

HEAVY OIL PRODUCED FROM MUNICIPAL MIXED WASTE PLASTICS BY FRACTIONAL DIS-TILLATION PROCESS

MOINUDDIN SARKER^{*}, MOHAMMAD MAMUNOR RASHID, MOHAMMAD MOLLA AND MUHAMMAD SADIKUR RAHMAN

Natural State Research, Inc., Department of Research and Development, 37 Brown House Road, (2nd Floor), Stamford, CT-06902, USA. *Corresponding Author: Email- msarker@naturalstateresearch.com

Received: April 27, 2012; Accepted: May 10, 2012

Abstract- Waste plastics found in our landfill are renewable energy sources that are capable of producing energy. After plastics are used and discarded, they become a problem for the environment and ecosystem they are very troublesome to get rid off. Waste plastics are nonbiodegradable so, they occupy landfill for a long period of time. When waste plastic come in contact with light and starts photo degrading, it starts releasing harmful compounds like carbon monoxide, nitrogen sulfide and sulfur dioxide in the environment. USA alone generate 48 million ton of waste plastics per year. The developed a thermal degradation method to convert waste plastics into liquid hydrocarbon fuel energy. The technology plans to collect waste plastics from municipalities for the fuel production process. It will not only help the municipality to save a lot of money but it will also help the environment at the same time. The fuel can be produced at low cost, since the resource is already at disposal. The technology produced heavy fuel is capable of operating of internal combustion engines including ship, heavy generator and so on. The technology will be able create many jobs to the locals, once the commercialization plant is established . **Key words-** Heavy oil, thermal, waste plastics, fractional distillation, GC/MS, Fuel

Citation: Moinuddin Sarker, et al. (2012) Heavy Oil Produced from Municipal Mixed Waste Plastics by Fractional Distillation Process. BIO-INFO Renewable & Sustainable Energy, ISSN: 2249-1694 & E-ISSN: 2249-1708, Volume 2, Issue 1, pp.-05-11.

Copyright: Copyright©2012 Moinuddin Sarker, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

The developed economies use oil much more intensively than the developing economies. United States and Canada consumptions equal almost 3 gallons per day per capita. The United States and Canada use oil more for transportation than for heat and power [1]. Canada's thirst for energy continues unabated into the 21st Century. Despite growing concerns about greenhouse gas emissions, as well as climate change and air quality, petroleum products remain key to satisfying that demand [2]. These petroleum products include heavy fuel oil, a highly polluting low-grade fuel of tar-like consistency. It is composed mostly of carbon, hydrogen, sulphur and other impurities such as ash, metals and water [2]. In Canada, no significant shift from the combustion of hydrocarbons toward more benign and renewable energy sources such as hydro -electricity has occurred during the past 15 years. Currently, more than one-third (37.6%) of our total energy demand is still met by refined petroleum products, one of which is heavy fuel oil. This ratio has not changed since 1990. However, some progress has

been made in the case of heavy fuel oil. There has been a small decline in its overall use as an energy source [2].

The sector most dependent on heavy fuel oil is marine transportation, where it accounts for more than 60% of energy consumed. The rest comes from diesel fuel. This sector is also the only major user that increased its consumption during this 15-year period. More than half of consumption occurred in British Columbia [2]. While not one of the main energy sources nationally, heavy fuel oil is still an important fuel source for some industries. This lowgrade carbon and sulphur-intensive petroleum product is burned in quantity for thermal-electric power generation, for heating boilers and furnaces in some manufacturing industries, and petroleum refining industry. It is also used to power large commercial marine vessels and heat some large, usually older commercial, institutional and multiple residential buildings [2]. HFO is used mainly to produce electricity, to fire boilers and blast furnaces in industry, notably the pulp and paper industry. Even though world, like many people in many other industrialized countries, are con-

cerned about increases in greenhouse gas emissions, consumption of energy keeps rising in their country. Demands from all major energy sources such as petroleum products, natural gas and electricity- produced mainly from the combustion of fossil fuels and from nuclear and hydro sources-have all increased in recent decades [2].

Heavy fuel oil (HFO) is a black, low-grade fuel of tar-like consistency. It is composed mostly of carbon, hydrogen, sulphur and other impurities such as ash, metals, and water. HFO is obtained from the petroleum distillation process after other lighter petroleum products such as gasoline and kerosene have been distilled off. Heavy fuel oil is a by-product or residue-along with asphalt-of the distillation process [2]. Day by day natural resources for energy demand is decreasing contrary in whole world energy demand is increasing. Natural State Research, Inc. developed their own process to produce Heavy Fuel oil from varieties of abundant waste plastics. Waste Plastics sources would be major City, Municipality and house hold resources. Many sources of waste plastics are concluded HDPE (High Density Polyethylene), LDPE (Low Density Polyethylene), PP (Polypropylene), PS (Polystyrene), PETE (Polyethylene Terepthalate), PVC (Polyvinyl Chloride) etc. Municipal waste plastic represents about 8 wt% of the municipal solid waste and it generally consists of mixture of different kind of plastics: 40.5 wt% HDPE and LDPE, 19.6 wt% PP, 11.9 wt% PS/EPS, 10.7 wt% PVC, 8.1 wt% PET, and about 5 wt% ABS and 4.2 wt% other polymers[3].

Experimental Section

Materials

To setting up experiment we collected different types of raw waste plastics from many sources like city, municipality and domestic resources including HDPE, LDPE, PP, PS, PETE and PVC. Among them HDPE, LDPE, PP and PS are sorting out separately then washed, cleaned and dried out properly. Subsequently we identified them as a polymer by initial analyzing by FTIR (Fourier Transform Infra-red Spectroscopy) and TGA (Thermo gravimetric Analyzer). FT-IR was used for functional group band energy determine for raw materials and TGA was used for raw material liquefaction temperature (onset temperature) determine.

Sample Preparation

Washed, cleaned and dried out sample were manually shredded by scissors according to small square sizes (2.3 square. inch each side). Again shredded samples are grinded by grinding machine. After grinding sample turns into small pellet sizes 2-3 mm.

Experimental Process

To preceding experimental procedure one 3000 ml round bottom empty boiling flask weighing out and recorded. Then 1000 gm sample were taken weighing by rough balance. Subsequently that grinded sample filled into the boiling flask with proper shielding. Filled boiling flask was set up into the 3000 ml heat mantle with neck stopper. 70 ° angle and condenser upper path joined using by apeizon grease, each condenser joint tighten by clump, variac meter connected to regulate temperature range and one 1000 ml collection flask set up with condenser lower path to collect heavy fuel. Whole boiling flask upper body was insulated by aluminum foil paper. Ultimately related wire and connection were connected to the electric port properly and confirmed, as well as experiment started. Condensation process was expedited in the under laboratory fume hood. Initial state of experiment set temperature was at 90% variac (1% variac = 4.5 °C) that's 405°C for quick melting waste plastic. It takes like half an hour to melt. After melting temperature was decreases to lower temperature range depends on experiment thermal circumstances. Sometimes noticed that boiling flask inside vapor accumulated and on this situation temperature were decrease to lower range to control vapor pressure. Similarly other time temperature was increased to high temperature to get expected vapor. Vapor traveling through the condenser path and due condenser inside surface touch into vapor then vapor turns into liquid fuel. Produced liquid fuel deposited into the collection flask rapidly as a dropping wise. When condensation was complete experiment were allowed to cool down for half an hour. After cool down experiment fuel was collected 920 g fuel from the experiment then by graduated cylinder measured volume is 1200 ml and calculated density is 0.77 g/ml. Obtained fuel is named as a Plastic fuel.

To perform fractional distillation process to produce heavy oil was utilize plastic fuel obtained by above mentioned process. Fractional distillation process has been conducted according to the laboratory scale. Plastic fuel was called also heating fuel. During the experiment time taken the weight of 1000 ml boiling flask (Glass Reactor), and all the related weight and function recorded in the experimental log book for further computation. Subsequently fuel took into the boiling flask, after that we put filled boiling flask in 1000 ml heat mantle as well as connected variac meter with heat mantle. Attached distillation adapter, clump joint, condenser and collection flask using high temperature apiezon grease and insulated by aluminum foil paper. Then experiment was investigating finally that every step of experimental procedure followed properly. Initially was run the experiment at low temperature that's 40 °C to starting up the experiment. Gradually raised up temperature and once condensation started, produced vapor traveling through the condenser, after that due to cooling air system in the inside hood condenser inside vapor turns into liquid fuel and its continuing up to at 260 °C, produced fuel is mixture of several category of fuel such as Gasoline, Naphtha, Aviation and Diesel. We collected them separately into fuel NFPA approved container. Subsequently again we started to raised up temperature from 261 °C to 340 °C. At this stage during the condensation period mentioned temperature range (at 261 °C to 340 °C) produced fuel was Heavy Oil. In the laboratory stage from each 700 ml of experiment we can collect 150 ml of Heavy oil; density is 0.84 g/ml.

