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## **Estimation of Hydrocarbon Components by the Chromatographic Study of the Naphtha like Component Extracted from Polyethylene Mix**

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### **Abstract**

The thirst for energy is ever increasing in this fast moving world. The polymer materials such as LDPE, LLDPE, MDPE and HDPE type of polyethylene materials become an indispensable part of our life. These waste polyethylene materials has become a big environmental problem today. The conversion of the waste polyethylene materials into useful hydrocarbon products is one of the key challenge world is facing today. The polymers having polyolefin are very useful materials with different applications, but are reluctant to degradation or deterioration. The thermal pyrolytic conversion of the waste polyethylene mix and the extraction of different useful hydrocarbon components were observed to be one of the key areas of study. The paper emphasizes on the estimation of the different type of the components observed in the naphtha like component recovered from such degradation process. The types of the paraffinic, iso-paraffinic, olefinic, naphthenic and aromatic components observed were studied. The reaction mechanism followed in the conversion process and the stability of the components in the liquid phase was observed. The conversions of the C<sub>40+</sub> components to the lighter components ranging from C<sub>1</sub> to C<sub>5</sub> and C<sub>6</sub> to C<sub>15</sub> components by the chromatographic and infra red spectroscopic techniques were investigated.

**Keywords:** Naphtha; polyethylene; depolymerization; chromatography; FTIR.

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## **1. Introduction**

Today waste polyethylene has become one of the major environmental pollutants. The developments of the newer and alternative sources of energy become one of the key research areas worldwide. The thermal degradation of the waste polyethylene into different hydrocarbon products ranging from C1 to C40+ hydrocarbon components and the extraction of the naphtha like component is being studied in this paper. Polyethylenes are non-biodegradable materials which are generally made up of large number of organic resins. Different types of the polyethylene resins are produced by the conjugation of the ethylene with gases such as vinyl acetate or other olefins such as butene, hexene, octene etc. to form copolymers. The study of the naphtha component and the identification of the components with the chromatographic techniques are being studied. The naphtha components were recovered and studied in the range of C5 to C15. The large amount of non-biodegradable polyethylene materials causes environmental problems which have led to the finding of the newer and alternative sources of the energy by recycling the solid wastes. Mostly, thermoplastics polymers make up a high proportion of waste, and this amount is continuously increasing around the globe. Hence, waste plastics pose a very serious environmental challenge because of their huge quantity and disposal problem as thermoplastics do not biodegrade for a very long time [1]. The thermal degradation of the polyethylene materials leads to the breakdown of the long hydrocarbon chain into the shorter one producing newer categories of liquid and gaseous samples. The most suitable decomposition products from polyethylene for the production of light gases and hydrocarbon liquid products are compounds close to 1-decene in both chain length and molecular structure. Several thermo chemical techniques have been employed to convert waste PP (Polypropylene) and LDPE (Low density polyethylene) into value added products [2]. The thermal degradation of the polyethylene materials splits the long chain hydrocarbon into gaseous product, which finally produces low molecular weight, gaseous and liquid products. These polymer wastes can be used as a potentially cheap source of chemicals and energy. Due to release of harmful gases like dioxins, hydrogen chloride, airborne particles, and carbon dioxide, incineration of polymer possesses serious air pollution problems. Due to high cost and poor biodegradability, it is also undesirable to dispose by landfill [1]. In this paper the study of the waste polyethylene is being carried out on the LDPE (low density polyethylene), LLDPE (linear low density polyethylene), MDPE (medium density polyethylene) and HDPE (high density polyethylene) materials into naphtha grade liquid products. The paraffinic, olefinic and the polyolefinic components get converted into the different paraffinic, olefinic, iso-paraffinic, naphthenic and aromatic components. This is confirmed by the gas chromatographic analysis of the naphtha equivalent product recovered by this process. The functional groups present, their energy value were also determined by the FTIR analysis of the product. The different reaction mechanism involving cyclization, isomerization, aromatization etc were also studied. The degradation of the long chain polyolefinic materials into different short chain hydrocarbon products produces high calorific value gaseous and liquid products. These hydrocarbon products produce scope for an alternative source of energy.

## **2. Methodology**

The waste polyethylenes used for such process are LDPE (low density polyethylene), LLDPE (linear low density polyethylene), MDPE (medium density polyethylene) and HDPE (High density polyethylene). The polymerization process generally follows the initiation, chain propagation and the termination process.

Initiation step: this step involves hemolytic fission of the radicals.



Chain propagation step: In this step new free radicals were produced by combining free radicals produced in the above step with the alkenes molecule



In this step the chain reaction is terminated by combination or disproportionation that is combination or loss of action.



The termination of the step produces un-reacted polymer.

The waste polyethylene contains different types of the organic, inorganic and biological residues which are present in the form of contamination. The waste polyethylene is very difficult to treat because of its complex nature and composition.

