



## INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

### CRACKING OF PALM OIL TO PRODUCE OLEOCHEMICALS

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#### ABSTRACT

The FTIR and GC-MS tests are necessary for identification of oleochemicals produced via cracking. In this research, thermal cracking (without catalyst) and catalytic cracking of palm oil were carried out in a batch reactor. The thermal cracking was performed at temperatures of 700°C to 900°C at a time of 30 to 150 minutes while the catalytic cracking was done at temperatures of 100°C to 400°C, time of 30 to 150 minutes and catalyst weight of 10 to 50 grams. The evaluation of products involved FTIR, GC-MS, and Effects of process parameters (Temperature, Time and catalyst weight) on acid value, density and kinematic viscosity. Viscosity, acid value and density of the liquid condensates fall within the accepted limit of the oleochemical standard, and this showed that triglyceride molecules in the palm oil were broken down to light molecules. The research also showed that Catalytic cracking of palm oil (at a much lower temperature levels) with the aid of clay catalyst yielded better oleochemicals to that obtained from thermal cracking of oil at a very high temperature. This work showed that it is a good process that can be used industrially in obtaining oleochemicals that can serve for different purposes.

**KEYWORD:** Fourier Transform Infrared Spectroscopy (FTIR), Gas Chromatography-Mass spectrometry (GC-MS), oleochemicals, palm oil, catalytic and thermal cracking

#### INTRODUCTION

One of the alternative fuels currently being studied is biofuels and chemical intermediates (Oleochemicals) obtained from vegetable oil. Liquid biofuel obtained from vegetable oil, is renewable and also free of nitrogen and Sulphur compound as compared with fossil fuel [1]. Among all of the Vegetable oils, palm oil is one of the vegetable oil that has the greatest possibility to be used in bio fuel production because of its abundance in nature. Oleochemicals are chemicals derived from oils and fats [2]. They are analogous to petrochemicals which are chemicals derived from petroleum [3]. Oleochemicals or derivatives based on C<sub>12</sub>-C<sub>14</sub> and C<sub>16</sub>-C<sub>18</sub> chain lengths have a variety of uses. Tallow and coconut oil have been the traditional raw materials used for the production of C<sub>16</sub>-C<sub>18</sub> and C<sub>12</sub>-C<sub>14</sub> chain lengths respectively [4]. The hydrolysis or alcoholysis of oils and fats formed the basis of the Oleochemicals industry. The five basic Oleochemicals are Fatty acids, Fatty Methyl esters and Ethyl esters, fatty

alcohol, fatty nitrogen compounds and glycerol [5]. The process of derivation or obtaining these chemical intermediates from palm oil requires high temperature pyrolysis, alcoholysis, gasification or destructive distillation in the presence of a catalyst. Activated clay has been used extensively for over 60 years as catalyst for bleaching of palm oil [4]. Therefore, this study intends to crack palm oil using thermal cum acid activated clay.

#### 2.0 Mechanism for the Cracking of Palm Oil:

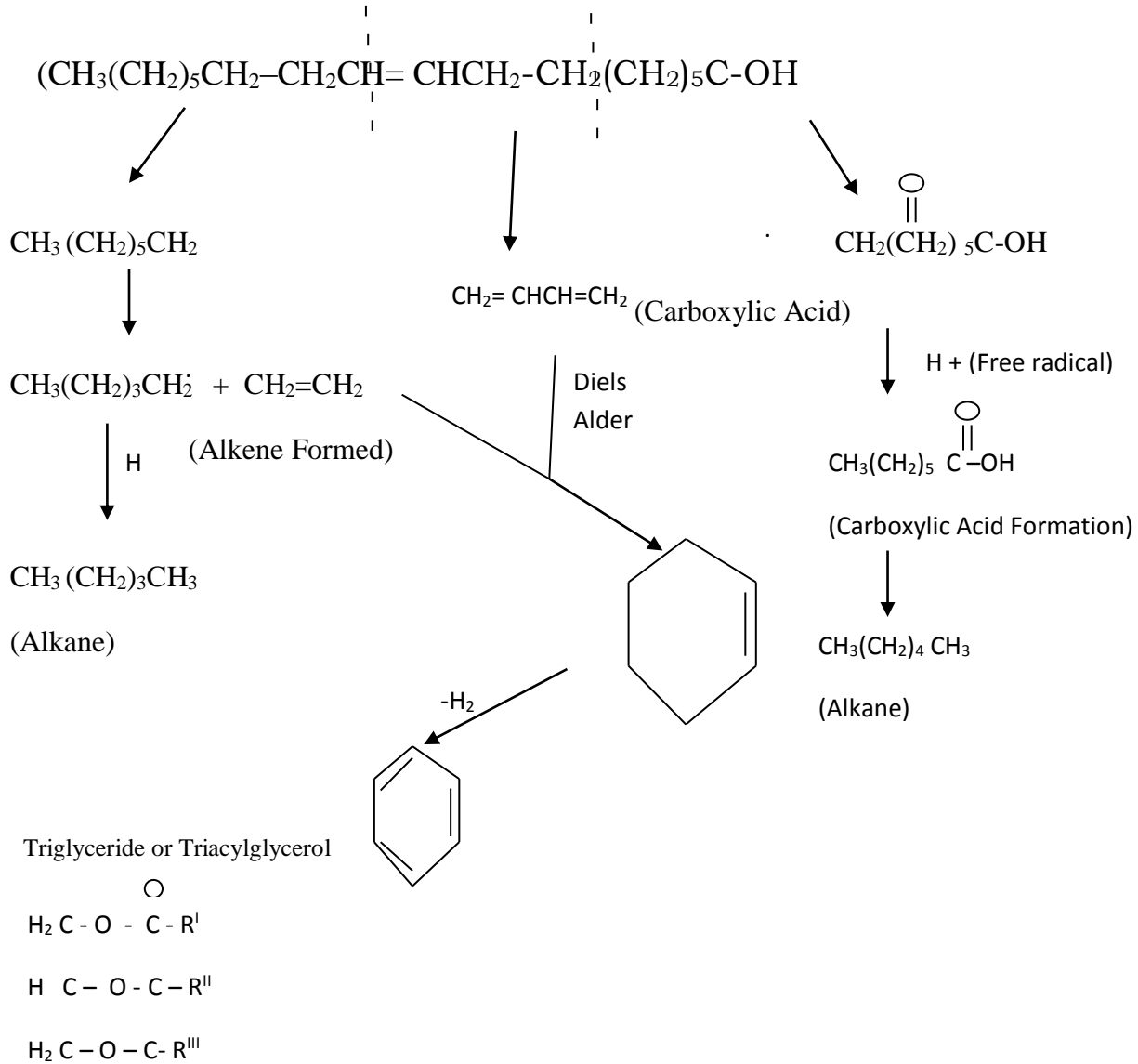
##### 2.1 Reaction pathways for triglyceride cracking in palm oil