Results and Discussion

Analytical Procedure

Perkin Elmer, GCMS Clarus-500 (Gas Chromatography and Mass Spectrometer) was use to analysis purposes. GC Method programs set up are point out here, that's elaborated below. Initial temperature was 40 °C for 1 minute. Ramping Rate: 10 °C/ minute, Highest Temperature: 325 °C, Hold at 325 °C for 15 minute, Run Time: 44.50 minute, Sample Inject Volume: 0.5µL, Carrier Gas: Helium (He). In MS Method Set up Solvent delay was 1 Minute. Mass detection: start at 35 m/z, End at 528 m/z. Ionization Mode: El+, Data: Centroid. Scan Time: 0.25 s and Inter Scan delay: 0.15s. Perkin Elmer GC Capillary Column Used.Elite-5MS Length, 30 meter, Inner Diameter 0.25, 0.5umdf, Maximum Program Temperature at 350 °C and Minimum Bleed at 330 °C. A f

ter all program set up sample analyzed by GCMS. From GCMS analysis in versus of retention time following types of hydrocarbon compounds are appeared. Perkin Elmer FT-IR (Fourier Transform Infra-red Spectroscopy), Spectrum-100, was employed to analysis purposes. FT-IR Program set up are elaborated, before sample run ,Visible ray range were 4000-400 cm⁻¹, used NaCl cell is 0.05mm,Taken Scan Number, 32 and Resolution number, 4. Per-kin Elmer TGA was used for solid sample analysis and carrier gas was helium and program temperature was 25-800 °C and temperature rate was 15°C/ min and isothermal was 50 °C for 1 minutes.

Pre-analysis Result

Table 1- Raw materials TGA analysis result

Plastics Name	Sample weight (mg)	On set temperature (°C)	Inflection temperature (°C)
LDPE	3.132	421.53	457.11
HDPE	3.044	420.65	430.98
PS	2.575	326.62	364.88
PP	2.952	359.63	403.72

Experimental purposes were used four types of raw waste plastics such as LDPE, HDPE, PP and PS as well. Those plastics are analyzed by TGA (Thermogravimetric Analyzer) in order to determined onset temperature of each individual plastic (table 1). To expedite the TGA experiment of LDPE, plastic sample was taken 3.3132 g and found Onset Temperature is 421.53 °C and Inflection Temperature is 457.11°C. HDPE plastic sample was taken 3.3132 g and found Onset Temperature is 420.65 °C and Inflection Temperature is 430.98°C. PP plastic sample was taken 2.575 g and found Onset Temperature is 326.62 °C and Inflection Temperature is 364.88°C. Eventually PS plastic sample was taken 2.952 g and found Onset Temperature is 359.63 °C and Inflection Temperature is 403.72°C. TGA Onset average temperature of all plastics is 382.10°C. TGA used 25°C to 800 °C temperature ranges to melt and volatile the solid sample in order to derived onset temperature of each raw plastic; between the temperature ranges TGA mostly used 550 °C highest temperature range to volatile the plastic sample. After done the TGA experiment in the crucible 5% LDPE residue are remained and rest of 95% are converted to volatile gases, for HDPE 4% residue are remained in the crucible and rest of 96% are already converted to volatile gases, for PP 4% residue are remained in the crucible and 96% sample are converted to volatile gases and ultimately for PS 7% residue are remained in the crucible and 93% sample are converted to volatile gases as well. Based on onset temperature of each plastics determined that at what temperature conversion of liquefaction process would be expedited as well as also giving clue that how much percentage of product conversion rate would be probably occur and how much residue yield percentage would be in the particular experiment.

LDPE (Figure blue color chromatogram) following types of wave numbers and functional groups appeared. In accordance to the wave number such as wave number 2949.39 cm⁻¹, 2917.42 cm⁻¹, 2866.47 cm⁻¹ and 2838.30 cm⁻¹, investigated functional group is C -CH₃, wave number 1743.81 cm⁻¹, functional group is Non-Conjugated and end of the spectrum phase wave number 1455.81 cm⁻¹, 1375.47 cm⁻¹ and 1358.81 cm⁻¹, functional group is CH₃ etc.

PP (Figure red color chromatogram) following types of wave numbers and functional groups appeared. In accordance to the wave number such as wave number 2949.94 cm⁻¹, 2917.66 cm⁻¹, 2867.11 cm⁻¹ and 2838.32 cm⁻¹, investigated functional group is C -CH₃, wave number 1743.99 cm⁻¹, functional group is Non-Conjugated and also on the spectrum phase wave number 1454.48 cm⁻¹, 1375.74 cm⁻¹ and 1359.00 cm⁻¹, functional group is CH₃ as well as at the end phase of the spectrum wave number 721.33 cm⁻¹, functional group is -CH=CH-(cis) etc. PS (Figure green color chromatogram) following types of wave numbers and functional groups appeared. In accordance to the wave number such as wave number 3059.62 cm⁻¹ and 3025.15 cm⁻¹, investigated functional group is =C-H, wave number 2921.91 cm-1 and 2850.69 cm⁻¹, investigated functional group is C-CH₃, wave number 1869.56 cm⁻¹, 1801.91 cm⁻¹, 1743.82 cm⁻¹,1600.85 cm⁻¹ functional group is Non-Conjugated and also on the spectrum phase wave number 1451.61 cm⁻¹ and 1371.06 cm⁻¹, functional group is CH₃, wave number 1027.74 cm⁻¹ functional group is Acetates, wave number 964.20 cm⁻¹, functional group is -CH=CH-(trans), wave number 905.91 cm⁻¹, functional group is -CH=CH₂, and at the end phase of the spectrum wave number 748.40 cm⁻¹, functional group is -CH=CH-(cis) etc.

Liquid Fuel Analysis

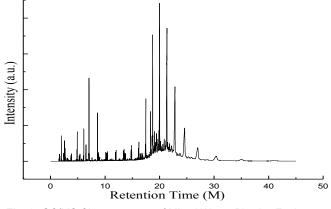


Fig. 2- GC/MS Chromatogram of Mixed Waste Plastics Fuel to 5th Fractional Fuel (Heavy Oil)

Gas Chromatography and Mass Spectrometer (GC/MS) analysis of mixed waste plastics to heavy fuel (fig.2 and table 2) 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 C₂₇. 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 1.55 and trace mass 41, compound is Cyclopropane (C3H6), retention time 1.65 and trace mass 41, compound is 1-Propene, 2-methyl- (C4H8), retention time 1.72 and trace mass 41, compound is 2-Butene, (E)- (C₄H₈), retention time 1.98 and trace mass 43, compound is Pentane, (C₅H₁₂), retention time 2.02 and trace mass 55, compound is Cyclopropane, 1,2-dimethyl-, cis-(C₅H₁₀), retention time 2.56 and trace mass 56, compound is 1-Pentene, 2-methyl- (C₆H₁₂), retention time 2.72 and trace mass 41, compound is 2-Butene, 2,3-dimethyl- (C₆H₁₂), retention time

2.98 and trace mass 56, compound name is Cyclopentane, methyl (C₆H₁₂), retention time 3.04 and trace mass 67, compound name is 2,4-Hexadiene, (Z,Z)-(C₆H₁₀), retention time 3.39 and trace mass 41, compound is Oxirane, (1-methylbutyl)- (C7H14O), retention time 3.66 and trace mass 56, compound is 1-Hexene, 2-methyl-(C7H14), retention time 3.90 and trace mass 81, compound is 3,5-Dimethylcyclopentene (C7H12), retention time 4.71 and trace mass 43, compound is 1-Heptene, 4-methyl- (C₁₈H₁₆), retention time 4.96 and trace mass 81, compound is Cyclohexene, 3-methyl -- (C₇H₁₂), retention time 5.17 and trace mass 56, compound is 1-Heptene, 2-methyl- (C₈H₁₆), retention time 5.76 and trace mass 43, compound is Heptane, 2,4-dimethyl- (C₉H₂₀), retention time 6.99 and trace mass 43, compound is 1-Undecene, 8-methyl-(C12H24) etc. Also at retention time 7.60 and trace mass 105, compound is Benzene, (1-methylethyl) - (C₉H₁₂), retention time 8.96 and trace mass 43, compound is Nonane, 2, 6-dimethyl- (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 10.87 and trace mass 43, compound is 1-Dodecanol, 3, 7, 11-trimethyl-(C₁₅H₃₂O), here also appearing that oxygenated compound are formed because in the glass reactor chamber much amount of steams are produced and also experiment executed in the presence of air. Retention time 12.64 and trace mass 57, compound is Decane, 2,3,5,8-tetramethyl- (C14H30), retention time 13.52 and trace mass 69, compound is 9-Eicosene, (E)- (C₂₀H₄₀), retention time 14.78 and trace mass 55, compound is 1-Tetradecene (C14H28), retention time 16.10 and trace mass 55, compound is 1-Pentadecene (C₁₅H₃₀), at retention time 17.38 and trace mass 55, compound is 1-Hexadecene (C16H32), benzene compounds are formed because when raw polystyrene are made benzene are added into the reactants. Retention time 18.35 (on third highest peak) and trace mass 92, compound is Benzene, 1,1'-(1,3propanediyl)bis- (C₁₅H₁₆) 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 19.86 and trace mass 55, compound is E-7-Octadecene (C18H36), at the first highest peak on retention time 20.01 and trace mass 43, compound is Octadecane (C18H38), at the second highest peak on retention time 21.35 and trace mass 57, compound is Nonadecane (C19H40), retention time 22.82 and trace mass 57, compound is Eicosane (C₂₀H₄₂), retention time 24.58 and trace mass 57, compound is Heneicosane $(C_{21}H_{44})$, and eventually retention time 27.00 and trace mass 57, compound is Heptacosane (C₂₇H₅₆) etc. Mentioned that practically found on the spectrum some retention time are acquired at highest peak height and maximum retention times are gained at in the normal peak height.

