	1-Hexene, 5-methyl-	C_7H_{14}	98	25.3	918
25	3.25	78	Benzene	C_6H_6	78	68.0	114388
26	3.50	67	Cyclohexene	C_6H_{10}	82	36.9	114431
27	3.60	56	1-Heptene	C_7H_{14}	98	43.1	107734
28	3.72	43	Heptane	C_7H_{16}	100	71.5	61276
29	3.82	55	2-Heptene	C_7H_{14}	98	28.1	160628
30	3.94	81	2-Heptene	C_7H_{14}	98	8.62	113119
31	4.05	81	Cyclopentane, 1-methyl-2-methylene-	C_7H_{12}	96	11.6	62523
32	4.15	83	Cyclohexane, methyl-	C_7H_{14}	98	61.8	118503
33	4.29	69	Cyclopentane, ethyl-	C_7H_{14}	98	42.1	940
34	4.37	79	Cyclopropane, trimethylmethylene-	C_7H_{12}	96	10.1	63085
35	4.43	81	Cyclohexane, methylene-	C_7H_{12}	96	11.4	235403
36	4.48	79	1,3,5-Hexatriene, 2-methyl-	C_7H_{10}	94	13.0	60713
37	4.53	81	Cyclobutane, (1-	C_7H_{12}	96	13.7	150272

			methylethylidene)-				
38	4.59	67	1-Ethylcyclopentene	C_7H_{12}	96	43.4	114407
39	4.80	91	Toluene	C_7H_8	92	44.9	291301
40	4.85	81	Cyclohexene, 1-methyl-	C_7H_{12}	96	12.3	139432
41	5.14	55	1-Octene	C_8H_{16}	112	30.6	1604
42	5.29	43	Octane	C_8H_{18}	114	49.5	61242
43	5.38	55	2-Octene, (Z)-	C_8H_{16}	112	12.8	113889
44	5.79	67	1-Methyl-2-methylenecyclohexane	C_8H_{14}	110	25.9	113437
45	5.91	81	2-Octyn-1-ol	$C_8H_{14}O$	126	6.39	113247
46	5.97	83	Cyclohexane, ethyl-	C_8H_{16}	112	46.6	113476
47	6.12	67	Cyclopentene, 1-propyl-	C_8H_{14}	110	14.1	142659
48	6.41	91	Ethylbenzene	C_8H_{10}	106	53.8	158804
49	6.54	81	Cyclohexene, 1,2-dimethyl-	C_8H_{14}	110	11.6	113912
50	6.90	56	1-Nonene	C_9H_{18}	126	20.8	107756
51	6.97	104	Styrene	C_8H_8	104	37.4	291542
52	7.02	57	Nonane	C_9H_{20}	128	40.1	228006
53	7.44	95	trans-1-Butenylcyclopentane	C_9H_{16}	124	20.8	113509
54	7.49	105	Benzene, (1-methylethyl)-	C_9H_{12}	120	49.1	228742
55	7.66	55	2,4-Pentadien-1-ol, 3-propyl-, (2Z)-	$C_8H_{14}O$	126	12.8	142179
56	7.87	67	1,3-Methanopentalene, 1,2,3,5-tetrahydro-	C_9H_{10}	118	11.2	221371
57	7.94	81	3,4-Octadiene, 7-methyl-	C_9H_{16}	124	10.8	54090
58	8.01	91	Benzene, propyl-	C_9H_{12}	120	71.1	113930
59	8.44	55	Cyclodecene, (E)-	$C_{10}H_{18}$	138	8.67	37628
60	8.50	118	α-Methylstyrene	C_9H_{10}	118	34.4	2021
61	8.59	55	1-Decene	$C_{10}H_{20}$	140	17.9	107686
62	8.74	57	Decane	$C_{10}H_{22}$	142	39.8	291484
63	8.81	55	2-Decene, (Z)-	$C_{10}H_{20}$	140	14.1	114151
64	8.95	55	cis-3-Decene	$C_{10}H_{20}$	140	11.3	113558
65	9.27	117	Benzene, 2-propenyl-	C_9H_{10}	118	13.4	114744
66	9.39	55	Cyclohexane, butyl-	$C_{10}H_{20}$	140	27.7	118766
67	9.53	91	Benzene, 3-butenyl-	$C_{10}H_{12}$	132	21.9	113933
68	9.65	105	1,5,7-Octatrien-3-ol, 2,6-dimethyl-	$C_{10}H_{16}O$	152	12.6	31915
69	9.75	91	Bicyclo[3.1.0]hex-2-ene, 4-methylene-1-(1-methylethyl)-	$C_{10}H_{14}$	134	14.3	250248
70	9.79	81	Cyclohexene, 3-(2-methylpropyl)-	$C_{10}H_{18}$	138	6.39	27008
71	9.91	105	cis-p-Mentha-2,8-dien-1-ol	$C_{10}H_{16}O$	152	19.6	292842
72	10.09	55	1,10-Undecadiene	$C_{11}H_{20}$	152	24.4	113574
73	10.24	55	1-Undecene	$C_{11}H_{22}$	154	9.06	34717
74	10.38	57	Undecane	$C_{11}H_{24}$	156	32.5	107774