Thermal decomposition of triglycerides produces compounds of classes including alkane, alkenes, alkadienes, aromatics and carboxylic acids. Thermal decomposition of its structures proceeds through either free-radical or carbonium ion mechanism as shown below:

- i) Formation of alkanes, alkenes, fuel gases (CO, CO<sub>2</sub>, H<sub>2</sub>) is by the generation of the

- RCOO radical from the triglyceride cleavage and subsequent loss of carbon (iv) oxides isomerisation results in formation of C<sub>5</sub> to C<sub>10</sub> alkanes
- ii) Formation of aromatics is supported by a Diels-Alder addition of ethylene to a

- conjugated diene formed in the pyrolysis reaction.
- iii) Carboxylic acids formed during the pyrolysis of vegetable oils probably result from cleavage of the glyceride moiety.

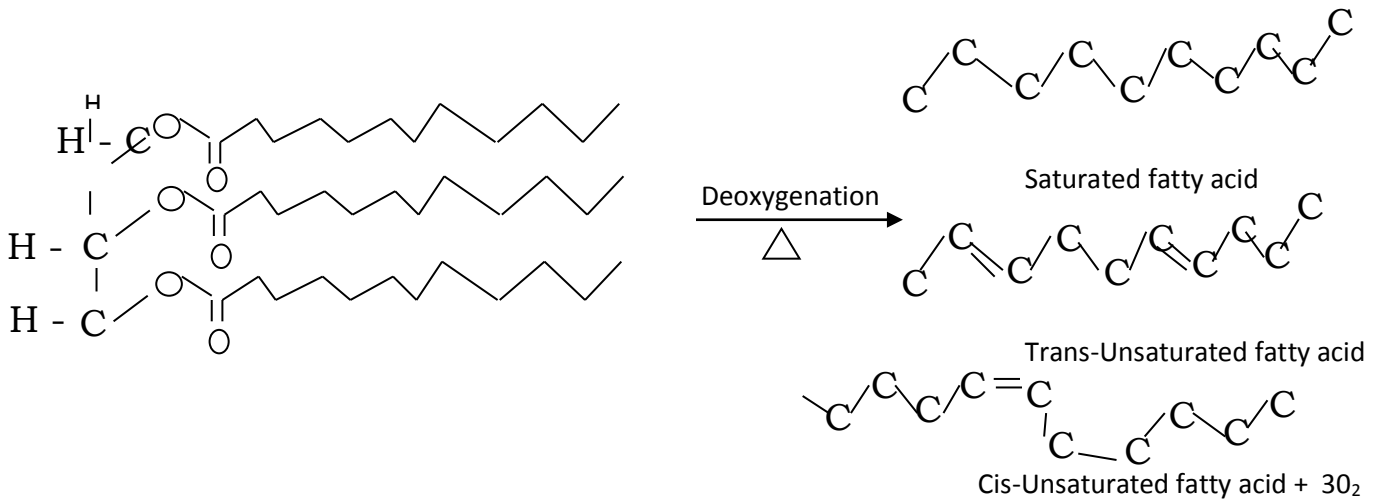


Where R<sup>I</sup>, R<sup>II</sup>, R<sup>III</sup> - Hydrocarbon

**A) Deoxygenation and Cracking:**

This involves the splitting of the carbon attached with the oxygen atom bonding it to form aliphatic hydrocarbons (e.g. Alkane were oxygen atom is replaced by H<sup>+</sup> as a result of heating the triglyceride

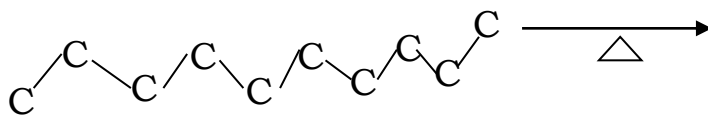
molecule. The effect of deoxygenation also leads to the formation of alkanones (Ketone) which is as a result of electromeric effect involves sharing of electrons from one atom to another joined by a double or triple bond.



**B) Secondary cracking and Deoxygenation:**

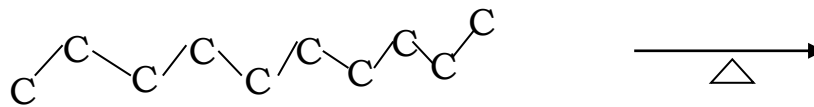
Further cracking here results in the formation of aliphatic hydrocarbons of 2 to 10 carbons (ethane, propane, pentane, Hexane, butane, heptane)

- i. At this Stage the Saturated Fatty Acid will Result in the Formation of Paraffin (an Alkane).