In this study the waste polyethylene were degraded by thermal hydrolytic process. The long chain complex hydrocarbon chain breaks down into short chain molecules. In order to produce and obtain different categories of liquid products the thermal degradation process is upgraded to fractional distillation process. Fractional distillation process is basically thermal degradation except the heat applied is divided into different groups based on specific temperature. Reference [3] Fractional distillations of these chains are divided into different groups based on the type of liquid produced. The naphtha liquid's carbon chain is in the range of C5–C15.

The degradation process mainly follows the mechanism of chain scissions which is generally caused by increase in the temperature and sheer stress and hence decreases the molecular weight. The chain branching and the cross linking have the opposite effect to the chain scission and are caused by the low sheer stress and high residence time. The mechanical degradation of the polymeric material occurs by breaking C-C and C-H bonds. The degradation depends on the nature such as the polar group and structure such as head to head or tail to tail weak linkages, double bonds or branching points of the polymeric chain on the ingredients in the polymer resin and on the type of the stress.

Polyethylene as well as other vinyl polymers degrade via a four step free radical mechanism, radical initiation,

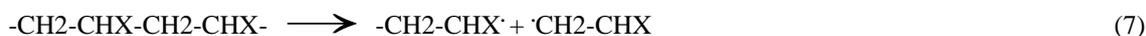
de-propagation (as opposed to propagation in the case of polymerization), intermolecular and intramolecular hydrogen transfer followed by  $\beta$ -scission (initial step in the chemistry of thermal cracking of hydrocarbons and the formation of free radicals) and, lastly, radical termination.  $\beta$ -Scission and hydrogen abstraction steps often occur together in a chain propagation sequence. That is, a radical abstracts a hydrogen atom from the reactant to form a molecule and a new radical. A bond is then broken to the radical centre ( $\beta$ -scission) to regenerate an abstracting radical and to produce a molecule with a double bond (a molecule with a double bond involving the carbon atom that had been the radical centre). Sample size and surface area to volume ratio of the melt have a significant influence on the rate and relative importance of the various mechanisms of polymer degradation. In pyrolysis, which is normally done on micro-scale, only random initiation and intermolecular transfer were reported to be important. Conversely, on milligram scale of polyethylene charges and samples, intermolecular transfer of hydrogen atoms via abstraction by free radicals was considered to be the predominant transfer mechanism to produce volatiles [4].

The reactivity of the macro radicals, the  $R-CH_2\cdot$  radical has a higher reactivity than the  $R_2CH\cdot$  and the mobility of the free hydrogen atoms in the backbone, the tertiary hydrogen is more reactive than the secondary and primary one which strongly affects the mechanism of polymer degradation and decomposition.

The depolymeriation of the polyolefins via hydrolytic process follows the following steps

### 3. Initiation

#### Random succession



#### End chain succession

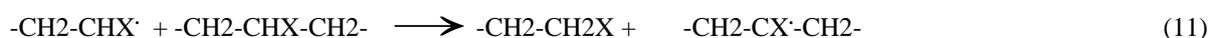


#### ii) Depropagation



#### Hydrogen Chain Transfer

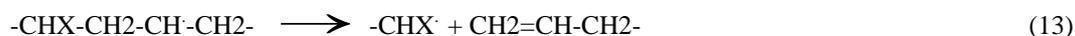
##### Intermolecular



##### Intramolecular



### **β-Cleavage**

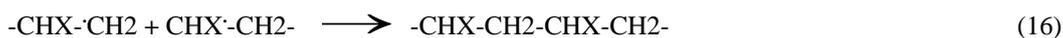


### **Formation of Branches**

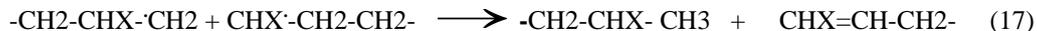


### **iii) Termination**

#### Bimolecular coupling



#### Disproportionation



Initiation, involves the succession of first bond in the chain yielding two radicals, which may occur at random or end chain position. De-prorogation resulting in the release of the olefinic monomeric fragments from primary radicals. Hydrogen chain transfer reaction may occur as intermolecular or intra molecular processes. This leads to the formation of olefinic species and polymeric fragments. β-cleavage of secondary radicals yields end chain olefinic groups and primary radicals. Branches were observed between two secondary radicals or between secondary and a primary radical. Termination process takes place either in a bimolecular mode, either by coupling of two primary radicals or by disproportion of radicals [5].

During the thermal degradation of many polymers, other reactions may take place at the same time as the cracking reactions, e.g. isomerization, cyclization, aromatization, recombination of species, etc. Thus, an increase in the degree of branching of the polymeric chains is usually observed as they are reduced in length by thermal decomposition. The thermal decomposition of polymers also involves the formation of volatile species within a highly viscous polymeric matrix. An important factor in the formation of gaseous product is the control of the reaction environment in terms of the components in each phase [6].