Table 3- Mixed Waste Plastics Fuel to 5th Fractional Fuel (Heavy Oil) FT-IR Functional Group List

		/			
Band Peak Number	Wave Number (cm-1)	Functional Group Name	Band Peak Number	Wave Number (cm-1)	Functional Group Name
1	2923.45	CH ₂	9	991.95	Secondary Cyclic Alcohol
2	2853.06	CH ₂	10	964.93	-CH=CH- (trans)
3	1746.10	Non-Conjugated	11	908.97	-CH=CH2
4	1641.30	Non-Conjugated	12	888.68	C=CH2
5	1602.35	Non-Conjugated	13	720.09	-CH=CH- (cis)
6	1464.70	CH ₂	14	698.20	-CH=CH- (cis)
7	1377.43	CH₃			

From FT-IR (spectrum 100) analyses of heavy fuel (fig. 3 and table 3) in accordance with the different wave number different types of functional groups are appeared. In according to wave number on the spectrum such as wave number 2923.45 cm⁻¹, functional group is CH₃, wave number 2853.06 cm⁻¹ functional group is CH₂, wave number 1746.10 cm⁻¹, 1641.30 cm⁻¹ and 1602.35 cm⁻¹ functional group is Non-Conjugated, wave number 1464.70 cm⁻¹ and 1377.43 cm⁻¹ functional group is CH_2/CH_3 etc. In the end of the spectrum phase wave number 991.95 cm⁻¹, functional group is -CH=CH₂, wave number 964.93 cm⁻¹, functional group is -CH=CH-(trans), wave number 908.97 cm⁻¹, functional group is -CH=CH₂, wave number 888.68 cm⁻¹, functional group is C=CH₂ and ultimately wave number 720.09 cm⁻¹ and 698.20 cm⁻¹. functional group is CH=CH-(cis) as well. Energy values are calculated, using formula is E=hu, Where h=Planks Constant, h =6.626x10⁻³⁴ J, u= Frequency in Hertz (sec⁻¹), Where u=c/ λ , c=Speed of light, where, c=3x10¹⁰ m/s, W=1/ λ , where λ is wave length and W is wave number in cm⁻¹. Therefore the equation E=hu, can substitute by the following equation, E=hcW. According to their wave number such as for 2923.45 (cm-1) calculated energy, E=5.80x10⁻²⁰ J. Similarly, wave number 1746.10 (cm⁻¹) energy, E =3.46x10⁻²⁰ J, wave number 1377.43 (cm⁻¹) energy, E = 2.73x10⁻²⁰ J and eventually wave number 991.95 (cm⁻¹) functional group is 1.97x10⁻²⁰ J respectively.

Some ASTM test was conducted from 3rd party of produces fuel and ASTM test was such as API Gravity at 60 °F (ASTM D287), Density (ASTM D1298), Relative Density (Elevated temp) (ASTM D4052), Flash Point Test (ASTM D93_B), Pour Point Test (ASTM D97), Sediment Content (ASTM D473), Sulfur Content (ASTM D4294), Viscosity - Kinematic at 40 & 100 °C (ASTM D445), Water Content (ASTM D95), Appearance or Haze (ASTM D4176), Cetane Index (Calculation Only) (ASTM D976), Cloud Point (ASTM D2500), Color (ASTM D1500), Copper Corrosion (ASTM D130), Distillation (ASTM D86), Oxidation Stability (ASTM D2274), pH Value (ASTM D1293), Btu value gal or Ib (ASTM D240).

Conclusion

In batch process laboratory scale heavy oil produced by fractional distillation process was two step. Initially municipal mixed waste plastics grinded sample was converted in to liquid hydrocarbon fuel and the experiment were executed without any catalyst. Produced plastic hydrocarbon fuel is mixture of several types of fuel such as gasoline, naphtha, aviation, diesel and heavy oil. 2nd step process was used for heavy oil first step plastic liquid hydrocarbon fuel was use to set up fractional distillation process. In the 2nd step experiment light fuel were gradually extracted by their temperature profile e.g. gasoline (at 40-65 °C) naphtha (at 110-135 °C), aviation fuel (at 180 -205 °C), diesel fuel (at 260 -285 °C) and finally between 260 °C to 340 °C temperature range obtained fuel was heavy oil. A thermal degradation process was applied to produce NSR Heavy Oil from waste plastic fuel. Fuel analysis result showed produced fuel has some aromatic compound and aliphatic compound because raw materials were LDPE, PP, HDPE and PS mixtures. This fuel could be used as feed stock refinery for further modification or it could be used as heating oil.

Acknowledgement The author acknowledges the support of Dr.

Karin Kaufman, the founder of Natural State Research, Inc. The author also acknowledges the valuable contributions NSR laboratory team members during the preparation of this manuscript.

References

- Aguado J., Serrano D.P., Vicente G. and Sanchez N. (2007) Ind. Eng. Chem. Res., 46, 3497-3504.
- [2] Antonio Marcilla, Ngela A.A., Garcıa N. and Maria del Remedio Hernandez (2007) Energy and Fuels, 21, 870-880.
- [3] Panda A.K., Singh R.K. and Mishra D.K. (2010) Renewable and Sustainable Energy Reviews, 14, 233-248.
- [4] Miskolczi N., Bartha L., Deak G. and Jover B. (2004) Polymer Degradation and Stability, 86, 357-366.

- [5] Miguel Miranda, Filomena Pinto, Gulyurtlu I., Cabrita I., Nogueira C.A. and Arlindo Matos (2010) *Fuel*, 89, 2217-2229.
- [6] Stelmachowski M. (2010) Energy Conversion and Management, 51, 2016-2024.
- [7] Karishma Gobin and George Manos (2004) Polymer Degradation and Stability, 83, 267-279.
- [8] Weibing Ding, Jing Liang and Larry L. Anderson (1997) Energy and Fuels, 11, 1219-1224.
- [9] Anthony Warren and Mahmoud El-Halwagi (1996) Fuel Processing Technology, 49, 157-166.
- [10]Aguado J. and Serrano D. (1999) RSC clean technology monographs, on feedstock recycling of waste plastic. Cambridge: Royal Society of Chemistry.

