

Research article

Fuel Oil and Home Heating Oil Produce from Polystyrene and Polypropylene Waste Plastics Mixture

Mohammad Mamunor Rashid, Moinuddin Sarker *

Natural State Research, Inc., Department of Research and Development, 37 Brown House Road (2nd Floor),
Stamford, CT-06902, USA

Phone: (203) 406-0675, Fax: (203) 406-9852

*E-mail: msarker@naturalstateresearch.com, mamun_sarker2004@yahoo.com

Abstract

Polypropylene (PP) and Polystyrene (PS) waste plastics mixture to fuel oil production process was performed laboratory batch scale. Under laboratory fume hood batch process was closed system and sample ration was 50:50 by weight. Two step process was applied in this experiment such as 1st step process was PP and PS to heating fuel production and at the same time 2nd step process was heating fuel to fuel oil production by fraction process. 1st step process temperature was use up to 405 °C and fuel oil production fraction process temperature was 340 °C. Fuel oil density is 0.84 g/ml. Fractional process collected fuel was 36.3 g and fuel was analysis by GC/MS to determine compounds structure. GC/MS analysis result indicates that product fuel has carbon chain C₄ to C₂₇. Product fuel can use as a home heating oil or water ship because fuel as long chain hydrocarbon compounds. **Copyright © IJWMT, all rights reserved.**

Keywords: PS, PP, fuel oil, heating oil, waste plastics, GC/MS

Introduction

Petrochemical based plastics, produced annually on the 100 million ton scale, pervade modern society as a result of their versatile and highly desirable properties [1]. However, once disposed of, many of these plastics pose major waste management problems due to their recalcitrance. In the U.S. alone, over 3 million tons of polystyrene are

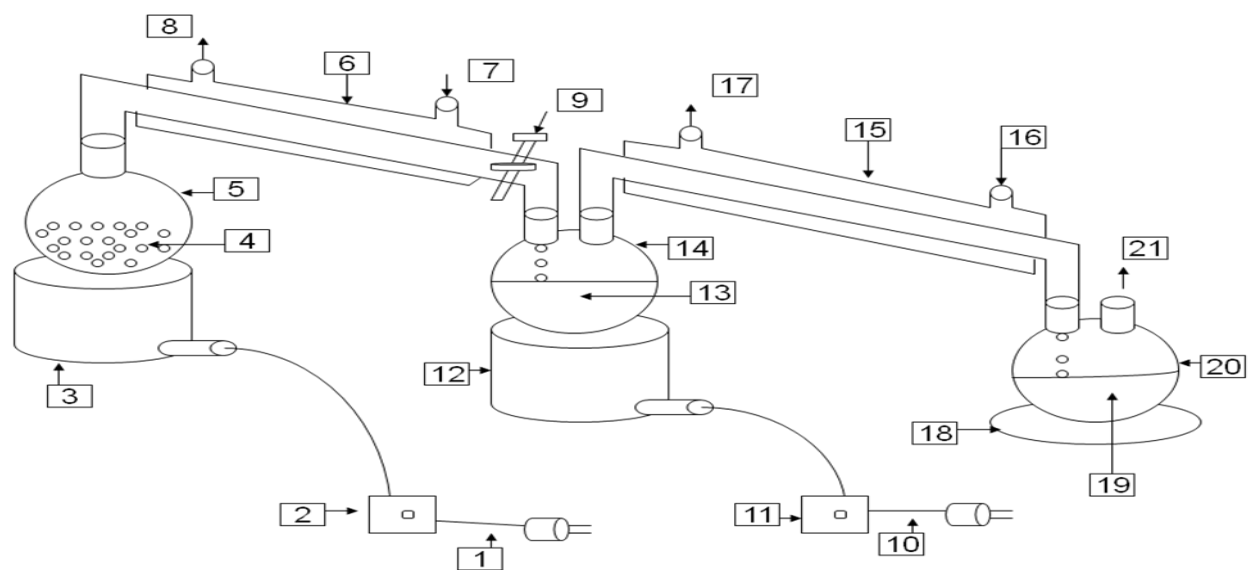
produced annually, 2.3 million tons of which end up in a landfill [2]. Furthermore only 1% of post-consumer polystyrene waste was recycled in the U.S. in 2000. The poor rate of polystyrene recycling is due to direct competition with virgin plastic on a cost and quality basis [3]. Consequently, there is little or no market for recycled polystyrene [4]. As an alternative to polymer recycling, polystyrene can be burned to generate heat and energy [5] or converted back to its monomer components for use as a liquid fuel [5-7]. Waste plastics are increasingly generated all over the world and have mostly been disposed of by landfill and incineration. However, they are now not the management methods that can gain social acceptance for environmentally serious reasons such as low biodegradability, lack of available space for landfilling, and emission of toxic chemicals. It is, hence, desired to develop an alternative technology to recycle or reuse plastic waste. Plastics can be recycled by three different methods: mechanical (primary) recycling, energy recovery (secondary recycling), and chemical (tertiary or feedstock) recycling. Because mechanical recycling by simply re-melting and shaping waste plastics usually results in a low-quality product, its application is highly limited. Energy recovery through combustion means a loss of potential for use as resources and may contribute to an environmental pollution caused by the generation of harmful materials. Because of these difficulties, chemical recycling that converts the plastics into fundamental chemicals or fuels is currently growing in importance as a promising solution to solve the problems relating to waste plastics. [8]