The carbonium ion intermediates can undergo rearrangement by hydrogen or carbon-atom shifts leading to a double-bond isomerization of an olefin. Methyl-group shift and isomerization of saturated hydrocarbons are the other important isomerization reactions. The cyclization reaction is followed by the Dials Alder reaction

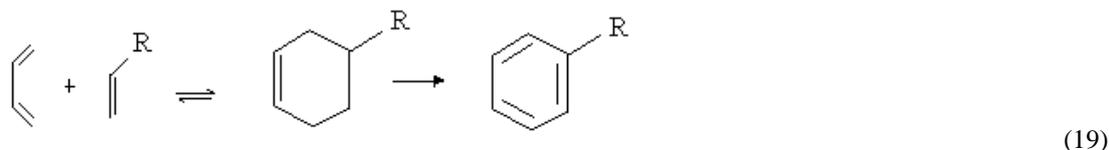
mechanism, in which the Dienes reacts with the Dienophiles in presence of thermal energy, produces a cyclic ring structure.

The cyclization reactions may occur through the formation of some carbonium ion intermediates. Such as when hybridising abstraction first locates in an olefin, at a position several carbons were removed from the double bond, these resulted in the formation of an olefinic carbonium ion. The carbonium ion involve intramolecular attack on the double bond, this will provided a route to cyclization and formation of aromatics. In the depropagation step of the polymer degradation, the molecular weight of the main polymer chains may be reduced to oligomer fraction approximately (C30–C80) by acidic sites. Gas formation and a liquid fraction (approximately C10–C25) may be resulted by direct  $\beta$ -scission of chain-end carbonium ions.

In order to avoid much too much liquid byproduct in the cracking of the gases for the manufacture of olefins, a definite minimum residence time must therefore be observed at a given temperature. If the residence time is greater, the newly produced olefin has too great an opportunity to undergo secondary reactions leading primarily to the formation of aromatic hydrocarbon. If however, at the most suitable residence time for cracking, the temperature is raised the formation of aromatics is again favored [7].

Thus each temperature corresponds to a particular time of contact both for olefin formation and aromatization, a certain minimum residence time being required for olefin formation and a certain maximum residence time for aromatization [7].

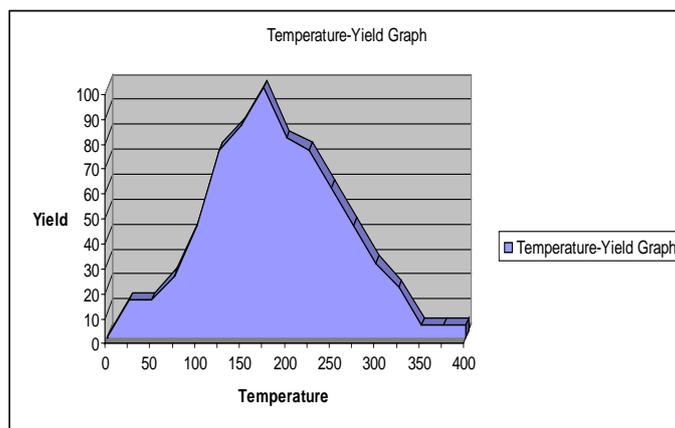
It was found that the formation of the aromatic from butadiene is assumed to proceed via dimerization to 4-vinylcyclohexene followed by double bond and/or skeleton isomerization, and finally by the dehydrogenation step of cyclohexadienes to aromatics. This aromatization is based on the Diels-Alder reaction between butadiene and lower olefins [8].



#### 4. Experimentation and Observations:-

The samples were collected, washed and dried. Then the dried samples were cut into small pieces or converted into pellets. These waste polyethylene mix containing LDPE, LLDPE, MDPE and HDPE type of polyethylene, were poured into a hopper which is connected with a batch reactor. The reactor is connected with a heater. When the reactor was filled with the waste polyethylene, then the temperature is raised slowly. At a temperature near 70°C, the gasification of the polyethylene mix started. With the gradual increase in temperature the liquefaction and the gasification of the mix increases. The gasified samples were passed through a connected pipe and were collected in a vessel containing demineralized water. Here the heated gaseous product is quenched in the chilled water. The quenching effect converts gaseous material into liquid product having higher carbon numbers. The liquid being lower in density were observed on the surface of the water. The gaseous