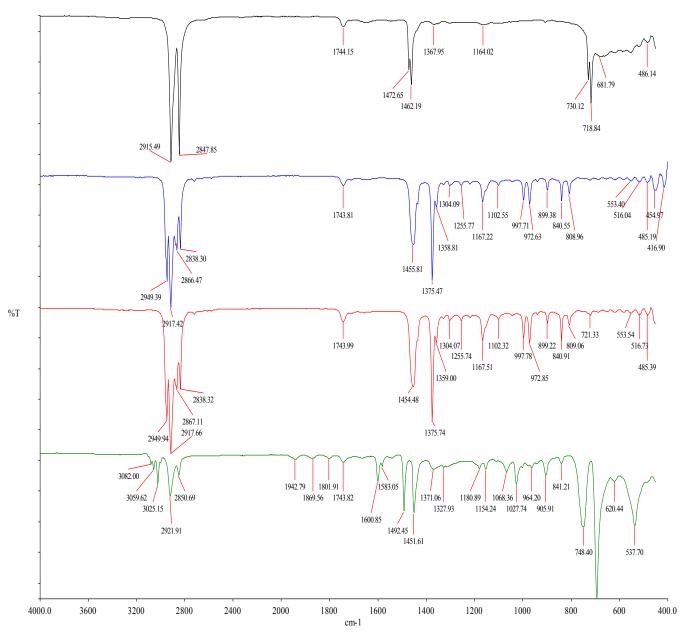


Fig. 1- FT-IT graph of four types of solid waste plastic

Number Time (10) Name Formula Weight Number 1 1.65 41 1-Propens, 2-methyl- Chik 56 2.1 105 1 1.72 41 2-Potterne, [C]- Chik 56 2.1 105 1 1.81 4.3 Burne, 2-methyl- Chik 70 2.1 19385 2 2.22 4.5 Cycloroparan, 1.2-dimethyl-, ca- Chiku 70 8.1 19385 2 2.32 4.5 Pertane, 2-methyl-, ca- Chiku 86 6.60 61279 9 2.52 57 Pertane, 2-methyl-, Chiku 64 88 64.5 18 118 2.856 67 Cyclorobare, 3.3-dimethyl-, Chiku 84 118 2.856 67 Cyclorobare, 2.2 Chiku 86 88 114 2.86 67 Cyclorobare, 2.2 Chiku 84 118 2.85688 1138 2.856 114 118 2.85688 114385 1144 113		Table 2- GC/MS Chromatogram Compound list of Mixed Waste Plastics Fuel to Heavy Oil							
1 155 41 Cpcborogram CH 42 286 1861 3 172 41 2-buten, (E)- CH 56 25.1 105 1 184 42 Puttine CH 56 25.1 105 1.84 42 Puttine CH 70 24.1 19007 5 1.94 42 Puttine CH 70 24.1 19007 5 2.92 57 Puttine CH 70 18.1 1907 9 2.92 57 Putine, 2.3-dimethy- CH 84 35.8 61220 12 2.72 41 2-buten, 2.3-dimethy- CH 84 114.8 65.7 13 2.81 67 Cyclobion, 3.3-dimethy- CH 84 114.8 265.2 14 2.86 66 Cyclobion, 3.dimethy- CH 84 114.2 114.4 15 3.94 7 2-thutadinn	Peak Number	Retention	Trace Mass (m/z)	Compound Name	Compound	Molecular	Probability %	NIST Library	
2 1.65 41 1-Progene_2-methyl- C.H. 56 27.4 105 4 1.81 43 Butane_2-methyl- C.H. 72 70.3 119107 5 1.84 42 1-Proteine C.H. 70 83.1 6103 6 1.89 45 Pertane C.H. 70 83.1 6103 7 2.83 33 Pertane C.H. 70 83.4 65.0 61279 9 2.82 57 Pertane C.H. 64 84 55.9 45.5 11 2.65 57 Hesane C.H. 84 85.9 455 12 2.72 41 2.9-Mates 2.4-Mates C.H. 84 67.1 114483 14 2.86 57 Cyclobatene A.H. 2.4 114483 114483 15 2.84 87 Cyclobatene A.H. 64 67.1 114483 16 3.34 12 A.H. 144 113546 114483							29.6		
4 181 43 Butane Znethyl- C.Hu, Pentare 72 73 19107 6 1.38 43 Pentare C.Hu, Pentare 72 23 13 19107 7 202 55 Cyclopropane, 1.2-dinethyl, cb- C.Hu, Pentare, Znethyl- C.Hu, B 85 18175 10 255 57 Fentare, Znethyl- C.Hu, B 85 18175 11 255 57 Fentare, Znethyl- C.Hu, B 85 18175 12 27 41 C.Autore, 3.3-dimethyl- C.Hu, B 85 18175 12 27 41 C.Autore, 3.3-dimethyl- C.Hu, B 84 67 2.99588 13 281 67 Cyclopropane, RZ, C.Hu, B 84 67 1144883 15 2.98 56 Cyclopropane, RZ, C.Hu, B 84 67 1144883 16 3.44 67 2.4-breesthyl-leventokardime, CZ C.Hu, B 83 114386						56			
5 1.94 4.2 1-Pentane CH-In 70 2.41 19001 7 2.02 55 Cyclopropane, 12-dimethyle, cis- CH-In 70 18.1 19070 8 2.39 43 Pentane, 2-methyl- CH-In 86 56.0 61729 9 2.52 57 Pentane, 2-methyl- CH-In 86 58.8 19376 11 2.55 7 Pentane, 2-methyl- CH-In 86 87.7 67.00 12 2.71 41 2.5.dimethyl- CH-In 84 10.8 2.528.8 14 2.6.dimethyl- 3.5.dimethyl- CH-In 84 10.7 11.4428 11.4428 15 2.9.6 67 2.4-Hoxadiene, Z.2 CH-In 82 14.4 113846 16 3.0.4 17 2.4-Hoxadiene, Z.2 CH-In 82 14.4 113846 17 3.0.9 67 2.4-Hoxadiene, Z.2 CH-In 82 14.4									
6 188 43 Pentane Cyclopropane, 1.2 dimethyl, cis- C.H-h 72 83 61286 9 2.22 57 Pentane, 2-methyl- C.H+a 86 66.0 61279 10 2.55 55 1-Pentane, 2-methyl- C.H+a 84 85.9 445 11 2.56 56 1-Pentane, 3-adimethyl- C.H+a 84 85.9 445 12 2.17 47 2-bentane, 3-adimethyl- C.H+a 84 85.1 62288 14 2.86 41 2-bentane, 3-adimethyl- C.H+a 84 67.1 114483 15 2.98 56 Cycloppentane, methyl- C.H+a 84 67.1 114483 16 3.04 67 2.4-Hexadine (Z,P) C.H+a 86 63.3 114488 17 3.09 67 2.4-Hexadine (Z,P) C.H+a 86 41.8 29124 18 3.26 1.4 2.4.0 methyl-1 1.4 11.7 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
7 2.02 55 Cyclopopane, 12-dimethyl, cis- Ci-H ₁₄ 70 18.1 19070 9 2.52 57 Pentane, 3-methyl- Ci-H ₁₄ 86 65.0 61279 10 2.56 56 1-Pentane, 3-methyl- Ci-H ₁₂ 84 85.9 495 11 2.56 57 Hexane, 3-admethyl- Ci-H ₁₂ 84 11.8 228958 12 2.72 41 2.4 16.1 11.4 82 10.4 62288 13 2.81 67 Cyclopentane, methyl- Ci-H ₁₂ 84 16.1 11.4428 14 2.80 57 Cyclopentane, methyl- Ci-H ₁₂ 84 16.3 11.4428 153 2.4 Hardiane, Za- Ci-H ₁₂ 84 16.3 11.4428 163 2.4 Hardiane, Za- Ci-H ₁₂ 96 84.1 12.8 173 3.6 1.4 Pentane, Za-methyl- Ci-H ₁₂ 96 41.4 11.4 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
8 2.39 4.3 Pertana, 2-methyl- C,H-4 86 65.0 61279 10 2.56 56 1-Pertane, 2-methyl- C,H-1 84 35.9 495 11 2.66 57 1-Pertane, 2-adimethyl- C,H-1 84 18.8 281 12 2.72 4.1 2-Burne, 2.3 dimethyl- C,H-1 84 18.8 218 14 2.86 4.1 2-Pertane, 3-methyl- C,H-1 84 16.8 114428 15 2.89 56 Crydopentrac, (2.2) C,H-1 84 16.3 114428 16 3.04 67 2.4 Hreadane, (2.2) C,H-1 85 14428 16 3.04 67 2.4 Hreadane, (2.2) C,H-0 114 117 14488 17 3.63 67 1.4 pertane, 2.4 methyl- C,H-4 98 12.1 1428 13 3.71 16.6 1.4 pertane, 4.4 methyl- C,H-4 98 12.1 1428									
9 2.52 97 Pertane, 3-methyl- C.H-I- 86 983 19375 11 2.65 57 Hexane C.H-I- 86 85.7 61280 13 2.81 67 Cyclobulere, 3.3 dimethyl- C.H-I- 84 118 228958 13 2.81 67 Cyclobulere, 3.3 dimethyl- C.H-I- 84 16.8 1114433 15 2.88 56 Cyclopentare, methyl- C.H-I- 84 67.1 114428 16 3.04 67 2.4 Hexadiner, (Z.P) C.H-I- 82 14.4 113846 17 3.09 67 2.4 Hexadiner, (Z.P) C.H-I- 78 76.8 114488 13 3.39 71 Damme C.H-I- 78 76.8 114488 23 3.64 Oximan C.Harpethyl- C.H-I- 96 41.1 114888 23 3.57 78 Bitanov 77.7 77.7 77.7 77.7	8								
10 2.56 56 1-Penten, 2-melhy- C,H-1 84 35.9 495 12 2.72 4.1 2-Bulene, 3.3 dimethyl- C,H-1 84 11.8 28958 12 2.81 6.7 Cyclobulene, 3.3 dimethyl- C,H-1 84 16.8 114428 14 2.86 4.1 2-Pentene, 3-methyl, C,D- C,H-1 84 6.71 111428 16 3.04 6.7 2.4 Hexatione, (Z,P) C,H-6 82 10.7 113866 18 3.24 6.8 1.4 4.13846 6.71 1114428 18 3.24 6.7 2.4 Hexatione, (Z,P) C,H-6 7.1 113466 13 3.8 7.8 Biomane C,H-6 7.1 11386 114488 21 3.83 43 2-pententrue C,H-4 9.8 2.71 2.21711 23 3.67 81 1.3-Pentehyl- C,H-4 9.8 2.71 1.3.4 1.49890									
12 2.72 41 2.24 Junne 2.3-dimethyl- Cirkip 64 11.8 285858 13 2.86 64 2-Pentene, 3-artentyl-, (2)- Cirkip 64 67.1 114423 15 2.96 66 Cyclopenten, methyl- Cirkip 64 67.1 114483 16 3.04 67 2.4-Hexadiene, (Z,Z)- Cirkip 62 14.4 113346 17 3.09 67 2.4-Hexadiene, (Z,Z)- Cirkip 66 14.48880 20 3.63 43 2.4-Entadiane Cirkip 66 14.48880 21 3.63 43 2.4-Entadiane Cirkip 66 14.8880 22 3.66 66 1-Hespine Cirkip 66 14.9880 10.3 107.74 23 3.71 56 1-Hespine Cirkip 96 12.7 13.94 23 3.61 4.9 43 Helppine Cirkip 96 12.7 113.94		2.56	56		C ₆ H ₁₂	84			
14 2.96 41 2.4mether, (Z)- Chip 84 67.1 114423 15 2.98 56 Cydopentan, methy- Chip 82 10.7 113846 17 3.09 67 2.4-Hexadene, (Z.2)- Chip 82 14.4 113846 18 3.24 81 2.4-Dimethyl 1.4-pentadene Chip 96 3.3 114488 21 3.63 43 2.4-Pentadone Chip 06 4.18 29128 22 3.66 56 1-Hesene, Z-methy- Chip 06 28 61 10.77 24 3.83 43 Heptane Chip 96 29.8 51276 25 3.87 81 3.5-Dimethylopclopentae Chip 96 29.8 51276 25 3.90 81 3.5-Dimethylopclopentae Chip 114 1134363 26 3.90 81 3.5-Dimethylopclopentae Chip 114 1134364									
15 2.98 56 Cyclopentane, methyl- C.Hw 84 67.1 1114248 16 3.04 67 2.4-Hexadiane, (Z.Z) C.Hw 62 10.7 113366 18 3.24 81 2.4-Direthylbutyli C.Hw 62 36.3 114488 19 3.36 78 Benzane (:methylbutyl) C.Hw 78 113366 21 3.63 43 2-Pentanone (:methylbutyl) C.Hw 66 41.8 292124 23 3.71 756 1-Heptane, 2-methyl- C.Hw 96 1.8 29124 24 3.83 43 +Heptane C.Hw 96 1.4.7 1.333 61276 25 3.87 81 1.3-Pentadiane. 2-dimethyl- C.Hw 96 1.4.7 113343 28 4.86 43 Heptane, 4-methyl- C.Hw 114 58.6 113916 29 4.90 91 Toluene C.Hw 112 2.6.7 1020									
16 3.04 67 2.4-Hexadiene, [Z.Z)-, C.Hu, 82 14.4 113646 17 3.09 67 2.4-Hexadiene, [Z.Z)-, C.Hu, 96 36.3 114468 18 3.24 81 2.4-Dimethyl 1.4-pentadiane C.Hu, 96 36.3 114468 20 3.39 41 Oxirane, (1-methylotyl)-, C.Hu,O 114 11.7 49880 21 3.65 56 1-Heptene C.Hu,O 86 41.8 291264 22 3.66 56 1-Heptene C.Hu,O 98 10.3 107734 24 3.83 43 Heptane C.Hu,O 96 24.9 114450 25 3.87 81 3.5-Dimethyloxidopentene C.Hu,B 96 26.9 114450 26 3.90 81 3.5-Dimethyloxidopentene C.Hu,B 96 24.9 114450 27 4.14 13 Heptane, 4-methyl- C.Hu,B 96 29.3 291301 27 4.14 13.4-betane, 2.3.atimethyl- C.Hu,B <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>									