The economic viability of waste plastic 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 plastic into monomers and fuels and to the complexity of adapting product conditioning steps to market requirements.[9] 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 plastic waste pyrolysis are flexible and may treat both mixtures of plastics and mixtures of these with residual materials (such as wood and agroforest wastes and tire derived fuel).[10-18] It may also operate autothermally, under a controlled O₂ content.[19] Plastics are widely used in everyday life as well as in hightech industries as an indispensable ingredient. The production of plastics has increased according to demand from society, and accordingly, the amount of waste plastics has also increased. Landfills and incineration are the most widely used among the existing methods of processing waste plastics. [20] Direct disposal of waste plastics in landfills is now almost impossible in developed countries because of legislation pressures and high costs. Incineration stimulates the emission of harmful gases, such as dioxin, furans, and acid gases, and heavy metals that can cause damage to the environment and health.[21] Furthermore, incineration emits carbon dioxide, which causes global warming. Therefore, there is an increasing need to recycle waste plastics. Toward this end, various technologies have been developed that can recover energy from waste plastics and use such energy as petrochemical feedstock or fuel oil.[22] Pyrolysis is a promising process for treating waste plastics, because it produces liquid and gas products with higher heating values (HHVs), which can help solve the problem of high oil prices.[23]. Our experiment main goal was PP and PS waste plastics mixture to home heating fuel production by using thermal degradation process.

Materials and Method

PP waste plastic and PS waste plastic mixture was taken 50:50 ration by weight for experiment. Polypropylene and Polystyrene waste plastics mixture to heating fuel production process was perform in to laboratory batch scale. Two step processes experiment was perform without catalyst and waste materials was use for experiment 250 gm. PP waste plastic weight was 125 g and PS waste plastic weight was 125 g. PP waste plastic was food container and PS waste plastic was drinking glass. Two step experiment process was perform at the same time. 1st step process temperature was use up to 405 °C and 2nd step process temperature was use 340 °C. Pyrex glass was using both steps and heat mental, variac meter was use for temperature controller. Figure 1 is shown fuel process diagram for visual

understanding. 1st step process waste plastics cut into small pieces and places into pyrex glass inside then setup condensation unit with collection flask. Heat mental was use for waste materials melting purposed and temperature was increased and decreased by using variac meter. Electrical heat was use for sample meting and glass condensation was use for vapor condensation without water flow. Usually water is using for condensation cooling purpose but in this experiment doesn't required water cooling for condensation. When heat was rise up gradually then waste plastics start to melt then it become slurry then it become a vapor. Vapors are traveled to condensation inside and due to room temperature inside vapor are become a cool at the end liquid fuel is collected. 1st step product fuel density is 0.89 g/ml. In this process liquid fuel was collected 192.1 g and volume was 217 ml. left over residues was 50.9 g and light gas was generated 7 g sample. In mass balance calculation percentage showed 1st step process 76.84 % liquid fuel, residue 20.36% and light gas was 2.8%. Residue percentage is high because polystyrene waste plastic additives percentage is high. After finished 1st step process then start 2nd step process for fractional process. In the 2nd fractional process 1st step produce fuel was fractionation temperature wise and collected fuel oil grade at 340 °C. Liquid 1st step heating fuel was fractionation at 340 °C and collected fuel oil grade fuel; in the 2nd step process also produce gasoline grade fuel, naphtha grade fuel, aviation or jet grade fuel and diesel grade fuel. Our experimental process goal was fuel oil collection. From 192.1 g liquid fuel to taken out 12.5 g for analytical analysis purpose to determine 1st step fuel compounds structure. In the 2nd step distillation process heating fuel was use 179.6 g and collected fuel oil grade fuel. Product fuel oil grade fuel density is 0.84 g/ml. From 179.6 g liquid to fuel oil was collected 36.3 g and volume was 43 ml. During fractional distillation production period other fuel was produced such as gasoline grade, naphtha grade, aviation or jet grade and diesel grade. Light gas was produce 32.7 gm and left over residue was 11.0 gm. Other grade fuel was produce 99.6 g. In percentage calculation 2nd step process diesel grade fuel collection was 19.49%. Fuel was thick and light yellow color. Fuel was not ignite due to heavy hydrocarbon was present.