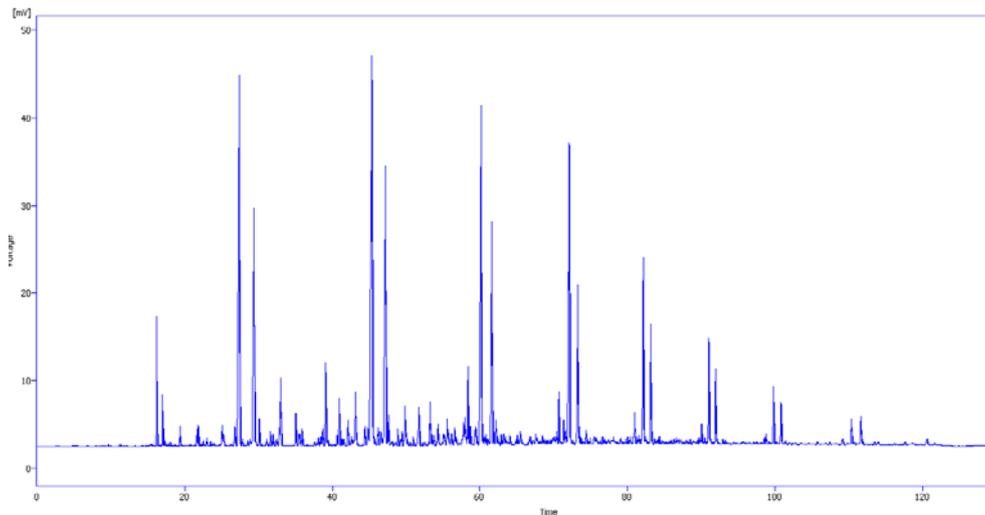
uncondensed part escapes from the vessel and were collected in another vessel containing demineralised water with temperature below 10<sup>0</sup>C (second vessel). The gases which does not get condensed were collected for further analysis. The liquid samples collected on the surface of the first and second vessel (if any) were poured into the separating funnel and were allowed to settle down for about half an hour. Then the water at the bottom of the separating funnel is removed and the liquid sample is collected. This liquid sample is then preserved for further analysis. The temperature yield graph for the liquid sample collected is observed and is shown in the Figure 1. The temperature-yield graph shows the variation of the yield of the hydrocarbon liquid and gases at various temperature ranges. At certain elevated temperature, maximum amount of the gaseous and the liquid hydrocarbon were recovered.



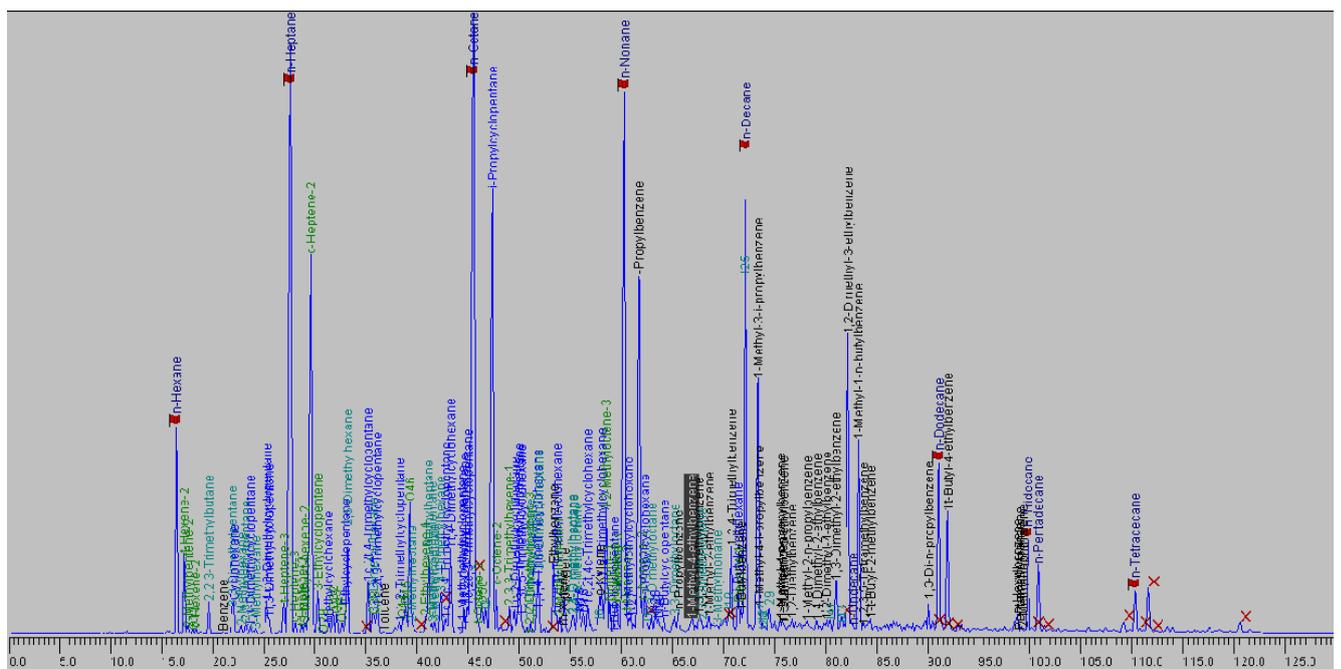
**Figure 1:** Temperature- Yield Graph of the gaseous product obtained by the hydrolytic depolymerisation of Waste Polyethylene.

The samples collected were then fractionated by fractional distillation process. The gaseous part is collected and sent for component analysis. The lighter liquid samples were collected from temperature range between 40<sup>0</sup>C to 160<sup>0</sup>C. The lighter sample collected were preserved at lower temperature to avoid evaporation of the very lighter components such as C5-C8. Different physical and chemical analyses of the sample were carried out. The Chromatographic analyses of the lighter liquid samples were carried out using PIONA analyzer (gas chromatography) [9].