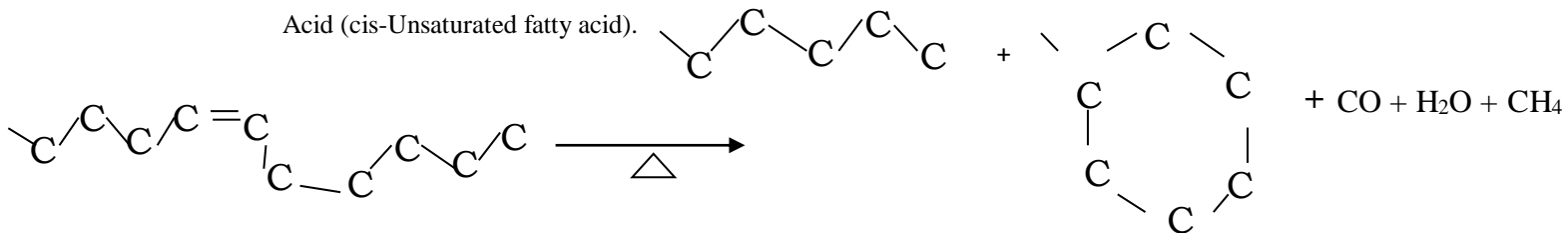
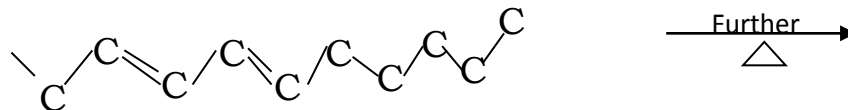
Alkane (paraffin) + CO<sub>2</sub> + H<sub>2</sub>O

- ii. The Breakdown of the Unsaturated Fatty Acid (Trans-Unsaturated Fatty Acid)



(Trans-unsaturated fatty acid)

- iii. The Breakdown of the Unsaturated Fatty Acid (cis-Unsaturated fatty acid).

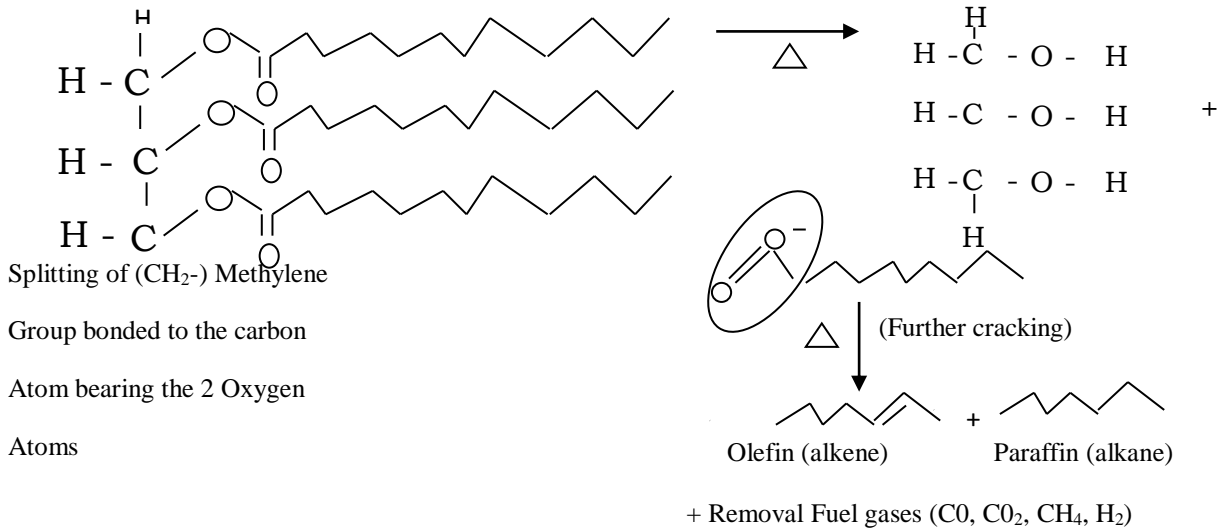


Cis-unsaturated fatty acid

iv Formation of Alcohol:

The triglyceride molecule has a tendency of forming water triglyceride as a result of the presence of the hydroxyl-OH group and the hydrogen covalently

bonded to the carbon. This is by a process called hydrolysis which can occur during the heating of the triglyceride resulting in the formation of a free fatty acid and glycerol.



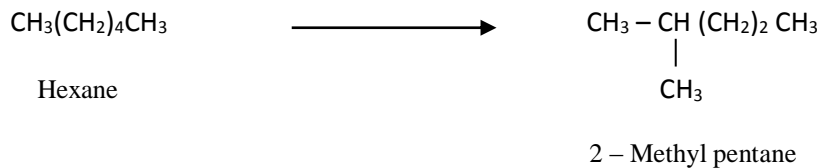
**C. Oligomerization:** This is the process of converting a monomer or a mixture of monomers to macromolecular complexes. This process results in the formation of olefins (called alkene) and paraffins (an alkane) as stated previously the splitting of the unsaturated and saturated fatty acids to formation of hydrocarbons of 2 to 10 carbons.