[1. Electric Cord, 2. Variac, 3. Heat Mantle, 4. Sample (Waste Plastic PP and PS), 5. Boiling Flask, 6. Condensation Unit, 7. Water Inlet, 8. Water Outlet, 9. Open & Close System Bulb, 10. Electric Cord, 11. Variac, 12. Heat Mantle, 13. Fuel (For Fraction), 14. Boiling Flask, 15. Condensation Unit, 16. Water Inlet, 17. Water Outlet, 18. Ring Cork, 19. NSR Fuel (Diesel Collection), 20. Collection Flask, 21. Lighter Gas Escape Path]

Figure 1: PP and PS mixture home heating fuel to fuel oil production process

Result and Discussion

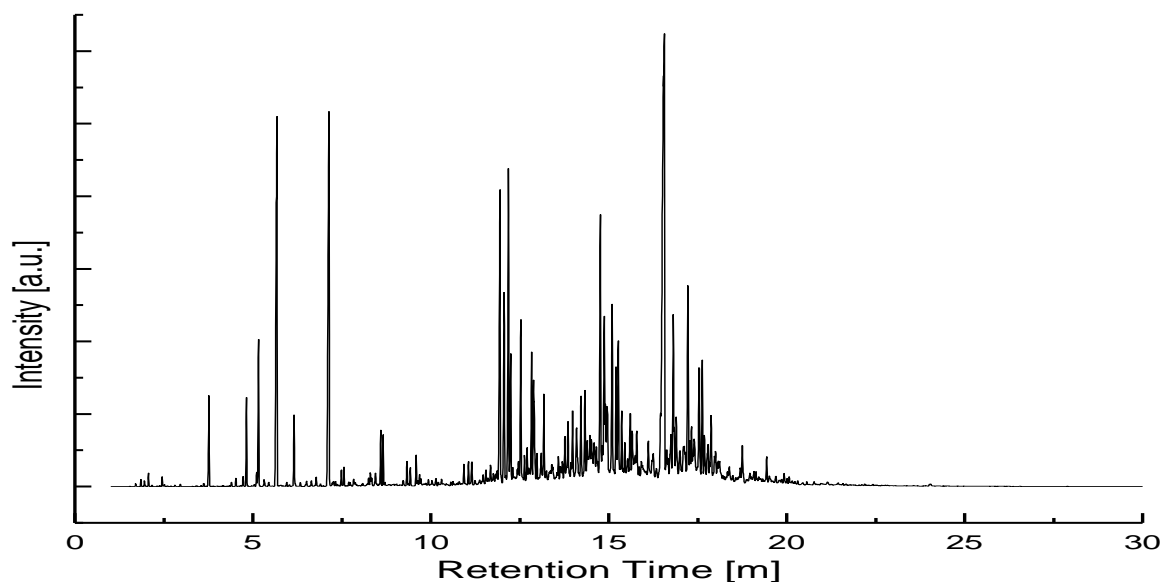


Figure 2: GC/MS chromatogram of PP and PS fuel to fuel oil

Table 1: GC/MS chromatogram compounds list of PP and PS fuel to fuel oil

Peak Number	Retention Time (M.)	Trace Mass (m/z)	Compounds Name	Compound Formula	Molecular weight	Probability Percentage	NIST Library Number
1	1.53	41	1-Propene, 2-methyl-	C ₄ H ₈	56	26.1	61293
2	1.71	43	Pentane	C ₅ H ₁₂	72	70.0	114462
3	1.95	43	Pentane, 2-methyl-	C ₆ H ₁₄	86	62.0	61279
4	2.07	56	1-Pentene, 2-methyl-	C ₆ H ₁₂	84	37.8	495
5	2.17	41	2-Butene, 2,3-dimethyl-	C ₆ H ₁₂	84	31.4	289588
6	2.31	43	Pentane, 2,4-dimethyl-	C ₇ H ₁₆	100	64.3	1043
7	2.38	67	1,3-Pentadiene, 2-methyl-, (E)-	C ₆ H ₁₀	82	14.1	113652
8	2.45	56	1-Pentene, 2,4-dimethyl-	C ₇ H ₁₄	98	62.6	913
9	2.52	81	2,4-Dimethyl 1,4-pentadiene	C ₇ H ₁₂	96	49.7	114468
10	2.59	78	Benzene	C ₆ H ₆	78	66.7	221957
11	2.70	43	Hexane, 3-methyl-	C ₇ H ₁₆	100	43.2	113081
12	2.81	43	2-Pentanone	C ₅ H ₁₀ O	86	16.6	291264
13	2.96	81	1,3-Pentadiene, 2,4-dimethyl-	C ₇ H ₁₂	96	31.9	114450
14	3.02	41	1-Hexene, 5-methyl-	C ₇ H ₁₄	98	9.96	231717
15	3.09	81	4-Hepten-1-ol	C ₇ H ₁₄ O	114	10.1	157563
16	3.25	55	2-Octyn-1-ol	C ₈ H ₁₄ O	126	6.93	53364