The samples were injected in the gas Chromatograph containing 100 m capillary Plot alumina column. The column was connected with a FID detector. The sample was analyzed by temperature programming method with oven temperature starting from 30<sup>0</sup>C to 180<sup>0</sup>C with a ramp temperature of 5<sup>0</sup>C per minute. The chromatogram produces different hydrocarbon peaks with carbon number ranging from C6- C15. These hydrocarbons were distributed according to the components such as paraffins, iso-paraffins, olefins, naphthenes and aromatics with carbon number, concentration and boiling point ranges. The elutions of the components were observed according to the respective boiling point range. The component wise distributions of the recovered naphtha like hydrocarbons were shown in Table 1.

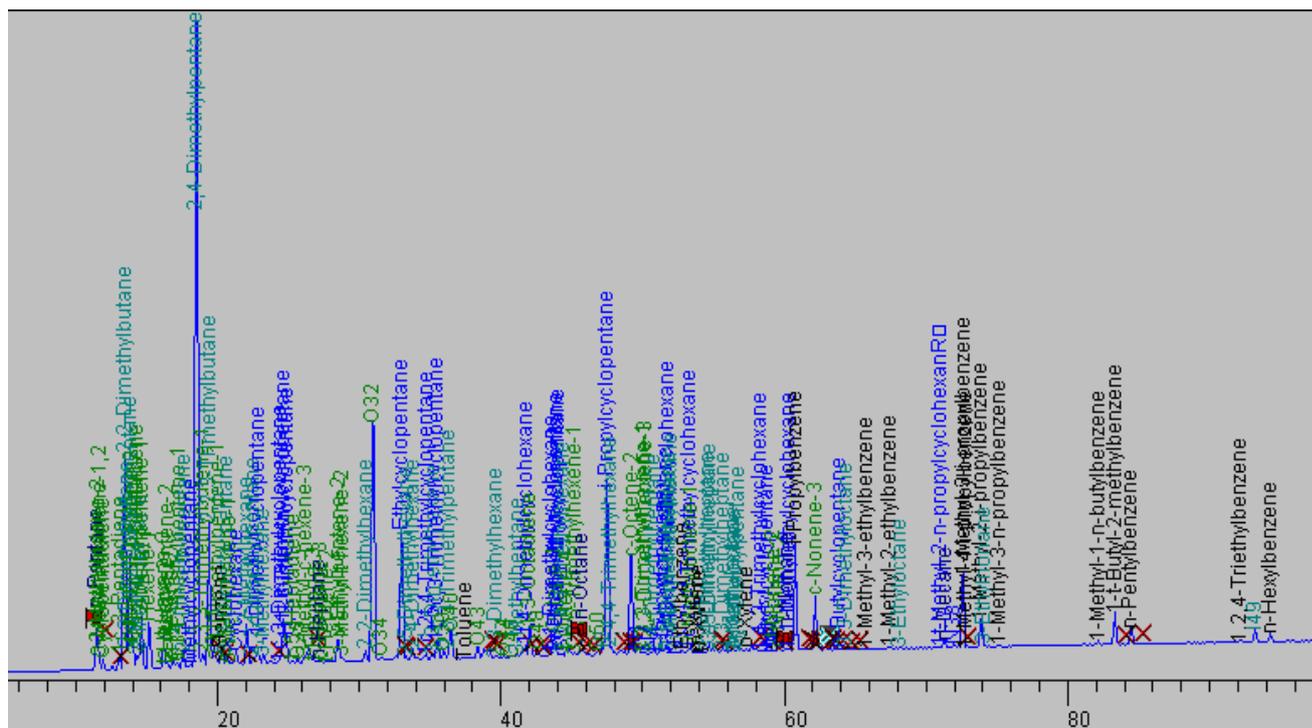


**Figure 2:** Chromatographic peaks showing component distribution of the naphtha like sample recovered from hydropyrolytic depolymeriation of the polyethylene mix



**Figure 3:** Chromatographic peaks showing component distribution of the naphtha like sample recovered from hydropyrolytic depolymeriation of the polyethylene mix

The percentage of the components such as paraffin, Iso-paraffin, olefins naphthenes and the aromatic components were observed according to the chromatographic studies of the light hydrocarbon components derived from the hydropyrolytic depolymerization of the polyethylene mix as shown above in Figure 2, Figure 3 and Figure 4. The percentage of the olefins is observed to be in higher percentage which is greater than 40 percent of the total volume of the liquid. The percentage of the paraffin and the aromatic components are more in percentage as compared to the naphthenes.