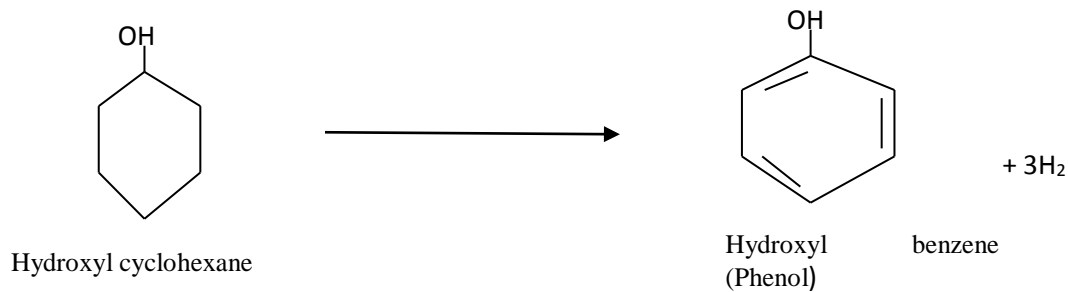
Before aromatization can occur Isomerization must have taken place. Isomerization is the arrangement of straight chain hydrocarbons to branched hydrocarbon, unsaturation leads to branching and formation of cyclic compound(s), this occurs as a result of breakdown of the Cis-and trans-fatty acid (which are unsaturated) yield of hydrocarbon of 2 to 10 carbons of which cyclohexane is formed.

**D. Aromatization:**

i. Formation of Aromatic compound from an alkane (cycloalkane) by dehydrogenation.

- Branching





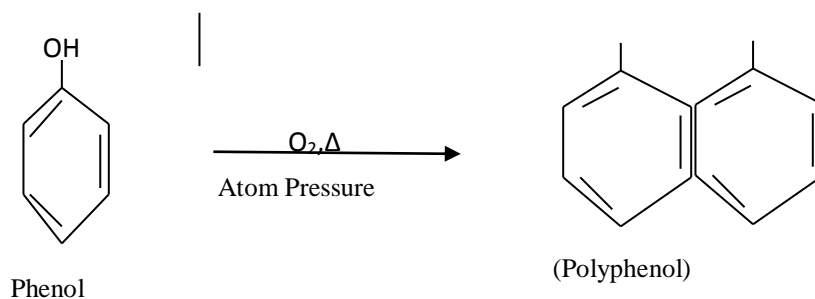
## ii. Alkylation:

The combination of alkene and alkane (olefin and paraffin) as cracking continues results in the

combination of the two aliphatic hydrocarbons to form a long chain hydrocarbon.

**E. Polymerization:**

When an alkane, alkene and Aromatic compound is heated with traces of oxygen or peroxide, a compound of higher molecular weight is obtained.

**F. Coke:**

This is basically fuels with impurities and high carbon content obtained during a cracking process of vegetable oil or petroleum.

**MATERIALS AND METHODS****Raw material:**

The raw material was purchased from the market; the palm oil obtained underwent degumming in order to remove particulate matter in form of impurities, followed by dehydration for removal of water. It was then characterized to check for its physio-chemical properties before it was used for cracking and was compared with ASTM standards with the results shown in Table 1.

**Preparation of catalyst:**

The clay catalyst used as an adsorbent underwent carbonization at a temperature of 500°C for 5 hours after which it was activated with sulphuric acid. Characterization of the clay sample is done to check for its physical and chemical properties, as well as the ability of the clay to act as adsorbent.

**Cracking of the Palm Oil:**

A known volume of palm oil was measured and placed in flat bottom flask in a rotary evaporator. It was then heated to a certain temperature for a particular time. The solution was allowed to settle for 30 minutes and separated to obtain the oleochemical. Then the yield of oleochemical was calculated using the equation below:

$$\text{Yield of oleochemical, } Y = \frac{\text{weight of oleochemical produced}}{\text{weight of palm oil}} \times 100 \quad (1)$$

The production of oleochemicals from palm oil cracking was optimized using Central composite design (response surface methodology) to determine the optimum values of the process variables. To examine catalytic cracking of palm oil the combined effect of the three different factors (independent variables): temperature, time and catalyst weight were used to develop experimental design to study their effect on the yield of oleochemicals production. The experiments were performed in random order to avoid systematic error.

## RESULTS AND DISCUSSION

### Characterization of raw palm oil

The physicochemical properties of raw palm oil were shown in Table 1. From the table, it could be seen that the palm oil met the ASTM standard and can be converted to oleochemical without treatment because of its low free fatty acid.

*Table 1: Characterisation result of raw palm oil as compared to ASTM standard*

Parameters	Concentration	ASTM standard
Acid value (g KOH/g %)	0.36	0.8max.
Saponification value (%)	65.92	62.31
Free fatty acid (%)	0.18	0.5
Peroxide value (mleq/kg)	25.25	40.31
Specific gravity	0.92	0.875-0.95
Bulk density (g/ml)	1.064	0.875-1.0
Cloud point( <sup>0</sup> C)	65	69
Pour point( <sup>0</sup> C)	95	93
Flash point( <sup>0</sup> C)	98	95
Viscosity (pa.s)	8.46	7.5-8.5

### Charaterization of clay

*Table 2: Characterisation result of the raw and activated clay*

Parameter/Adsorbents	RAW	ACTIVATED
Ash content (%)	10.05	7.51
Bulk density (g/cm <sup>3</sup> )	0.83	0.59
Moisture content (%)	5.00	2.00
Volatile matter (%)	5.50	3.20

From Table 2, the raw clay has higher value of ash content, bulk density, moisture content and volatile matter. Raw clay has higher value of ash and volatile content than activated clay because carbonization quickly destroys the useless mineral substances in the carbon during activation. Also heating reduces the moisture build up in the activated clay. The lower % yield observed for the activated clay could be because of the heat destroying the aliphatic and aromatic species present in the substrate and hence removing the volatile matter during the significant removal of organic by products and minerals present in the activated carbon surface during activation.