17	3.30	81	Cyclopropane, trimethylmethylene-	C ₇ H ₁₂	96	12.0	63085
18	3.40	43	Methyl Isobutyl Ketone	C ₆ H ₁₂ O	100	59.0	19811
19	3.44	70	Hexane, 2-methyl-4- methylene-	C ₈ H ₁₆	112	26.5	113454
20	3.55	56	2,4-Dimethyl-1-hexene	C ₈ H ₁₆	112	50.2	227584
21	3.62	41	2-Hexene, 3,5-dimethyl-	C ₈ H ₁₆	112	22.4	149385
22	3.70	43	2-Heptanone, 6-methyl-	C ₈ H ₁₆ O	128	58.3	114339
23	3.76	91	Toluene	C ₇ H ₈	92	61.6	291301
24	4.01	56	1-Heptene, 2-methyl-	C ₈ H ₁₆	112	50.4	113675
25	4.09	55	3-Heptene, 4-methyl-	C ₈ H ₁₆	112	31.0	149383
26	4.15	95	4-Methyl-1,3-heptadiene (c,t)	C ₈ H ₁₄	110	15.0	113091
27	4.17	109	3,3,5,5- Tetramethylcyclopentene	C ₉ H ₁₆	124	24.5	113497
28	4.28	109	Cyclohexene, 3,3,5- trimethyl-	C ₉ H ₁₆	124	48.1	114765
29	4.35	69	1-Hexene, 3,3-dimethyl-	C ₈ H ₁₆	112	16.3	113441
30	4.40	83	Cyclopentane, 1,1,3,4- tetramethyl-, cis-	C ₉ H ₁₈	126	11.3	27589
31	4.53	43	Heptane, 2,4-dimethyl-	C ₉ H ₂₀	128	31.0	155382
32	4.62	95	Cyclohexene, 3,5- dimethyl-	C ₈ H ₁₄	110	16.9	158136
33	4.68	83	2-Hexene, 4,4,5- trimethyl-	C ₉ H ₁₈	126	14.6	26930
34	4.82	43	2,4-Dimethyl-1-heptene	C ₉ H ₁₈	126	65.2	113516
35	5.16	91	Ethylbenzene	C ₈ H ₁₀	106	58.5	158804
36	5.68	104	Styrene	C ₈ H ₈	104	58.0	291542
37	6.16	105	Benzene, (1-methylethyl)-	C ₉ H ₁₂	120	53.0	228742
38	6.33	43	2-Heptanone, 4-methyl-	C ₈ H ₁₆ O	128	31.0	35099
39	6.51	117	Benzene, 2-propenyl-	C ₉ H ₁₀	118	17.3	231964
40	6.64	91	Benzene, propyl-	C ₉ H ₁₂	120	69.1	228007
10	6.78	77	Benzaldehyde	C ₇ H ₆ O	106	73.2	291541
42	6.90	105	Benzene, 1,2,3-trimethyl-	C ₉ H ₁₂	120	20.9	228017
43	7.14	117	α -Methylstyrene	C ₉ H ₁₀	118	35.8	2021
44	7.32	43	3-Undecene, (E)-	C ₁₁ H ₂₂	154	3.92	60565
45	7.38	43	2-Piperidinone, N-[4- bromo-n-butyl]-	C ₉ H ₁₆ BrN O	233	11.9	251632
46	7.49	43	Nonane, 2,6-dimethyl-	C ₁₁ H ₂₄	156	7.29	61438
47	7.56	43	Octane, 3,3-dimethyl-	C ₁₀ H ₂₂	142	7.55	61706
48	7.69	43	4-Decene, 7-methyl-, (E)-	C ₁₁ H ₂₂	154	11.1	60846
49	7.74	117	Benzene, (2-methyl-2- propenyl)-	C ₁₀ H ₁₂	132	22.1	113536
50	7.83	117	Benzene, 2-propenyl-	C ₉ H ₁₀	118	20.9	114744
51	7.88	69	3-Undecene, (Z)-	C ₁₁ H ₂₂	154	8.05	142598
52	8.09	91	Benzene, 3-butenyl-	C ₁₀ H ₁₂	132	46.7	211005
53	8.30	91	1,2,3,4,5,8-	C ₁₀ H ₁₄	134	18.9	113559