**Figure 4:** Chromatographic peaks showing component distribution of the naphtha like sample recovered from hydropyrolytic depolymeriation of the polyethylene mix

**Table1:** Different hydrocarbon component (paraffin, iso-paraffin, olefin, naphthene and aromatic) distribution on the basis of the chromatographic study as observed in Figure 3 and Figure 4

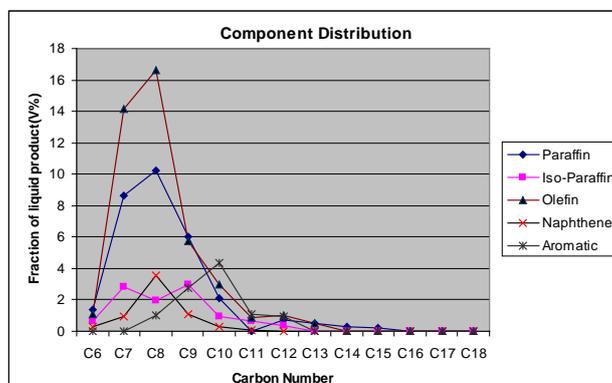
<b>Paraffin</b>	t-Nonene-2 c-Nonene-2 Decene-1
n-Hexane n-Heptane n-Octane n-Nonane n-Decane n-Undecane n-Dodecane n-Tridecane n-Pentadecane n-Tetradecane	<b>Naphthenes</b>  Cyclopentene Cyclohexane 1,1-Dimethylcyclopentane 1c,3-Dimethylcyclopentane 1t,3-Dimethylcyclopentane Methylcyclohexane Cyclopentene Ethylcyclopentane 1c,2t,4-Trimethylcyclopentane 1c,2t,3-Trimethylcyclopentane 1,1,2-Trimethylcyclopentane 1c,2c,4-Trimethylcyclopentane 1t,4-Dimethylcyclohexane 1,1-Methylethylcyclopentane 1t,2 Dimethylcyclohexane 1c,2c,3-Trimethylcyclopentane i-Propylcyclopentane 1c,2-Dimethylcyclohexane
<b>I-Paraffins</b>	
2,2,3-Trimethylbutane 2,4 Dimethylpentane 3,3- Dimethylheptane 2-Methylhexane 2,3-Dimethylheptane 3-Methylhexane 2,5-Dimethylhexane 3,3-Dimethylhexane 2-Methylheptane	

4-Methylheptane	n-Propylcyclopentane
3-Methyl-3-ethylpentane	1c,3c,5-Trimethylcyclohexane
3-Methylheptane	1,1,4-Trimethylcyclohexane
3,4-Dimethylhexane	1c,2t,4t-Trimethylcyclohexane
I2	N15
3,3-Dimethylhexane	N16
3,5-Dimethylhexane	1c,2t,4c-Trimethylcyclohexane
2,3- Dimethylhexane	1,1,2-Trimethylcyclohexane
3,4- Dimethylhexane	i-Butylcyclopentane
2-Methyloctane	1,1-Methylethylcyclohexane
I6	N27
I11	i-Propylcyclohexane
2,2- Dimethyloctane	N28
3,3- Dimethyloctane	N29
2,3- Dimethyloctane	n-Butylcyclopentane
3-Methyloctane	i-Butylcyclohexane
I19	
I25	<b>Aromatics</b>
I27	Benzene
I28	Toluene
I29	Ethylbenzene
I41	m-Xylene
I43	p-Xylene
	o-Xylene
<b>Olefins</b>	i-Propylbenzene
t-Hexene-2	n-Propylbenzene
2-Methylpentene-2	1-Methyl-4-ethylbenzene
O13	1,3,5-Trimethylbenzene
c-Hexene-2	1-Methyl-2-ethylbenzene
t-Heptene-3	1,2,4-Trimethylbenzene
c-Heptene-3	i-Butylbenzene
t-Heptene-2	1-Methyl-3-i-propylbenzene
3-Methyl-t-hexene-2	1-Methyl-4-i-propylbenzene
c-Heptane-2	1-Methyl-4-n-propylbenzene
3-Ethylcyclopentene	n-Butylbenzene
O29	1,3-Dimethyl-5-ethylbenzene
O32	1-Methyl-1-n-butylbenzene
O33	1- Methyl-2n-propylbenzene
O36	1,4 Dimethyl-2-ethylbenzene
O38	1,2 Dimethyl-4-ethylbenzene
O44	1,3 Dimethyl-2-ethylbenzene
O45	1,2 Dimethyl-3-ethylbenzene
O46	1-Methyl-1-n-butylbenzene
2-Ethylhexene-1	1,2,3,5-Tetramethylbenzene
t-Octene-2	1-t-Butyl-2-methylbenzene
O50	1,3-Di-n-propylbenzene
c-Octene-2	1t-Butyl-4-ethylbenzene
2,3,3-Trimethylhexene-1	n-pentylbenzene
t-2,2-Dimethylheptene-3	1,2,4 triethylbenzene
2-Methyloctene-1	n-Hexylbenzene
t-2-Methyloctene-3	Pentamethylbenzene
Nonene-1	2-Methylnaphthalene
t-Nonene-3	
c-Nonene-3	

**Table2:** Observation of the different components of the light components derived from hydrolyrolytic depolymerization of polyethylene mix as shown in Figure 3, Figure 4 respectively and Table 1

Components	As observed in first observation (%V)	As observed in second observation (%V)
Paraffin	30	31
Iso-Paraffin	11	9
Olefin	43	42
Naphthenes	6	7
Aromatic	10	11

The different components on the basis of the carbon number are shown in the Figure 5 and Figure 6. These graphs describe the distribution of the different paraffins, iso-paraffins, olefins, naphthenes and the aromatic hydrocarbon components ranging from C6-C15 [10]. This indicates that the olefin is higher in percentage then the other components.