17 3.09 67 2.4-Hexadiene (.Zz)-, C.Ha, 82 114.4 113646 18 3.24 81 2.4-Omethyl 1.4-pentadiene C.Ha, 78 86.3 114488 19 3.65 78 Berzene C.Ha,O 114 117 49880 21 3.63 43 2.2-Pentanone C.Ha,O 86 21 23.71 56 1-Hespine 2-methyl- C.Ha,O 86 21 23.71 56 1-Hespine 2-methyl- C.Ha,O 98 27.1 23.71 103 107.734 24 3.83 43 Heptane 2-methyl- C.Ha,O 98 27.1 23.71 13.65 1.4-pentene C.Ha,O 96 14.7 113640 27 4.71 43 1.4-pentene/s-methyl- C.Ha,O 96 14.7 113640 28 466 43 1-teptene/s-methyl- C.Ha,O 96 14.7 113640 28 466 43 1-teptene/s-methyl- C.Ha,O 114 516 114563 29 400 91 Tol									
18 3.34 81 2.4-Dimethyl 1.4-pentadiane Ch-Ho 96 36.3 114488 20 3.39 41 Oxirane. (1-methylutyl) Ch-Hu-O 114 11.7 49880 21 3.63 43 2-Pentanone Ch-Hu-O 186 41.8 291284 22 3.66 56 1-Heptane Ch-Hu 98 10.3 107734 23 3.71 56 1-Heptane Ch-Hu 98 10.3 107734 24 3.83 33 Heptane Ch-Hu 96 14.7 113430 25 3.87 81 3.5-Dimethylcyclopantane Ch-Hu 96 14.7 113430 27 4.71 4.3 1-Heptane, 4-methyl- Carhu 112 11.9 113430 24 486 43 Heptane, 4-methyl- Carhu 114 56 11316 25 55 1-Octene 3.methyl- Carhu 112 26.7 1604 31 5.17 Totane Cyetopentan, 1.1.3.Hetramethyl-, 6:- Carhu <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>									
20 3.39 41 Oxirane. (1-methylbutyl)- C, H ₄ , O 11 11.7 49880 21 3.63 43 2-Pentanone C, H ₄ 96 27.1 23171 23 3.71 56 1-Hexene, 2-methyl- C, H ₄ 98 10.3 107734 24 3.83 43 Heptane C, H ₄ 96 26.9 114450 25 3.87 81 1.3-Pentatione, 2.4-(imethyl- C, H ₄ 96 26.9 114450 26 4.71 1.4-pentaclene, 2.4-(imethyl- C, H ₄ 91 11 14450 27 4.71 43 1.4-pentaclene, 3.methyl- C, H ₄ 91 11 3436 113916 28 252 55 1.0-Cetene C, H ₄ 112 26.7 1604 33 5.34 95 1.4-Pentaclene, 2.3-trimethyl- C, H ₄ 114 5.4 22407 35 5.50 55 3-Octene C, H ₄ 112 <td< td=""><td></td><td>3.24</td><td></td><td>2,4-Dimethyl 1,4-pentadiene</td><td>C7H12</td><td>96</td><td></td><td></td></td<>		3.24		2,4-Dimethyl 1,4-pentadiene	C7H12	96			
21 3.63 43 2-Pentanone C,H ₁₄ 98 271 231711 23 3.71 56 1-Heptene, 2-methyl- C,H ₁₄ 98 10.3 107734 24 3.83 43 Heptene, 2-d-dimethyl- C,H ₁₂ 96 10.3 107734 25 3.87 81 1.3-Pentalaine, 2.4-dimethyl- C,H ₁₂ 96 26.9 11480 26 3.90 81 3.5-Dimethyl- C,H ₁₁ 96 26.9 114840 27 4.71 4.3 1-Heptene, 4-methyl- C,H ₁₂ 96 9.7 123031 28 4.86 4.3 Heptane, 4-methyl- C,H ₁₄ 114 56.6 273031 31 5.1.7 56 1-Heptene, 2-methyl- C,H ₁₆ 112 26.7 100248 32 5.25 55 1-Octene C,H ₁₆ 112 26.7 1604 33 5.34 95 1.4-Pentalaine, 2.3-stimethyl- C,H ₁₆ 128					C ₆ H ₆				
22 3.66 56 1-Hexene, 2-methyl- C,Hia 98 27.1 23171 23 3.71 56 1-Heptene C,Hia 98 27.1 23171 24 3.83 43 Heptane C,Hia 100 79.8 61275 25 3.87 81 1.3-Pentadiene, 2,4-dimethyl- C,Hia 96 24.7 113443 26 3.90 81 3.5-Dimethylocobeniene C,Hia 96 24.7 113443 27 4.71 43 1-Heptene, 4-methyl- C,Hia 114 56.6 131 11456.6 131916 29 4.90 91 Toluene C,Hia 112 26.7 1604 31 5.17 56 1-Heptene, 2-methyl- C,Hia 112 26.7 1604 33 5.34 95 1.4-Pentadiene, 2,3-trimethyl- C,Hia 112 26.7 16043 34 5.40 43 Octane C,Ji-Hia 114									
23 3.71 56 1-Heptene C,H ₄ 98 10.3 10773 24 3.83 43 Heptane C,H ₁₀ 100 79.8 61276 25 3.97 81 1.3-Pontadiene, 2.4-dimethyl- C,H ₁₀ 96 26.9 114450 27 4.71 43 1-Heptene, 4-methyl- C,H ₁₀ 96 14.7 11340 28 4.86 43 Heptane, 4-methyl- C,H ₁₀ 112 4.6 213131 30 4.96 81 Cyclohexene, 3-methyl- C,H ₁₀ 112 4.7 107288 31 5.17 55 1-Octene C,H ₁₀ 112 26.7 1604 33 5.34 95 1.4-Pertadiene, 2.3-stimethyl- C,H ₁₀ 112 26.7 1604 35 5.50 5.3 Octane C,H ₁₀ 112 26.7 15338 36 6.03 Cyclohexane, 1.3.5-trimethyl-, cis- C,H ₁₀ 128 23.8 155322 37 5.76 43 Heptane, 2.4-dimethyl-, cis- C,H ₁₀ <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
24 3.83 43 Heptane CHus 96 28.9 61276 25 3.87 81 1.3-Pomethysopentene CHus 96 1.47 113460 26 3.90 81 3-Domethysopentene CHus 96 1.47 113460 27 4.71 43 Heptane, 4-methyl- CHus 112 11.9 113433 28 4.86 43 Heptane, 4-methyl- CHus 112 4.6 107268 29 4.90 91 Toluene CHus 112 4.6 107268 31 5.17 56 1-Octane CHus 114 54.8 226.7 32 5.25 55 1-Octane CHus 114 54.8 229407 35 5.40 43 Octane CHus 114 54.8 229407 36 5.66 83 Cyclonetane 1.3.4 tetramethyl-, cis- CHus 114 54.8 229407 37 5.76 43 Heptane, 2.4-dimethyl- CHus 126 33.7 <td></td> <td></td> <td></td> <td>1-Heptene</td> <td></td> <td></td> <td></td> <td></td>				1-Heptene					
26 3.87 81 1.3-Pentadiene, 2.4-dimethyl- C.Hu 96 2.6.9 114450 27 4.71 43 1-Heptene, 4-methyl- Cahis 112 11.9 113433 28 4.86 43 Heptene, 4-methyl- Cahis 112 11.9 113433 29 4.90 91 Toluene CH 24 64.3 291301 30 4.96 81 Cyclohexene, 3-methyl- CH 112 24.7 1004 31 5.17 56 1-Heptene, 2-methyl- CH 112 24.7 1004 33 5.34 95 1.4-Pentadiene, 2.3.3-trimethyl- CH 114 54.8 224077 36 5.66 83 Cyclopentane, 1.1, 3.4-tetramethyl-, cis- CH 114 54.8 224077 37 5.76 43 Heptane, 2.4-dimethyl-, cis- CH 128 23.8 15352 38 6.03 111 Cyclopentane, 1.3, 5-trimethyl-, (ci, 30, 58)- CH 128 23.9 12807 39 6.10 43									
26 3.90 81 3.5-Dimethylopciopentane C.H. ₁₂ 96 1.4.7 11343a 27 4.71 4.3 1-Heptane, 4-methyl- C.H. ₁₆ 112 11.9 11343a 28 4.86 4.3 Heptane, 4-methyl- C.H. ₁₂ 96 9.73 23066 21 5.17 56 1-Heptane, 2.3.3-timmethyl- C.H. ₁₆ 112 4.76 107288 22 5.25 55 1-Octore C.H. ₁₆ 112 2.6.7 1604 33 5.34 95 1.4-Pentadiene, 2.3.3-timmethyl- C.H. ₁₆ 112 6.2.9 227617 36 5.60 83 Cyclopentane, 1.3.4-timmethyl-, cis- C.H. ₁₆ 128 2.8.8 155382 37 5.76 4.3 Heptane, 2.4-dimethyl-, (tis- C.H. ₁₆ 128 2.3.8 153382 38 6.03 111 Cyclohexane, 1.3.5-timethyl-, (ti, 3.0.5)- C.H. ₁₆ 126 5.2 113716 40 6.46 6.9	25								
28 4.86 4.3 Heptane, 4-methyl- ChHs 92 64.3 291301 30 4.96 81 Cyclohexane, 3-methyl- ChHs 92 64.3 291301 30 4.96 81 Cyclohexane, 3-methyl- ChHs 112 47.6 107268 31 5.17 56 1-Octene ChHs 112 26.7 1604 33 5.34 95 1.4-Pentadiene, 2.3.3-trimethyl- ChHs 114 54.8 229407 35 5.50 55 3-Octene (2)- ChHs 112 6.29 227617 36 5.66 83 Cyclopentane, 1.1.3-tetramethyl-, cis- ChHs 126 5.0 27589 37 5.76 43 Heptane, 2.4-dimethyl- ChHs 126 3.7 21480 38 6.03 111 Cyclohexane, 1.3.5-timethyl- ChHs 126 3.7 2480 41 6.51 91 Ethylbenzane ChHs 126 3.	26	3.90	81	3,5-Dimethylcyclopentene	C7H12	96	14.7	113640	
294.9091TolueneCollocationCollocation9264.3291301304.9681Cyclohexane, 3-methyl-CollocationCollocation969.73236066315.17561-Heptene, 2-methyl-CollocationCollocation11247.6107/268325.25551-OcteneCollocationCollocation11226.71604335.34951.4-Pentadiene, 2.3-trimethyl-Collocation11454.8229407345.4043Octane2.3-trimethyl-Collocation1126.29227617355.6683Cyclopentane, 1,1,3,4-tetramethyl-, cis-Collocation12823.8155382375.7643Heptane, 2,4-dimethyl-Collocation12823.8155382386.03111Cyclohexane, 1,3,5-trimethyl-Collocation12823.72480416.5191EthylbenzaneCollocationCollocation61.5114918426.99431-Undecene, 8-methyl-CollocationCollocation61.5114918437.0578StyreneCollocationCollocation23.6228006447.1243NonaneCollocationCollocation24.9138344576.0105Benzene, (1-methylethyl)Collocation24.12050.0228742468.1391Benzene, (1-met									
30 4.96 81 Cyclohexene, 3-methyl- C-H12 96 9.73 236066 31 5.17 56 1-Heptene, 2-methyl- CaH16 112 26.7 1604 33 5.34 95 1.4-Pentadiene, 2.3.3-trimethyl- CaH16 112 26.7 1604 33 5.34 95 1.4-Pentadiene, 2.3.3-trimethyl- CaH16 112 6.29 227617 36 5.66 83 Cyclopentane, 1.1.3.4-tetramethyl-, cis- CaH16 112 6.29 227617 36 5.66 83 Cyclopentane, 1.1.3.4-tetramethyl-, cis- CaH16 112 6.29 2175789 37 5.76 43 Heptane, 2.4-dimethyl-Hoptane CaH16 126 65.2 113516 40 6.46 69 Cyclohexane, 1.3.5-timethyl-, (1c, 3a, 50)- CaH16 126 65.2 113516 41 6.51 91 Ehytheptane CaH16 126 65.2 113516 42 6.99 43									