75	10.44	55	5-Undecene, (E)-	$C_{11}H_{22}$	154	12.3	114227
76	11.66	55	1,11-Dodecadiene	$C_{12}H_{22}$	166	11.0	113595
77	11.80	55	1-Dodecene	$C_{12}H_{24}$	168	15.4	107688
78	11.92	57	Dodecane	$C_{12}H_{26}$	170	34.7	291499
79	11.98	55	3-Dodecene, (E)-	$C_{12}H_{24}$	168	10.2	70642
80	12.13	55	3-Dodecene, (E)-	$C_{12}H_{24}$	168	12.7	70642
81	13.14	55	1,12-Tridecadiene	$C_{13}H_{24}$	180	17.7	7380
82	13.27	55	1-Tridecene	$C_{13}H_{26}$	182	18.0	107768
83	13.39	57	Tridecane	$C_{13}H_{28}$	184	47.2	107767
84	13.43	55	5-Tridecene, (E)-	$C_{13}H_{26}$	182	10.7	142619
85	13.58	55	4-Nonene, 5-butyl-	$C_{13}H_{26}$	182	4.68	34734
86	14.53	55	1,9-Tetradecadiene	$C_{14}H_{26}$	194	5.06	187543
87	14.65	55	1-Tetradecene	$C_{14}H_{28}$	196	6.15	69725
88	14.76	57	Tetradecane	$C_{14}H_{30}$	198	43.0	113925
89	14.80	55	4-Tetradecene, (E)-	$C_{14}H_{28}$	196	6.75	142625
90	14.94	55	7-Tetradecene	$C_{14}H_{28}$	196	7.15	70643
91	15.84	55	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	11.2	245485
92	15.95	55	1-Pentadecene	$C_{15}H_{30}$	210	9.41	69726
93	16.05	57	Pentadecane	$C_{15}H_{32}$	212	40.0	107761
94	16.09	55	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	4.83	131101
95	16.23	55	E-2-Hexadecacen-1-ol	$C_{16}H_{32}O$	240	5.17	131101
96	17.09	55	Z-10-Pentadecen-1-ol	$C_{15}H_{30}O$	226	15.4	245485
97	17.18	55	1-Hexadecene	$C_{16}H_{32}$	224	12.7	69727
98	17.28	57	Hexadecane	$C_{16}H_{34}$	226	40.6	114191
99	17.31	55	1-Hexadecene	$C_{16}H_{32}$	224	6.22	69727
100	17.45	55	1-Hexadecene	$C_{16}H_{32}$	224	2.99	118882
101	18.13	92	Benzene, 1,1'-(1,3-propanediyl)bis-	$C_{15}H_{16}$	196	94.1	229725
102	18.26	92	E-2-Octadecadecen-1-ol	$C_{18}H_{36}O$	268	6.78	131102
103	18.35	55	E-14-Hexadecenal	$C_{16}H_{30}O$	238	6.67	130980
104	18.44	57	Heptadecane	$C_{17}H_{36}$	240	30.4	107308
105	18.62	55	2-Methyl-E-7-hexadecene	$C_{17}H_{34}$	238	9.45	130870
106	19.45	55	E-15-Heptadecenal	$C_{17}H_{32}O$	252	7.70	130979
107	19.54	57	Octadecane	$C_{18}H_{38}$	254	19.0	57273
108	19.71	55	1-Eicosanol	$C_{20}H_{42}O$	298	4.17	113075
109	20.51	55	9-Nonadecene	$C_{19}H_{38}$	266	10.9	113627
110	20.59	57	Nonadecane	$C_{19}H_{40}$	268	21.7	114098
111	20.76	55	1-Nonadecanol	$C_{19}H_{40}O$	284	6.36	13666
112	21.51	55	5-Eicosene, (E)-	$C_{20}H_{40}$	280	7.71	62816
113	21.59	57	Eicosane	$C_{20}H_{42}$	282	25.5	290513
114	21.71	204	1-Docosanol	$C_{22}H_{46}O$	326	6.40	23377
115	22.48	55	10-Heneicosene (c,t)	$C_{21}H_{42}$	294	9.31	113073
116	22.54	57	Heneicosane	$C_{21}H_{44}$	296	27.5	107569
117	23.40	55	1-Docosene	$C_{22}H_{44}$	308	16.4	113878
118	23.46	57	Heneicosane	$C_{21}H_{44}$	296	16.4	107569