**Figure 5:** Component distribution of the different hydrocarbon component as per first observation in table 2

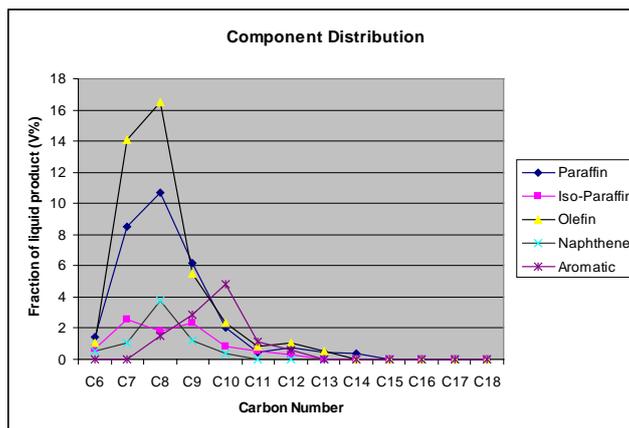


Figure 6: Component distribution of the different hydrocarbon component as per second observation in table 2

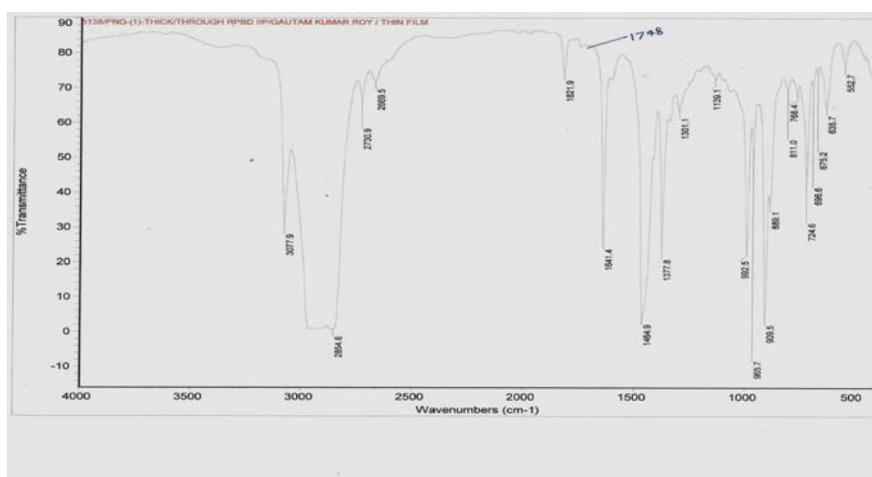


Figure 7: Thick film FTIR study of the recovered Naphtha grade fuel sample by hydrolytic depolymerization of the polyethylene mix

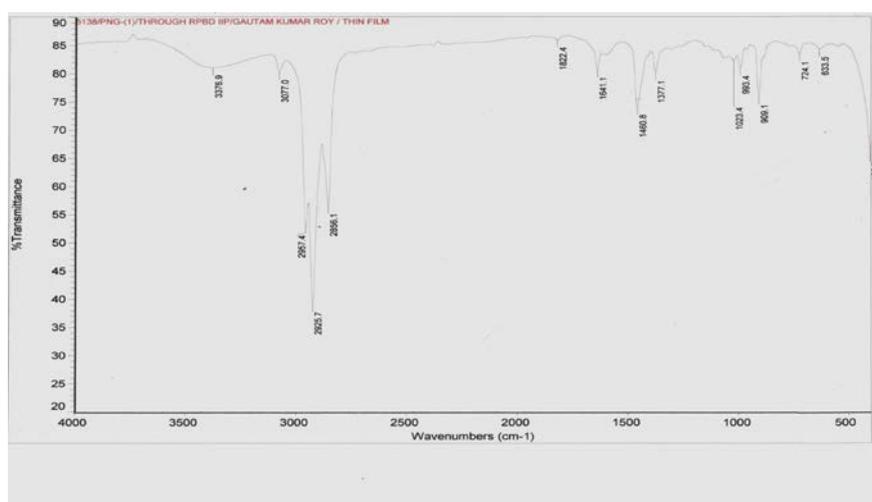


Figure 8: Thin film FTIR study of the recovered Naphtha grade fuel sample by hydrolytic depolymerization of the polyethylene mix

**Table3:** Peak position, possible Functional group/ band and the frequency strength as observed in FTIR study (Figure 7 and Figure 8) of the Lighter Naphtha like component from the polyethylene mix