315.17561-Heptene, 2-methyl-CaHig11247.6107268325.25551-OctaneCaHig11226.71604335.34951,4-Peritatiene, 2,3,3-trimethyl-CaHig11454.8229407355.50553-Octane, (2,1-CaHig11464.8229407365.6683Cyclopentane, 1,1,3,4-tetramethyl-, cis-CaHig1126.71604375.7643Heptane, 2,4-dimethyl-, cis-CaHig12637.9114702396.03111Cyclopextane, 1,3,5-trimethyl-CaHig12637.9114702396.10432,4-Dimethyl-1-hepteneCaHig12637.72480416.5191EthylbenzeneCaHig12637.72480426.99431-Undecene, 8-methyl-CaHig12633.72480437.0578StyreneCaHig10661.5114918447.1243NonaneCaHig12050.0228742457.60105Benzene, (1-methylethyl)-CaHig12050.0228742468.1391Benzene, (1-methylethyl)-CaHig1183.0228006478.1857DecaneCaHig1408.95118833488.28105Benzene, (1-methylethyl)-CaHig1408.9511883347<									
$\begin{array}{cccccccccccccccccccccccccccccccccccc$									
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$									
345.404.3OctaneCithie1145.4.8229407355.50553-Octane, (Z)-Cithie1126.29227617365.6683Cyclopentane, 1,1,3,4-tetramethyl-, cis-Cithie12615.027589375.7643Heptane, 2,4-dimethyl-Cithie12637.9114702386.03111Cyclohexane, 1,3,5-trimethyl-Cithie12637.9114702396.10432,4-Dimethyl-1-hepteneCithie12637.72480416.5191EthylbenzaneCithie1263.7.72480416.5191EthylbenzaneCithie10661.5114918426.99431-Undecene, 8-methyl-Cithie12830.9228006437.0578StyreneCithie12050.0228742447.1243NonaneCithieCithie12050.0228742458.1391Benzene, propyl-Cithie12072.6113930478.1857Nonane, 4-methyl-Cithie1408.56118833488.28105Benzene, futhyleCithieCithie34.9291541498.60118a-MethylstyreneCithie1408.55118833518.6457DecaneCithie14234.9291484528.96<	33								
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	34	5.40	43		C ₈ H ₁₈	114		229407	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$									
386.03111Cyclohexane, 1,3,5-trimethyl- inmethyl-1-hepteneCalHis CalHis12637.9114702396.10432,4-Dimethyl-1-hepteneCalHis CalHis12665.2113516406.4669Cyclohexane, 1,3,5-trimethyl-, (1a,3a,5β)-CalHis CalHis12663.72480416.5191EthylbenzeneCalHis CalHis12663.72480426.99431-Undecerne, 8-methyl-CalHis CalHis10661.5114918426.99431-Undecerne, 8-methyl-CalHis CalHis10661.5114918437.0578StyreneCalHis10442.8291542447.1243NonaneCalHis12830.9228006457.60105Benzene, propyl-CalHis12072.6113930478.1857Nonane, 4-methyl-CigHis1408.9511883488.28105BenzaldehydeCalHis1408.9511883508.69411-DeceneCigHis1408.9511883518.8457DecaneCigHis11813.020403528.669.411-DeceneCigHis11813.020403539.38117Benzene, 1,1-dimethyl-2propyl-CigHis1408.95118883518.8457DecaneCigHis <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>									
396.10432.4-Dimethyl-1-heptene $C_{a}H_{18}$ 1266.5.2113516406.4669Cyclohexane, 1.3,5-trimethyl-, (10,30,5β)- $C_{a}H_{16}$ 10661.5114918416.5191Ethylbenzene $C_{a}H_{16}$ 10661.5114918426.99431-Undecene, 8-methyl- $C_{12}H_{24}$ 1684.2861823437.0578Styrene $C_{a}H_{6}$ 1044.2.8291542447.1243Nonane $C_{a}H_{2}$ 12050.0228742468.1391Benzene, propyl- $C_{a}H_{12}$ 12050.0228742468.1391Benzene, propyl- $C_{a}H_{2}$ 14229.13834478.1857Nonane, 4-methyl- $C_{a}H_{2}$ 14229.13834488.28105Benzaldehyde $C_{7}H_{60}$ 10653.6229166508.69411-Decene $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{20}$ 1408.95118883539.38117Benzene, 1, 2-methyl-5-(ri-methylethenyl)- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1, 2-methyl-5-(ri-methylethenyl)- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl-5-(ri-methylethenyl)- $C_{12}H_{25}$ 2025.299094 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
406.4669Cyclohexane, 1,3,5-trimethyl-, (1α,3α,5β)- CaHaCaHa CaHa12633.72480416.5191EthylbenzeneCaHa CaHa10661.5114918426.994.31-Undecene, 8-methyl-CaHa CaHa10442.8291542437.0578StyreneCaHa10442.8291542447.1243NonaneCaHa12830.9228006457.60105Benzene, (1-methylethyl)-CaH1212072.6113930478.1857Nonane, 4-methyl-CaH1212072.6113930478.1857Nonane, 4-methyl-CaH1214229.13834488.28105BenzalehyldeCaHaO11836.6229186508.69411-DeceneCaH1011836.6229186518.8457DecaneCaH2214234.9291484528.9643Nonane, 2,6-dimethyl-C1:H241569.4061438539.38117Benzene, 1,9ropenyl-C1:H2215413.1698175556Cyclohexane, 1,1-dimethyl-2-propyl-C1:H2215413.169817570.76432-Undecanethiol, 2-methyl-C1:H2215413.169817580.18433-Tetradecene, (E)-C1:H221546.366066560 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
416.5191Ethylbenzene $C_{0}H_{0}$ 10661.5114918426.99431-Undecene, 8-methyl- $C_{1}H_{24}$ 1684.2861823437.0578Sbyrene $C_{1}H_{24}$ 1684.2861823447.1243Nonane $C_{2}H_{20}$ 12830.9228006457.60105Benzene, (1-methylethyl)- $C_{3}H_{12}$ 12050.0228742468.1391Benzene, propyl- $C_{3}H_{12}$ 12072.6113930478.1857Nonane, 4-methyl- $C_{1}H_{22}$ 14229.13834488.28105Benzaldehyde $C_{1}H_{22}$ 14229.13834488.28105Benzaldehyde $C_{1}H_{22}$ 14234.929168508.69411-Decene $C_{1}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{1}H_{22}$ 14234.9291484539.38117Benzene, 1,propenyl- $C_{1}H_{22}$ 14234.9291484549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{1}H_{22}$ 14234.92914845710.116969.015219.1114684570.11694061.336614.38579.86912-Cyclohexane, 1,2-methyl-5 $C_{1}-methylethenyl)-C_{1}H_{2}154$									
437.0578Styrene C_8H_8 10442.8291542447.1243Nonane C_8H_{20} 12830.9228006457.60105Benzene, (1-methylethyl)- C_8H_{12} 12050.0228742468.1391Benzene, propyl- C_8H_{12} 12072.6113930478.1857Nonane, 4-methyl- $C_{10}H_{22}$ 14229.13834488.28105Benzaldehyde $C_{10}H_{20}$ 1408.9511883508.69411-Decene $C_{10}H_{20}$ 1408.9511883518.8457Decane $C_{10}H_{20}$ 1408.9511883528.9643Nonane, 2.6-dimethyl- $C_{10}H_{20}$ 1408.9511883539.38117Benzene, 1-propenyl- $C_{10}H_{20}$ 1408.9511883549.5556Cyclohexane, 1.1-dimethyl-2-propyl- $C_{10}H_{20}$ 1403.52614085710.1169Cyclohexane, 1.4-dimethyl-1, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{14}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{20}$ 1403.52614085910.24563-Undecene									
447.1243Nonane C_9H_{20} 128 30.9 228006457.60105Benzene, (1-methylethyl)- C_9H_{12} 120 50.0 228742 468.1391Benzene, propyl- C_9H_{12} 120 72.6 113930 478.1857Nonane, 4-methyl- C_10H_{22} 142 29.1 3334 488.28105Benzaldehyde C_7H_6O 106 53.6 291541 498.60118 α -Methylstyrene C_9H_{10} 118 36.6 22916 508.69411-Decene C_10H_{22} 142 34.9 291484 528.9643Nonane, 2.6-dimethyl- C_1H_{22} 142 34.9 291484 528.9643Nonane, 2.6-dimethyl- C_1H_{22} 142 34.9 291484 539.38117Benzene, 1-propenyl- C_1H_{22} 142 34.9 291484 549.5556Cyclohexane, 1,1-dimethyl-2-propyl- C_1H_{10} 118 13.0 20403 549.5556Cyclohexane, 1,0, 2-methyl-5-(1-methylethenyl)- C_10H_{20} 140 3.52 61408 5710.1169Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- C_10H_{20} 140 3.52 61408 5810.18433-Tetradecene, (E)- C_1H_{22} 154 5.26 142623 5810.1463552-Undecene, (E)- C_1H_{22						168			
457.60105Benzene, (1-methylethyl)- C_9H_{12} 12050.0228742468.1391Benzene, propyl- C_9H_{12} 12072.6113930478.1857Nonane, 4-methyl- $C_{10}H_{22}$ 14229.13834488.28105Benzaldehyde C_7H_6O 10653.6291541498.60118 α -Methylstyrene C_9H_{10} 11836.6229186508.69411-Decene $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1,propenyl- $C_{9}H_{10}$ 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2.propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethyl-2.propyl- $C_{11}H_{22}$ 15413.169817559.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{16}O$ 15219.11146845710.1169Cyclocotane, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656110.4857Undecane $C_{11}H_{22}$ 1545.261426235910.24563-Undecene, (Z)- $C_{11}H_{22}$ 1545.2614262359<				,					