### Scanning Electron Microscopy analysis

The surface morphology of the clay without activation and that with activation is measured with the help of SEM and is presented in the Figures 1 and.2. It is clearly observed that the surface of the clay in Fig. 2 has been changed into new shiny bulk particles and whitish patches structure after activation which shows that the carbonization

creates higher surface area and pore structure. It is therefore observed that activation of clay improved the adsorptive sites on the surface of clay.

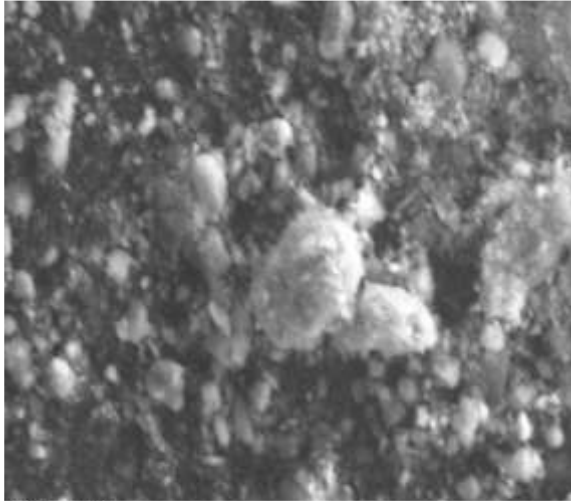


Figure 1: SEM result of raw clay sample

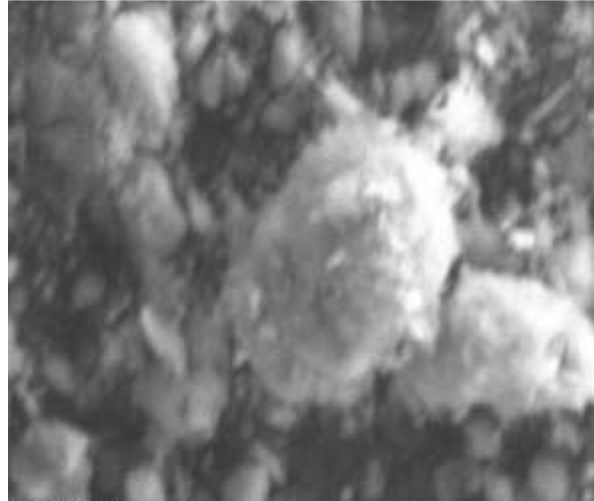


Figure. 2: SEM result of the activated clay sample

#### X-Ray Fluorescence analysis

The XRF characterization was performed to know the chemical compositions of the minerals that are present in the clay. The  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  are the key minerals that are responsible for the strength of the clay in acting as an adsorbent, which makes it function as a catalyst. It is seen from the table below that the percentage composition of the minerals (with exception of  $\text{TiO}_2$  and  $\text{NiO}$ ) increased after activation which indicates that chemical activation of clay promotes the minerals present in the clay. This confirms the chemical analysis of the clay sample.

Table 3: XRF result of the raw and activated clay samples

Chemical Constituents	Raw Clay (%)	Activated Clay (%)
$\text{Al}_2\text{O}_3$	34.80	35.70
$\text{SiO}_2$	41.90	43.00
$\text{K}_2\text{O}$	2.95	3.05
$\text{CaO}$	0.72	0.85
$\text{TiO}_2$	3.78	1.81
$\text{V}_2\text{O}_5$	0.15	0.17
$\text{Cr}_2\text{O}_3$	0.10	0.10
$\text{MnO}$	1.02	1.08
$\text{Fe}_2\text{O}_3$	12.08	14.00
$\text{NiO}$	2.43	0.23

**Effect of process parameters on oleochemical production****Table 4: Design of Experiment using Response Surface Methodology: Thermal Cracking of palm oil (without catalyst) Temperature: 700 – 900°C, Time: 30 - 150 Minutes**

S/NO	TEMP (°C)	TIME (MINS)	YIELD (%)	KINEMATIC VISCOSITY (Pa.S)	DENSITY (g/cm <sup>3</sup> )	ACID VALUE (mg NaOH/g)
1	700	30	84	3.44	0.80	0.08
2	900	30	85	3.85	0.77	0.15
3	700	150	82	4.38	0.81	0.08
4	900	150	84	4.32	0.97	0.09
5	658.58	90	81	6.78	0.74	0.14
6	941.42	90	82	4.24	0.86	0.33
7	800	5.15	88	4.85	0.85	0.09
8	800	174.85	85	3.48	0.78	0.16
9	800	90	86	2.37	0.76	0.12
10	800	90	87	3.58	0.86	0.19
11	800	90	89	3.23	0.82	0.23
12	800	90	87	3.19	0.85	0.18
13	800	90	86	3.183	0.83	0.19

**Table 5: Design of experiment using response surface methodology: catalytic cracking of palm oil temperature: 100 – 400°C, time: 30 – 150 mins, catalyst: 10 – 50 grams**

S/NO	TEMP (°C)	TIME (MINS)	CATALYST (GRAMS)	YIELD (%)	KINEMATIC VISCOSITY (Pa.S)	DENSITY (g/cm <sup>3</sup> )	ACID VALUE (mg NaOH/g)
1	400	150	10	84	2.499	0.88	0.22
2	400	30	50	85	1.891	0.86	0.18
3	100	150	50	85	2.555	0.78	0.20
4	100	30	10	89	2.139	0.74	0.15
5	37.87	90	30	85	1.566	0.70	0.19
6	462.13	90	30	84	1.957	0.80	0.21
7	250	5.15	30	87	2.080	0.82	0.26
8	250	174.85	30	87	2.540	0.87	0.17
9	250	90	1.72	90	2.304	0.70	0.16
10	250	90	58.28	89	2.923	0.90	0.18
11	250	90	30	89	2.068	0.86	0.14
12	250	90	30	90	2.592	0.87	0.15
13	250	90	30	91	1.887	0.90	0.13
14	250	90	30	90	2.511	0.82	0.23
15	250	90	30	89	2.068	0.86	0.22