119	24.35	57	Heneicosane	$C_{21}H_{44}$	296	12.0	107569
120	25.20	57	Tetracosane	$C_{24}H_{50}$	338	19.1	248196
121	26.03	57	Heneicosane	$C_{21}H_{44}$	296	8.90	107569
122	26.84	57	Octacosane	$C_{28}H_{58}$	394	9.32	134306
123	27.64	57	Octacosane	$C_{28}H_{58}$	394	14.0	134306
124	27.88	57	1-Heptacosanol	$C_{27}H_{56}O$	396	10.8	16909
125	28.43	57	Octacosane	$C_{28}H_{58}$	394	24.4	134306
126	29.21	57	Hexatriacontane	$C_{36}H_{74}$	506	11.6	34744
127	29.73	306	1,1':3',1"-Terphenyl, 5'-phenyl-	$C_{24}H_{18}$	306	45.3	113345
128	30.00	57	Octacosane	$C_{28}H_{58}$	394	10.5	134306
129	30.84	57	Heptacosane	$C_{27}H_{56}$	380	9.58	79427
130	31.80	57	Octacosane	$C_{28}H_{58}$	394	9.21	149865

Waste plastic mixture and 20% ZnO catalyst to product fuel was analysis by using Perkin Elmer GC/MS (Model Clarus 500). For liquid sample analysis purpose solvent was use carbon disulfide (C_2S) and capillary column was use for GC. Chromatogram and analysis compounds are showed into figure 3 and table 1. GC chromatogram analysis purpose NIST library was followed and compound was traces based on retention time (m), traces mass (m/z), compounds formula, molecular weight and compounds probability percentage wise. Analysis compound are showed product fuel has aliphatic compounds including alkane, alkene, alkyl group, aromatic group, alcoholic group and oxygen content compounds. Product fuel starting compound is C_3 and long chain compound is C_{36}. GC/MS compound was traced short chain hydrocarbon compound to long chain hydrocarbon compounds. Some compounds are describing in this section based on retention time, trace mass and compounds probability percentage. Initial compounds was Cyclopropane (C_3H_6) (t=1.49, m/z=41) compound probability percentage is 43.6%, Butane (C_4H_{10}) (t=1.61, m/z=43) compound probability percentage is 62.4%, 1, 1-dimethyl-Cyclopropane (C_5H_{10}) (t=1.75, m/z=55) compound probability percentage is 21.4 %, (E)- 2-Pentene (C_5H_{10}) (t=1.98, m/z=55) compound probability percentage is 18.5 %, Hexane (C_6H_{14}) (t=2.56, m/z=57) compound probability percentage is 87.2 %, (Z,Z)-2,4-Hexadiene (C_6H_{10}) (t=2.82, m/z=67) compound probability percentage is 7.45 %, 1-methyl-1,3-Cyclopentadiene (C_6H_8) (t=3.04, m/z=79) compound probability percentage is 22.1 %, Benzene (C_6H_6) (t=3.25, m/z=78) compound probability percentage is 68.0 %, Heptane (C_7H_{16}) (t=3.72, m/z=43) compound probability percentage is 71.5 %, 1-methyl-2-methylene-Cyclopentane (C_7H_{12}) (t=4.05, m/z=81) compound probability percentage is 11.6 %, trimethylmethylene-Cyclopropane (C_7H_{12}) (t=4.37, m/z=79) compound probability percentage is 10.1 %, Toluene (C_7H_8) (t=4.80, m/z=91) compound probability percentage is 44.9 %, 2-Octyn-1-ol ($C_8H_{14}O$) (t=5.91, m/z=81) compound probability percentage is 6.39 %, Ethylbenzene (C_8H_{10}) (t=6.41, m/z=91) compound probability percentage is 53.8 %, Styrene (C_8H_8) (t=6.97, m/z=104) compound probability percentage is 37.4 %, (2Z)- 3-propyl- 2,4-Pentadien-1-ol ($C_8H_{14}O$) (t=7.66, m/z=55) compound probability percentage is 12.8 %, α-Methylstyrene (C_9H_{10}) (t=8.50, m/z=118) compound probability percentage is 34.4 %, 2-propenyl-Benzene (C_9H_{10}) (t=9.27, m/z=117) compound probability percentage is 13.4 %, 2,6-dimethyl-1,5,7-Octatrien-3-ol ($C_{10}H_{16}O$) (t=9.65, m/z=105) compound probability percentage is 12.6 %, 3-(2-methylpropyl)-Cyclohexene ($C_{10}H_{18}$) (t=9.79, m/z=81) compound probability percentage is 6.39 %, Undecane ($C_{11}H_{24}$) (t=10.38, m/z=57) compound probability percentage is 32.5 %, Dodecane ($C_{12}H_{26}$) (t=11.92, m/z=57) compound probability percentage is 34.7 %, Tridecane ($C_{13}H_{28}$) (t=13.39, m/z=57) compound probability percentage is 47.2 %,