468.1391Benzene, propyl- C_9H_{12} 12072.6113930478.1857Nonane, 4-methyl- $C_{10}H_{22}$ 14229.13834488.28105Benzaldehyde $C_7H_{6}O$ 10653.6291541498.60118 c^{-} Methylstyrene $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- $C_{9}H_{10}$ 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{10}H_{20}$ 1403.52614085710.1169Cyclohexen-1-0, 2-methyl-5(1-methylethenyl)- $C_{10}H_{10}$ 15219.11146845710.1169Cyclohexen, (E)- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecane $C_{1-1}H_{20}$ 1545.261425236110.4857Undecane $C_{11}H_{20}$ 1545.261425636310.87 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
478.1857Nonane, 4-methyl- $C_{10}H_{22}$ 14229.13834488.28105Benzaldehyde $C_{1}H_{6}O$ 10653.6291541498.60118 α -Methylstyrene $C_{9}H_{10}$ 11836.6229186508.69411-Decene $C_{10}H_{20}$ 1408.95118833518.8457Decane $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- $C_{6}H_{10}$ 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{24}$ 1569.40614385710.6432-Undecanethiol, 2-methyl- $C_{12}H_{28}$ 2025.299094569.86912-Cyclohexan-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{10}$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (Z)- $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{15}H_{32}O$ 228 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>									
488.28105Benzaldehyde C_7H_6O 10653.6291541498.60118 α -Methylstyrene C_9H_{10} 11836.6229186508.69411-Decene $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- C_9H_{10} 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{10}H_{20}$ 1403.52614085710.1169Cyclohexane, 1,4-dimethyl-trans- $C_{10}H_{10}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{10}H_{20}$ 1403.52614085910.24563-Undecene, (E)- $C_{10}H_{20}$ 1403.52614086110.4857Undecane $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{10}H_{20}$ 2263.512454856310.87431-Dodecanol, 3.7,11-trimethyl- $C_{16}H_{20}$ 2285.4411406564 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>									
498.60118a-Methylstyrene C_9H_{10} 11836.6229186508.69411-Decene $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2.6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- $C_{11}H_{22}$ 15413.169817549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{12}H_{26}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{10}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{22}$ 1546.36605656110.4857Undecane $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{13}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{15}H_{30}O$ 2263.512454856411.2469(2,4,6-Trimethylcyclohexyl) methanol $C_{10}H_{20}O$ </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
508.69411-Decene $C_{10}H_{20}$ 1408.95118883518.8457Decane $C_{10}H_{22}$ 14234.9291484528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- $C_{9}H_{10}$ 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethyl-2-propyl- $C_{12}H_{28}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{16}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecane, 3,7,11-trimethyl- $C_{12}H_{26}$ 17031.72914996411.2469(2,4,6-Trimethylcyclohexyl) methanol $C_{12}H_{26}$ 17031.72914996712.5157Dodecane $C_{12}H_{26}$ <td>49</td> <td>8.60</td> <td>118</td> <td></td> <td>C₉H₁₀</td> <td>118</td> <td>36.6</td> <td>229186</td>	49	8.60	118		C ₉ H ₁₀	118	36.6	229186	
528.9643Nonane, 2,6-dimethyl- $C_{11}H_{24}$ 1569.4061438539.38117Benzene, 1-propenyl- $C_{9}H_{10}$ 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{12}H_{26}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{16}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1545.261425966110.34552-Undecene, (Z)- $C_{11}H_{22}$ 1545.261425966110.4857Undecane $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{15}H_{32}O$ 2285.441140656411.2469(2,4,6-Trimethylcyclohexyl) methanol $C_{10}H_{20}O$ 1567.461137576511.91553-Dodecene, (E)- $C_{12}H_{26}$ 17031.72914996712.5157Dedecane, 2,6,10					C ₁₀ H ₂₀				
539.38117Benzene, 1-propenyl- C_9H_{10} 11813.020403549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{12}H_{26}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{10}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{22}$ 1545.261425966110.4857Undecene C_{12} -1545.633.1077746210.5555Z-10-Pentadecen-1-ol $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{16}H_{20}O$ 1567.461137576511.91553-Dodecene, (E)- $C_{12}H_{26}$ 17031.72914996712.5157Tetradecane, 2,6,10-trimethyl- $C_{12}H_{26}$ 17031.72914996712.5157Decane, 2,3,5,8-tetramethyl- $C_{14}H_{30}$ 19812.2149589	51								
549.5556Cyclohexane, 1,1-dimethyl-2-propyl- $C_{11}H_{22}$ 15413.169817559.76432-Undecanethiol, 2-methyl- $C_{12}H_{26}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{16}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{22}$ 1545.261425966110.4857Undecene $C_{1-1}H_{22}$ 1545.261425966210.5555Z-10-Pentadecen-1-ol $C_{11}H_{22}$ 1545.261425966310.87431-Dodecanol, 3,7,11-trimethyl- $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{16}H_{30}O$ 2285.441140656411.2469(2,4,6-Trimethylcyclohexyl) methanol $C_{10}H_{20}O$ 1567.461137576511.91553-Dodecene, (E)- $C_{12}H_{26}$ 17031.72914996712.5157Decane, 2,6,10-trimethyl- $C_{12}H_{26}$ 17031.72914996812.6457 <t< td=""><td>52 53</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	52 53								
559.76432-Undecanethiol, 2-methyl- $C_{12}H_{26}S$ 2025.299094569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- $C_{10}H_{16}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{22}$ 1545.261425966110.4857Undecane $C_{11}H_{22}$ 1545.261425966310.87431-Dedecanol, 3,7,11-trimethyl- $C_{15}H_{32}O$ 2285.441140656411.2469(2,4,6-Trimethylcyclohexyl) methanol $C_{10}H_{20}O$ 1567.461137576511.91553-Dodecane, (E)- $C_{12}H_{24}$ 1686.98706426612.0357Dodecane $C_{12}H_{26}$ 17031.72914996712.5157Tetradecane, 2,6,10-trimethyl- $C_{14}H_{30}$ 19812.2149589	54								
569.86912-Cyclohexen-1-ol, 2-methyl-5-(1-methylethenyl)- C10H16O $C_{10}H_{16}O$ 15219.11146845710.1169Cyclooctane, 1,4-dimethyl-, trans- Cyclooctane, 1,4-dimethyl-, trans- C10H20C10H201403.52614085810.18433-Tetradecene, (E)- C14H28C14H281962.651426235910.24563-Undecene, (E)- C11H22C11H221546.36605656010.34552-Undecene, (Z)- UndecaneC11H221545.261425966110.4857UndecaneC11H2415632.31077746210.5555Z-10-Pentadecen-1-olC18H30O2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- C10H20OC16H32O2285.441140656411.2469(2,4,6-Trimethylcyclohexyl) methanolC10H20O1567.461137576511.91553-Dodecene, (E)-C12H241686.98706426612.0357DodecaneC12H2617031.72914996712.5157Tetradecane, 2,6,10-trimethyl-C14H3019812.2149589	55								
5710.1169Cyclooctane, 1,4-dimethyl-, trans- $C_{10}H_{20}$ 1403.52614085810.18433-Tetradecene, (E)- $C_{14}H_{28}$ 1962.651426235910.24563-Undecene, (E)- $C_{11}H_{22}$ 1546.36605656010.34552-Undecene, (Z)- $C_{11}H_{22}$ 1545.261425966110.4857Undecane $C_{11}H_{24}$ 15632.31077746210.5555Z-10-Pentadecen-1-ol $C_{15}H_{30}O$ 2263.512454856310.87431-Dodecanol, 3,7,11-trimethyl- $C_{15}H_{32}O$ 2285.441140656411.2469(2,4,6-Trimethylcylohexyl) methanol $C_{10}H_{20}O$ 1567.461137576511.91553-Dodecene, (E)- $C_{12}H_{24}$ 1686.98706426612.0357Dodecane $C_{12}H_{26}$ 17031.72914996712.5157Tetradecane, 2,6,10-trimethyl- $C_{14}H_{30}$ 19812.2149589	56	9.86	91			152	19.1	114684	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	57	10.11	69						
	58								
$ \begin{array}{ccccccccccccccccccccccccccccccc$									
67 12.51 57 Tetradecane, 2,6,10-trimethyl- C ₁₇ H ₃₆ 240 9.76 11556 68 12.64 57 Decane, 2,3,5,8-tetramethyl- C ₁₄ H ₃₀ 198 12.2 149589		12.03		Dodecane	$C_{12}H_{26}$		31.7	291499	
	67			Tetradecane, 2,6,10-trimethyl-	$C_{17}H_{36}$				
69 13.28 56 3-Tetradecene (E)- Cultan 106 4.37 130081		12.64	57	Decane, 2,3,5,8-tetramethyl-	$C_{14}H_{30}$	198	12.2	149589	
	69	13.28	56	3-Tetradecene, (E)-	C ₁₄ H ₂₈	196	4.37	139981	