ASTM standard was used to obtain the sample with the best yield and most suitable condition based on the results of the dependent variables being studied such as Kinematic Viscosity, Density and Acid Value. From the different runs it is seen that sample 10 (from the thermal cracking in Table 4) and sample

12 (from the catalytic cracking in Table 5) gave the best yield when compared to standard in Table 6. These samples are now subjected to machine test analysis (FTIR and GS-MS) in order to determine the oleochemicals present.

**Table 6: US and Indian standards for oleochemicals**

Standards for oleochemicals	ASTM D-6751	IS 15607 : 2005
Density	0.86 – 0.90 g/cm <sup>3</sup>	860 - 900 g / cm <sup>3</sup>
Ester Content	Not Mentioned	96.5 %
Flash point (closed cup)	130°C min. (150°C average)	120°C
Water and sediment	0.050% by vol., max.	500 mg / Kg, max.
Kinematic viscosity at 40°C	1.9-6.0 mm <sup>2</sup> /s	2.5-6.0 mm <sup>2</sup> /s
Oxidation Stability	Not Mentioned	6 hours min, at 110°C
Cetane Number	47 min.	51 min.
Carbon residue	0.050% by mass, max.	
Acid number, mg KOH/g	0.80 max.	0.50 max.
Methanol or Ethanol	Not Mentioned	0.2 % m/m, max
Free glycerin	0.020 % mass	0.020 % mass
Total glycerine (free glycerine and unconverted glycerides combined)	0.24% by mass, max.	0.25% by mass, max.
Group I Metal (Na+K)	5 mg/Kg, max	5 mg/Kg, max
Group II Metal (Ca+Mg)	Not Mentioned	5 mg/Kg, max
Phosphorus content	0.001 max. % mass	10 mg/Kg, max

Witchakorn and Vitidsant (2003), [9].

### Tests and Results of FTIR Spectra analysis

FTIR analysis of the palm was done to predict the functional groups and hydrocarbons of both the raw palm oil sample before cracking, and that for the thermal and catalytic cracking optimum process conditions. The samples selected for the FTIR and GC-MS tests are the samples whose dependent variables such as kinematic viscosity, density and acid values conform best to the biodiesel standard used as a bench mark in this work. The profiles by FTIR spectroscopy for raw palm oil, thermal and catalytic cracked oil samples are shown in Tables 7, 8 and 9 and in Figures 2, 3 and 4. From Table 7, 8 and 9 and Figures 3, 4 and 5, the FTIR spectra of thermal and catalytic processes indicated the presence of carbonyl compounds (Alkane C-H, Alkene C-H, Aldehyde C=O, Ketone C=O, Ester C=O, Carboxylic Acid C=O and Amide C=O stretch) which is one of the strongest IR absorption and is very useful in structure determination of hydroxyl, esters, aliphatic hydrocarbons (alkane, alkene), phenols, carboxyl and anhydrides groups. FTIR spectra of activated carbons wave number (cm<sup>-1</sup>) increases after activation, from 616.28 to 1257.63 for catalytic cracked oil and from 558.31 to 1195.91 for thermal cracked oil. The peak around 616.28 cm<sup>-1</sup> (C-H bond) shifted to higher frequencies 1257.63 cm<sup>-1</sup> (C-C(O)-C stretch in ester and alcohol, C-C stretch in ketone), also the peak around 588.31 cm<sup>-1</sup> (C-Cl stretch in alkyl halide) shifted to higher frequencies 1195.91 cm<sup>-1</sup> (C-O Stretch in alcohol). Butzetski et al (2010) reported a similar result. The above changes in the spectra may be attributed to the interaction effect of heat on the triglyceride molecule resulting in different pathways such as deoxygenation, isomerization, polymerization etc.

**Table 7: Fourier Transform Infrared Spectrum for raw palm oil**

Wave number (cm <sup>-1</sup> )	Bond Source
558.31	C-CL stretch in alkyl halide
616.28	C-Cl, C-Br in alkyl halides and C-H bend in alkynes
872.82	PH bend in phosphine
1119.71	C-O-C, Alkyl-substituted ether, C=O stretch
1274.03	O-H, Primary or secondary, OH in-plane bend
1480.42	C=C stretch in aromatics
1607.72	N-H bend in amines
1867.16	Aromatic Combination bands
2099.59	Transition Metal carbonyl
2236.54	C=C stretch in alkynes
2498.86	O-H stretch in carboxylic acids
2646.42	O-H stretch in carboxylic acids
2866.32	C-H stretch of alkanes
3031.23	Medial, <i>cis</i> - or <i>trans</i> -C-H Stretch in alkenes
3105.5	C=H stretch in alkenes
3271.38	Hydroxyl group, H-bonded OH stretch
3437.26	Hydroxyl group, H-bonded OH stretch
3656.19	O-H Stretch in phenols and alcohols
3788.32	O-H Stretch in phenols and alcohols
3962.88	O-H Stretch in phenols and alcohols