Peak Position/ Wavelength in $\text{cm}^{-1}$	Possible band/ Functional Group	Frequency Strength
3376.9	Moisture	Weak, In Traces
3077	-C=C-H	Medium
2957.4, 2925.7, 2856.1, 2730.9, 2669.5	Alkyl C-H Strech, Alkane C-H bond	Medium/ Strong/ Weak
1821.9	-C=O Streching , non-conjugate	Weak/ Medium
1641.4	Unsaturated Olefins, (C=C Strech isolate/ conjugate)	Strong
1464.9	CH <sub>2</sub> Bend	Strong
1377.8	CH <sub>3</sub> Bend	Strong
1301.1	C-H Vibration	Weak
992.5, 965.7	Vibration from CH <sub>2</sub> , CH <sub>3</sub> group, - CH=CH- (trans)	Weak to Strong
909.5	C-H bend	Strong
889.1, 811.0, 768.4	C-H bend	Weak
724.6	Short Chain N-Alkane	Medium
696.6	C-H Vibration	Weak, Medium
675.2	-CH=CH- (cis)	Weak
635.7, 552.7	C-H Vibration	Weak, Medium

FTIR spectrum of the above spectra in thick film and thin film respectively is produced in the Figure 7 and Figure 8 and the results were observed in table 3. The FTIR study produces the evidence of the different possible bands having different functional groups present. The different stretching and bending vibrations of the groups were also observed by such study. The energy value of the above data is calculated using the formula  $E=h\nu$  Where  $h$ = Planks constant which is equal to  $6.62 \times 10^{-34}$  J and  $\nu$  = frequency of photon in Hertz ( $\text{sec}^{-1}$ ) Again  $\nu = c/\lambda$ , where  $\lambda$  = wave length,  $W = 1/\lambda$ , Therefore  $E = hcW$ , Where  $c$ = speed of light having value  $3 \times 10^{10}$  cm/sec and  $W$ = Wave number .

This equation indicates that high wave number light has more energy than low wave number light. Thus accordingly the equivalent wave number and its energy value is given in table 4 below.

The chromatographic study and the FTIR study of the naphtha like components were compared with the conventional naphtha components. It was observed that the recovered naphtha components extracted from the polyethylene mix contains higher percentage of the olefinic components, the aromatic and naphthene components were observed to be in low in percentage. The conversion of the saturates into cyclic components is

due to the Dials Alder reaction. The C5-C15 components in different structures were observed in the process of the study. The FTIR study of the thick film and the thin film graph shows different functional groups with different stretching and bending vibrations having different wavelength strengths. The FTIR study also provides the energy values in accordance to the strength of the wavelength produced as given in Table 4.

**Table 4:** Energy values of the functional group in accordance to the wavelength produced in Table 3

Wavelength in $\text{cm}^{-1}$	Energy value (E) in Joule(J)
3077	$6.1109 \times 10^{-20}$
2957.4	$5.8733 \times 10^{-20}$
2925.7	$5.8104 \times 10^{-20}$
2856.1	$5.6722 \times 10^{-20}$
2730.9	$5.4325 \times 10^{-20}$
2669.5	$5.3016 \times 10^{-20}$
1821.9	$3.6182 \times 10^{-20}$
1641.4	$3.2598 \times 10^{-20}$
1464.9	$2.9092 \times 10^{-20}$
1377.8	$2.7363 \times 10^{-20}$
1301.1	$2.5839 \times 10^{-20}$
992.5	$1.9711 \times 10^{-20}$
965.7	$1.9178 \times 10^{-20}$
909.5	$1.8062 \times 10^{-20}$
889.1	$1.7657 \times 10^{-20}$
811.0	$1.6106 \times 10^{-20}$
768.4	$1.5260 \times 10^{-20}$
724.6	$1.4390 \times 10^{-20}$
696.6	$1.3834 \times 10^{-20}$
675.2	$1.3409 \times 10^{-20}$
635.7	$1.2625 \times 10^{-20}$
552.7	$1.0976 \times 10^{-20}$

## 5. Conclusion

The conversion of the waste polyethylene mix such as LDPE, LLDPE, MDPE and HDPE type of the polyethylene into useful hydrocarbon components is one of the key challenges today. The conversions of the waste polyethylene mix into different hydrocarbon components from C5-C15 were studied. The different hydrocarbon components observed by the chromatographic study of the extracted naphtha component is estimated. The characteristic properties of the components according to their carbon number is also studied. The

distributions of the hydrocarbon such as paraffinic, iso-paraffinic, olefinic, naphthenic and aromatic components were studied and their distributions of components according to the carbon number were observed. It was observed that the olefinic material in the naphtha like components under study is more in percentage than the paraffinic and aromatic components. It was observed from the chromatographic study that the olefinic components were in the range of 40%-45% of the total volume of the extracted naphtha like component from waste polyethylene mix. The study also reveals the formation of the aromatic and cyclic components with increase in the residence time and by following Diels Alder reaction mechanism. The thin film and the thick film FTIR study of the naphtha like component produce and confirm the different functional groups with single, double and triple bond hydrocarbon components. The FTIR study produces the evidences of the stretching and the bending situation of the different components with their strengths according to the different wave number. The above study also provides the calculated energy value of the functional groups according to their wave number. With the decrease in the wave number the energy value decreases. The above findings provide an information regarding the naphtha like component extracted from the waste polyethylene mix which may be used as a key component for different useful chemical compounds and as an alternative fuel source.

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