Table 2- GC/MS Chromatogram Compound list of Mixed Waste Plastics Fuel to Heavy Oil

Table 2- Continue

DIE Z- CC	Jilling							
	70	13.39	55	1-Tridecene	C ₁₃ H ₂₆	182	5.74	232738
	71	13.50	57	Tridecane	C ₁₃ H ₂₈	184	44.0	114282
	72	13.52	69	9-Eicosene, (E)-	C ₂₀ H ₄₀	280	3.0	62815
	73	14.78	55	1-Tetradecene	C ₁₄ H ₂₈	196	5.32	69725
	74	14.88	57	Tetradecane	C ₁₄ H ₃₀	198	30.3	113925
	75	16.10	55	1-Pentadecene	C ₁₅ H ₃₀	210	7.64	69726
	76	16.20	57	Pentadecane	C ₁₅ H ₃₂	212	31.2	107761
	77	16.91	83	1-Docosanol	C ₂₂ H ₄₆ O	326	3.98	23377
	78	17.38	55	1-Hexadecene	C ₁₆ H ₃₂	224	6.85	118882
	79	17.48	57	Hexadecane	C ₁₆ H ₃₄	226	39.8	114191
	80	18.35	92	Benzene, 1,1'-(1,3-propanediyl)bis-	C ₁₅ H ₁₆	196	91.4	229725
	81	18.63	55	3-Heptadecene, (Z)-	C17H34	238	8.78	141673
	82	18.73	71	Heptadecane	C ₁₇ H ₃₆	240	37.5	107308
	83	19.09	69	1-Nonadecanol	C ₁₉ H ₄₀ O	284	5.83	232931
	84	19.86	55	E-7-Octadecene	C ₁₈ H ₃₆	252	5.96	130920
	85	20.01	43	Octadecane	C ₁₈ H ₃₈	254	22.6	57273
	86	20.85	83	1-Docosanol	C ₂₂ H ₄₆ O	326	7.51	23377
	87	21.35	57	Nonadecane	C ₁₉ H ₄₀	268	9.54	114098
	88	22.82	57	Eicosane	C ₂₀ H ₄₂	282	23.1	290513
	89	24.58	57	Heneicosane	C ₂₁ H ₄₄	296	22.6	107569
	90	27.00	57	Heptacosane	C ₂₇ H ₅₆	380	7.55	79427

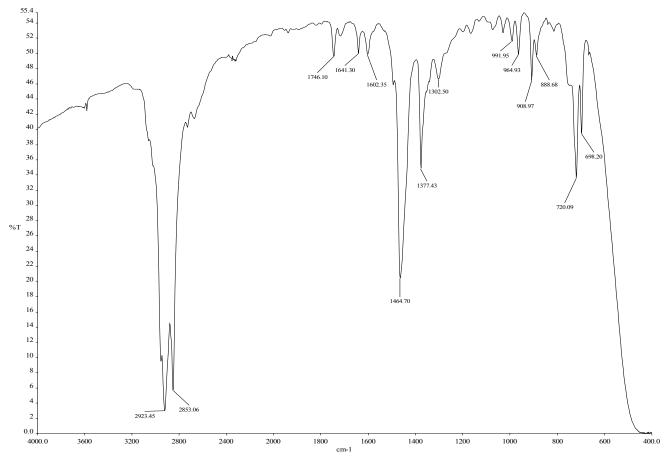


Fig. 3- FTIR Spectra of Mixed Waste Plastic Fuel to Heavy Fuel