**Table 8: Fourier Transform Infrared Spectrum thermal cracked oil**

Wave number (cm <sup>-1</sup> )	Bond Source
612.42	C – CL bend In alkyl Halides
752.26	C- O stretch in alcohols
1195.91	C – O Stretch in alcohol
1263.42	C-O Stretch in carboxylic acid
1418.69	C-H in plane bend in alkenes, aromatic phosphate
1584.57	N – H bend in amines, N-O in nitro compounds
1873.91	Aromatic Combination Bands
2261.61	C=N stretch Aliphatic cyanide/nitrile
3067.88	O – H stretch in carboxylic acids
3178.79	O – H stretch in carboxylic acids
3351.43	N-H stretch in Aliphatic secondary amines
3394.83	O– H, Normal polymeric O-H stretch
3409.3	N – H stretch(1 per N-H bond) in amines
3547.21	O – H, H – bonded OH stretch
3655.23	O – H stretch in phenols and alcohols
3832.68	O – H stretch in phenols and alcohols
3901.16	O - H stretch in phenols and alcohols

**Table 9: Fourier Transform Infrared Spectrum for catalytic cracked oil**

Wave number (cm <sup>-1</sup> )	Bond Source
767.69	C-H bend (mono) in aromatics, methyl
927.79	Cyclohexane ring vibrations
1257.63	C – C Stretch in ketone, C-C(O)-C in ester, alcohol
1320.32	C=C Conjugation stretch in alkenes
1431.23	Methyl C-H asymmetric bend
1585.58	C = C-C, Aromatic ring stretch
1617.37	C- C stretch in alkynes
1774.7	C– H stretch in alkanes, ester
1873.91	Aromatic Combination Bands
2085.12	Transition metal carbonyl
2566.37	O-H stretch in carboxylic acids, alcohol, phenol
2677.29	O-H stretch in carboxylic acids, alcohol
3293.56	O– H, Normal polymeric OH stretch
3472.95	O – H, Dimeric OH stretch
3648.48	O – H stretch in phenols and alcohols
3842.33	O – H stretch in phenols and alcohols
3959.03	O – H, stretch in phenols and alcohols

**GC-MS result analysis**

To identify the fatty acid content and quantity of the cracked palm oil, GC-MS analysis were conducted on the raw, catalyzed and thermal cracked palm oil samples. GC-MS analysis was used to identify the Fatty acids present and hydrocarbon content of palm oil before the thermal and catalyzed reaction for comparison. The results of the analysis of the palm oil and cracked palm oil samples are shown in Tables 10, 11 and 12 and Figures 6, 7 and 8. From the images of the GC-MS on palm oil samples, it was observed that heat had a significant effect in the thermal and catalytic cracked oil samples with the increase in the peak as shown in their results whereas for the raw palm oil sample it appears in traces. This showed that the palm oil was cracked resulting in the formation of more useful fatty acids and oleochemicals, however catalytic oil sample gave the best result for the three due to the formation of more fatty acids and hydrocarbons and also the increase in the yield values of the fatty acids and oleochemical products. Also based on the result of GC-MS analysis on the palm oil, there are 8 main fatty acid molecules in the palm oil triglyceride: some having single bond while others having double bond, The catalyst pore or a high temperature was expected at least to be able to crack the double bond in the oleic acids structure of catalyst pore trapped triglyceride because double bonds are easier to be cracked compared to single bonds [1]. Non-saturated molecules are not wanted in fuels because they tend to react with some impurities or even react to each other in a polymerization reaction forming unwanted big molecules. The expected reaction mechanism is illustrated below:

**Table 10: Possible Fatty acids/hydrocarbons present and their % weight in raw palm oil**

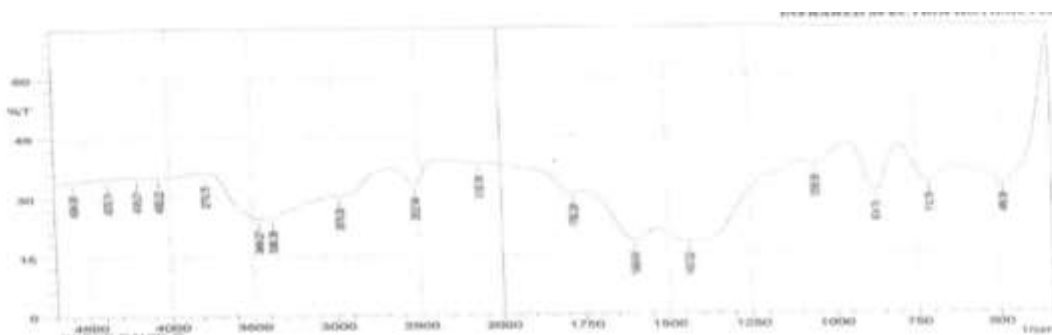
Hydrocarbon molecule (fatty acids)	Name	% weight
C <sub>12</sub>	Lauric acid	5.71
C <sub>14</sub>	Myristate	50.13
C <sub>10</sub>	Capric acid	1.52
C <sub>11</sub>	Undecylic acid	10.29
C <sub>16:1</sub>	Palmitoleate	4.87
C <sub>18:2</sub>	Linoleate	4.37
C <sub>17</sub>	Margaric acid	0.82
C <sub>18</sub>	Methyl stearate	10.16
C <sub>9</sub>	Dimethyl pentane	4.00
C <sub>8</sub>	Dimethyl hexanone	1.10
C <sub>6</sub>	Dimethyl tetrahydrofuran	7.03