54	8.34	43	Hexahydronaphthalene					
			Dodecane, 2,6,10-trimethyl-	C ₁₅ H ₃₂	212	6.08	114045	
55	8.45	105	Acetophenone	C ₈ H ₈ O	120	66.2	34989	
56	8.59	43	2-Undecanethiol, 2-methyl-	C ₁₂ H ₂₆ S	202	2.76	9094	
57	8.66	43	1-Nonene, 4,6,8-trimethyl-	C ₁₂ H ₂₄	168	3.55	6413	
58	8.71	117	Benzene, (2-methyl-1-propenyl)-	C ₁₀ H ₁₂	132	14.2	113562	
59	8.99	105	Benzene, (1,2-dimethylpropyl)-	C ₁₁ H ₁₆	148	27.9	232483	
60	9.23	83	1-Isopropyl-1,4,5-trimethylcyclohexane	C ₁₂ H ₂₄	168	6.18	113584	
61	9.38	117	Benzene, (2-methyl-2-propenyl)-	C ₁₀ H ₁₂	132	14.0	113536	
62	9.43	43	1-Dodecanol, 3,7,11-trimethyl-	C ₁₅ H ₃₂ O	228	5.76	114065	
63	9.59	91	Benzene, (3-methyl-3-butenyl)-	C ₁₁ H ₁₄	146	70.7	113578	
64	9.63	118	Benzene, (1-ethyl-2-propenyl)-	C ₁₁ H ₁₄	146	48.6	113986	
65	9.68	69	(2,4,6-Trimethylcyclohexyl) methanol	C ₁₀ H ₂₀ O	156	14.8	113757	
66	9.86	91	Benzene, pentyl-	C ₁₁ H ₁₆	148	40.9	113915	
67	9.93	69	1-Isopropyl-1,4,5-trimethylcyclohexane	C ₁₂ H ₂₄	168	37.5	113584	
68	10.03	131	Benzene, (3-methyl-2-butenyl)-	C ₁₁ H ₁₄	146	34.8	186387	
69	10.15	105	Benzene, (1,3-dimethyl-3-butenyl)-	C ₁₂ H ₁₆	160	34.3	45481	
70	10.22	131	Benzene, (3-methyl-2-butenyl)-	C ₁₁ H ₁₄	146	26.2	186387	
71	10.30	118	Benzene, (3-methyl-1-methylenebutyl)-	C ₁₂ H ₁₆	160	65.2	64019	
72	10.80	69	1-Tetradecanol, 14-chloro-	C ₁₄ H ₂₉ ClO	248	4.05	156095	
73	10.87	43	3-Hydroxy-2-hydroxymethyl-4,4-dimethylcyclopentanecarboxylic acid, methyl ester	C ₁₀ H ₁₈ O ₄	202	6.43	195416	
74	10.93	43	Dodecane, 4,6-dimethyl-	C ₁₄ H ₃₀	198	10.8	61041	
75	11.06	71	Dodecane, 4,6-dimethyl-	C ₁₄ H ₃₀	198	12.0	45335	
76	11.24	69	7-Tetradecene	C ₁₄ H ₂₈	196	4.72	70643	
77	11.37	91	Benzene, hexyl-	C ₁₂ H ₁₈	162	7.14	113954	
78	11.38	83	3-Octene, 2,2-dimethyl-	C ₁₀ H ₂₀	140	4.20	186136	
79	11.55	43	Dodecane, 2,6,10-trimethyl-	C ₁₅ H ₃₂	212	4.69	114045	
80	11.94	69	1-Nonene, 4,6,8-	C ₁₂ H ₂₄	168	3.47	6413	