Tetradecane ($C_{14}H_{30}$) (t=14.76, m/z=57) compound probability percentage is 43.0 %, Pentadecane ($C_{15}H_{32}$) (t=16.05, m/z=57) compound probability percentage is 40.0 %, Hexadecane ($C_{16}H_{34}$) (t=17.28, m/z=57) compound probability percentage is 40.6 %, Heptadecane ($C_{17}H_{36}$) (t=18.44, m/z=57) compound probability percentage is 30.4%, Octadecane ($C_{18}H_{38}$) (t=19.54, m/z=57) compound probability percentage is 19.0 %, Nonadecane ($C_{19}H_{40}$) (t=20.59, m/z=57) compound probability percentage is 21.7 %, Eicosane ($C_{20}H_{42}$) (t=21.59, m/z=57) compound probability percentage is 25.5 %, Heneicosane ($C_{21}H_{44}$) (t=23.46, m/z=57) compound probability percentage is 16.4 %, Tetracosane ($C_{24}H_{50}$) (t=25.20, m/z=57) compound probability percentage is 19.1 %, 1-Heptacosanol ($C_{27}H_{56}O$) (t=27.88, m/z=57) compound probability percentage is 10.8 %, Octacosane ($C_{28}H_{58}$) (t=30.00, m/z=57) compound probability percentage is 10.5 %, Hexatriacontane ($C_{36}H_{74}$) (t=29.21, m/z=57) compound probability percentage is 11.6 % respectively.

Conclusion

Waste plastics mixtures and 20% ZnO catalyst to fuel recovers was successfully in the batch process, and conversion rate was 87.19% including liquid and light gas and rest of percentage was solid black residue. Residue was black and hard it can use for road carpeting or roof carpeting. Liquid product was analysis by GC/MS and compounds showed C_3-C_{36} carbon length. Product fuel has aromatic group compounds such as Benzene, Toluene, Ethylbenzene, Styrene, (1-methylethyl)-Benzene, propyl-Benzene, α-Methylstyrene, 2-propenyl-Benzene, 3-butenyl-Benzene, bis-1,1'-(1,3-propanediyl)Benzene and so on. Benzene group compounds appeared from polystyrene plastic because polystyrene waste plastic has aromatic compounds. Fuel color is light yellow and fuel odor is plastic and benzene smell. Most of the aliphatic compounds are present in product fuel including alkane, alkene, and alkyl group. Fuel can use internal combustion engines and produce electricity using large generator because product fuel has long chain hydrocarbon. Using this process can convert all waste plastics into liquid fuel and save environment waste plastic problem at a time. Waste plastics are creating environmental problem such as land fill problem, dumping problem and incineration problem.

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