81	12.06	43	trimethyl- 9-Eicosene, (E)-	C ₂₀ H ₄₀	280	3.35	62815
82	12.18	43	1-Octanol, 2-butyl-	C ₁₂ H ₂₆ O	186	3.92	114639
83	12.25	92	Benzene, heptyl-	C ₁₃ H ₂₀	176	79.0	118464
84	12.30	105	Benzene, (1-methylheptyl	C ₁₄ H ₂₂	190	14.2	8185
85	12.43	83	9-Eicosyne	C ₂₀ H ₃₈	278	4.66	62817
86	12.47	105	Benzene, (1- methylnonadecyl)-	C ₂₆ H ₄₆	358	8.68	16096
87	13.18	91	Cyclooctane, phenyl-	C ₁₄ H ₂₀	188	27.2	155843
88	13.59	69	Isotridecanol-	C ₁₃ H ₂₈ O	200	5.97	298499
89	13.77	167	Diphenylmethane	C ₁₃ H ₁₂	168	46.9	114004
90	13.85	71	Decane, 2,3,5,8- tetramethyl-	C ₁₄ H ₃₀	198	10.3	149589
91	14.40	43	Heptadecane, 2,6,10,15- tetramethyl-	C ₂₁ H ₄₄	296	7.13	14103
92	14.48	167	Benzene, 1,1'- ethylidenebis-	C ₁₄ H ₁₄	182	39.0	22224
93	14.59	43	tert-Hexadecanethiol	C ₁₆ H ₃₄ S	258	7.45	234966
94	14.65	83	Trichloroacetic acid, hexadecyl ester	C ₁₈ H ₃₃ Cl ₃ O ₂	386	3.98	280518
95	14.91	91	Benzene, 1,1'-(1,2- ethanediyl)bis-	C ₁₄ H ₁₄	182	84.8	187213
96	14.95	43	1-Hexadecanol, 3,7,11,15-tetramethyl-	C ₂₀ H ₄₂ O	298	5.95	194527
97	15.27	105	Carbonic acid, hexadecyl propyl ester	C ₂₀ H ₄₀ O ₃	328	7.18	314543
98	15.60	69	1,19-Eicosadiene	C ₂₀ H ₃₈	278	5.21	241604
99	16.11	91	Benzene, 1,1'-[3-(3- cyclopentylpropyl)-1,5- pentanediyl]bis-	C ₂₅ H ₃₄	334	34.3	23398
100	16.57	91	Benzene, 1,1'-(1,3- propanediyl)bis-	C ₁₅ H ₁₆	196	92.2	133399
101	16.81	105	Benzene, 1,1'-(1-methyl- 1,3-propanediyl)bis-	C ₁₆ H ₁₈	210	85.8	149665
102	16.90	43	Tetradecane, 2,6,10- trimethyl-	C ₁₇ H ₃₆	240	4.32	11556
103	17.28	105	tert-Hexadecanethiol	C ₁₆ H ₃₄ S	258	5.90	234966
104	17.40	194	Phenanthrene, 9,10- dihydro-1-methyl-	C ₁₅ H ₁₄	194	48.4	80195
105	17.63	91	Benzeneacetic acid, 4- pentadecyl ester	C ₂₃ H ₃₈ O ₂	346	48.9	282028
106	17.79	92	Naphthalene, 1,2,3,4- tetrahydro-1-phenyl-	C ₁₆ H ₁₆	208	52.6	62822
107	17.87	105	Carbonic acid, octadecyl propyl ester	C ₂₂ H ₄₄ O ₃	356	9.83	314545
108	18.00	92	Benzene, [3-(2- cyclohexylethyl)-6- cyclopentylhexyl]-	C ₂₅ H ₄₀	340	25.8	23414
109	18.08	115	Benzene, 1,1'-(3-methyl-	C ₁₆ H ₁₆	208	15.5	9505

110	18.34	117	1-propene-1,3-diyl)bis-Benzene, 1,1'-(2-butene-1,4-diyl)bis-	C ₁₆ H ₁₆	208	14.3	152950
111	18.70	57	Heptacosane	C ₂₇ H ₅₆	380	5.95	79427
112	18.75	204	Naphthalene, 1-phenyl-	C ₁₆ H ₁₂	204	20.7	67947
113	20.31	92	Benzene, (3-octylundecyl)-	C ₂₅ H ₄₄	344	54.1	15748
114	21.14	218	9-Phenyl-5H-benzocycloheptene	C ₁₇ H ₁₄	218	25.3	200996
115	26.23	44	Benzene, 1,1'-[1-(2,2-dimethyl-3-butenyl)-1,3-propanediyl]bis-	C ₂₁ H ₂₆	278	10.3	61097

Polypropylene waste plastic and polystyrene waste plastic to fuel production process was successfully. Product fuel was analysis by GC/MS and GC/MS chromatogram gives us compounds structure inside the fuel (figure 2 and table 1). Perkin Elmer provides gas chromatography and mass spectrometer was use with 30 meter length capillary column. Carrier gas was Helium (He). GC/MS chromatogram showed Carbon chain start C₄ and long chain hydrocarbon was determining C₂₇. Product fuel has some aromatic group compound because an initial raw material was polystyrene mixture with polypropylene waste plastic. Polystyrene waste plastic has benzene group compounds. GC/MS analysis result showed initial compounds traced 2-methyl-1-Propene (C₄H₈) (t=1.53, m/z=41) then rest of compounds was traced according to carbon number smaller to bigger numbers. In this case we noticed that some time large compounds also traced from GC/MS with small intensity. GC/MS chromatogram large compound was traced (1-methylnonadecyl)-Benzene (C₂₆H₄₆) (t=12.47, m/z=105) compound molecular weight is 358 and probability percentage is 8.68, and Heptacosane (C₂₇H₅₆) (t=18.70, m/z=57) compound molecular weight is 380 and probability percentage is 5.95%. Large carbon number compound intensity was low then small carbon number compounds. Table 1 showed all of compounds which are present in the produce fuel. Product fuel has hydrocarbon including alkane, alkene and alkyl groups, aromatic group, methyl group, oxygenated group, halogenated, nitrogen content compounds also determine. Some of compounds are elaborated based on carbon number, retention time, trace mass, molecular weight and probability percentage such as 2,4-dimethyl- Pentane () (t=2.31, m/z=43) compound molecular weight is 100 and probability percentage is 64.3%, Benzene (C₆H₆) (t=2.59, m/z=78) compound molecular weight 78 and probability percentage is 66.7%, 2,4-Dimethyl-1-hexene (C₈H₁₆) (t=3.55, m/z=56) compound molecular weight is 112 and probability percentage is 50.2%, 3,3,5-trimethyl-Cyclohexene (C₉H₁₆) (t=4.28, m/z=109) compound molecular weight is 124 and probability percentage is 48.1%, Ethylbenzene (C₈H₁₀) (t= 5.16, m/z=91) compound molecular weight is 106 and probability percentage is 98.5%, 1,2,3-trimethyl-Benzene (C₉H₁₂) (t=6.90, m/z=105) compound molecular weight is 120 and probability percentage is 20.9%, 3-butenyl-Benzene (C₁₀H₁₂) (t=8.09, m/z=91) compound molecular weight is 132 and probability percentage is 46.7%, 1,2-dimethylpropyl-Benzene (C₁₁H₁₆) (t=8.99, m/z=105) compound molecular weight is 148 and probability percentage is 27.9 %, 1-ethyl-2-propenyl-Benzene (C₁₁H₁₄) (t=9.63, m/z=118) compound molecular weight is 146 and probability percentage is 48.6%, 3-methyl-1-methylenebutyl-Benzene (C₁₂H₁₆) (t=10.30, m/z=118) compound molecular weight is 160 and probability percentage is 65.5%, 4,6,8-trimethyl-1-Nonene (C₁₂H₂₄) (t=11.94, m/z=69) compound molecular weight is 168 and probability percentage is 3.47%, phenyl-Cyclooctane (C₁₄H₂₀) (t=13.18, m/z=91) compound molecular weight is 188 and probability percentage is 27.2%, 2,3,5,8-tetramethyl-Decane (C₁₄H₃₀) (t=13.85, m/z=71) compound molecular weight is 198 and probability percentage is 10.3%, 3,7,11,15-tetramethyl-1-Hexadecanol (C₂₀H₄₂O) (t=14.95, m/z=43) compound molecular weight is 298 and probability percentage is 5.95%, [3-(2-cyclohexylethyl)-6-cyclopentylhexyl]- Benzene (C₂₅H₄₀) (t=18.00, m/z=92) compound molecular weight is 340 and probability percentage is 25.8% and so on. Due to high percentage of aromatic groups are present in this fuel efficiency can increasing when this fuel use for combustion engine. Product fuel is appropriate for heavy combustion equipment because this fuel carbon chain length start C₄ to C₂₇.

Conclusion

PP and PS to fuel oil production was performing without catalyst under laboratory fume hood in batch process system. Polypropylene and polystyrene waste plastics mixture was 50:50 ratios. Production temperature was for heating oil 405 °C and fraction fuel oil temperature was 340 °C. In this experiment main concern was fuel oil collection from PP and PS waste plastics mixture. Collected fuel was thick and density is 0.84 g/ml. Fuel color was light yellow and fuel was not ignited because fuel was combination of long chain hydrocarbon. In GC/MS analysis result indicate that fuel has hydrocarbon chain C₄ to C₂₇ including aromatics group. Fuel can use for home heating or heavy internal combustion engines. GC/MS analysis result indicate that product fuel has high percentage of aromatic group compounds such as Benzene (C₆H₆), Toluene (C₇H₈), Ethylbenzene (C₈H₁₀), Styrene (C₈H₈), (1-methylethyl)-Benzene (C₉H₁₂), 2-propenyl-Benzene (C₉H₁₀), propyl-Benzene (C₉H₁₂), 1,2,3-trimethyl-Benzene (C₉H₁₂), α-Methylstyrene (C₉H₁₀), 2-methyl-2-propenyl-Benzene (C₁₀H₁₂), 1,2-dimethylpropyl-Benzene (C₁₁H₁₆), 1-methylheptyl Benzene (C₁₄H₂₂), bis-1,1'-[3-(3-cyclopentylpropyl)-1,5-pentanediy]Benzene (C₂₅H₃₄) and many more. Due to high percentage of aromatic group and its can increase fuel efficiency when fuel is combustion. By using this technology all waste plastic can produce valuable energy resource for our next generation. Same way waste plastics problem can reduce from environment.

Acknowledgement

The authors acknowledge the support (Financial) of Dr. Karin Kaufman, the founder and sole owner of Natural State Research, Inc. The author also acknowledges the valuable contributions NSR laboratory team members during the preparation of this manuscript.

References

- [1] PATRICK G. WARD, MIRIAM GOFF, MATTHIAS DONNER, WALTER KAMINSKY, AND KEVINE. O'CONNOR, A Two Step Chemo-biotechnological Conversion of Polystyrene to a Biodegradable Thermoplastic, Environ. Sci. Technol. 2006, 40, 2433-2437
- [2] Municipal solid waste in the United States: 2001 facts and figures; EPA 530-R-03-011; U.S. Environmental Protection Agency, U.S. Government Printing Office: Washington DC, 2003.
- [3] Smith S. Recyclers looking-up, despite downside. Plastics News, January 19, 1998, p 10.
- [4] Polystyrene commodity profile market assessment; North Carolina Department of Environment and Natural Resources, Division of pollution prevention and environmental assistance: Raleigh NC, 1998.
- [5] Kaminsky W.; Kim S. J. Pyrolysis of mixed plastics into aromatics. J. Anal. Appl. Pyrolysis. 1999, 51, 127-134.
- [6] Lilac, W.D.; Lee S. Kinetics and mechanisms of styrene monomer recovery from waste polystyrene by supercritical water partial oxidation. Adv. Environ. Res. 2001, 6, 9-16.
- [7] Kiran, N.; Ekin, E.; Snape, C. E. Recycling plastics via pyrolysis. Res. Conserv. Recycl. 2000, 29, 273-283.
- [8] Kazuhiko Takuma, Yoshio Uemichi,* Masatoshi Sugioka, and Akimi Ayame, Production of Aromatic Hydrocarbons by Catalytic Degradation of Polyolefins over H-Gallosilicate, Ind. Eng. Chem. Res. 2001, 40, 1076-1082
- [9] Jose M. Arandes, Iker Torre, Pedro Castan˜o, Martin Olazar, and Javier Bilbao, Catalytic Cracking of Waxes Produced by the Fast Pyrolysis of Polyolefins, Energy & Fuels 2007, 21, 561-569

- [10] Williams, P. T.; Williams, E. A. J. *Inst. Energy* 1998, 71, 81-93.
- [11] Williams, P. T.; Williams, E. A. *Energy Fuels* 1999, 13, 188-196.
- [12] Kaminsky, W.; Schmidt, H.; Simon, C. M. *Macromol. Symp.* 2000, 152, 191-199.
- [13] Kaminsky, W.; Predel, M.; Sadiki, A. *Polym. Degrad. Stab.* 2004, 85, 1045-1050.
- [14] Kaminsky, W.; Kim, J. S. J. *Anal. Appl. Pyrolysis* 1999, 51, 127- 134.
- [15] Predel, M.; Kaminsky, W. *Polym. Degrad. Stab.* 2000, 70, 373- 385.
- [16] Mastral, F. J.; Esperanza, E.; Garcí'a, P.; Juste, M. J. *Anal. Appl. Pyrolysis* 2002, 63, 1-15.
- [17] Mastral, F. J.; Esperanza, E.; Berruenco, C.; Juste, M.; Ceamanos, J. J. *Anal. Appl. Pyrolysis* 2003, 70, 1-17.
- [18] Faravelli, T.; Bozzano, G.; Colombo, M.; Ranzi, E.; Dente, M. J. *Anal. Appl. Pyrolysis* 2003, 70, 761-777.
- [19] Wey, M. Y.; Lo, C. S.; Wu, S. Y.; Lee, Y. T. *Waste Manage. Res.* 1998, 16, 72-82.
- [20] Min-Hwan Cho, Su-Hwa Jung, and Joo-Sik Kim, Pyrolysis of Mixed Plastic Wastes for the Recovery of Benzene, Toluene, and Xylene (BTX) Aromatics in a Fluidized Bed and Chlorine Removal by Applying Various Additives, *Energy Fuels* 2010, 24, 1389–1395 : DOI:10.1021/ef901127v
- [21] Williams, E. A.; Williams, P. T. *J. Anal. Appl. Pyrolysis* 1997, 40-41, 347–363.
- [22] Kaminsky, W. J. *Phys. IV* 1993, 3, 1543–1552.
- [23] Angyal, A.; Miskolczi, N.; Bartha, L. J. *Anal. Appl. Pyrolysis* 2007, 79, 409–414.