**Table 11: Possible fatty acids/hydrocarbon molecules present and their % weight in thermal cracked palm oil**

Hydrocarbon molecules	Name	%weight
C <sub>10</sub>	Capric acid	1.27
C <sub>11</sub>	Undecyclic acid	6.49
C <sub>12</sub>	Lauric acid	4.00
C <sub>20:2</sub>	Arachidic acid	12.16
C <sub>14</sub>	Myristste	6.59
C <sub>16:1</sub>	Palmitoleate	25.82
C <sub>17</sub>	Magaric acid	3.84
C <sub>18</sub>	Ethyl Stearate/Stearic Acid	12.22
C <sub>25</sub>	Pentacosylic acid	2.70
C <sub>30</sub>	Melissic acid	4.75
C <sub>19</sub>	Octadecenoic acid	3.08
C <sub>6</sub>	Nitrohexane	2.12

**Table 12: Possible fatty acids and hydrocarbons present and their % weight in catalytic cracked palm oil**

Hydrocarbon molecules	Name	% weight
C <sub>10</sub>	Capric acid/Nonanoic acid	1.27
C <sub>11</sub>	Undecyclic acid	7.49
C <sub>12</sub>	Lauric acid/ Ethyl ester	6.04
C <sub>18:2</sub>	Linoleic acid	12.13
C <sub>14</sub>	Myristste/ Tridecanoic acid	4.59
C <sub>16:1</sub>	Palmitoleate	19.88
C <sub>17</sub>	Magaric acid	4.84
C <sub>18</sub>	Stearic Acid	10.21
C <sub>25</sub>	Pentacosylic acid	3.70
C <sub>30</sub>	Melissic acid	4.75
C <sub>19</sub>	Octadecanoic acid methyl ester	3.01
C <sub>13</sub>	Dodecanoic acid	7.06
C <sub>15</sub>	Tetradecanoic acid Ethyl ester	5.03



**Figure. 3: FTIR Result of the raw palm oil sample**

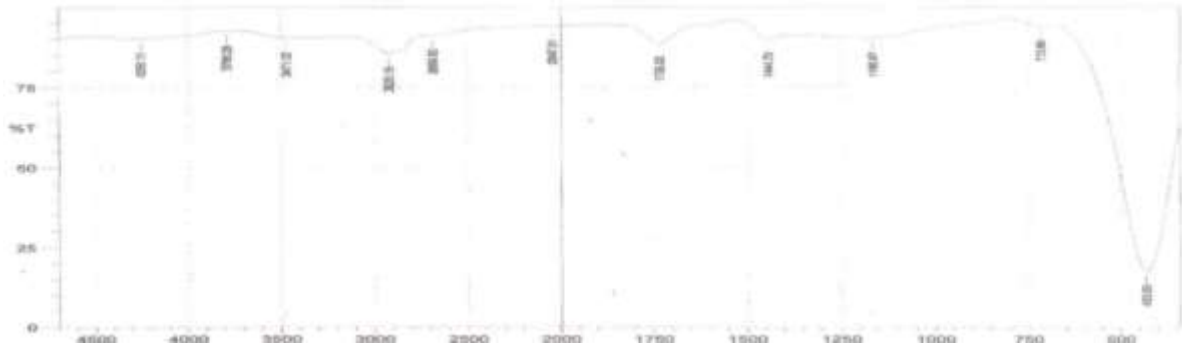


Figure 4: FTIR result of catalytic cracked palm oil sample (Temp: 250°C, Time: 90mins, Catalyst weight: 30 grams)

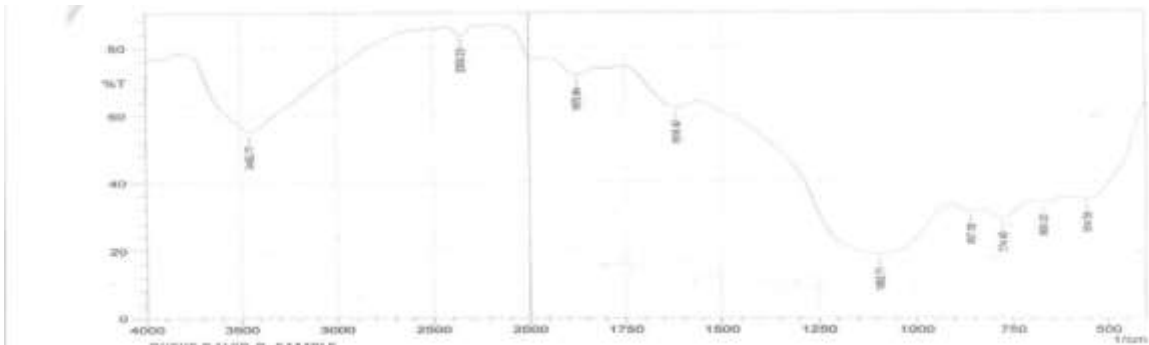


Figure 5: FTIR result of thermal cracked palm oil sample (Temp: 800°C, Time: 90mins)

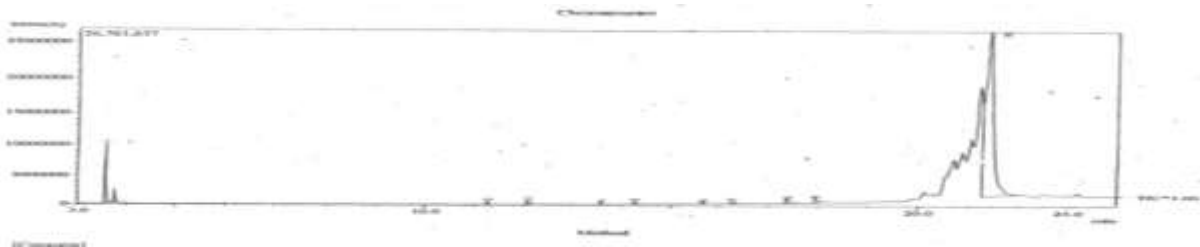


Figure 6: GC-MS result of the raw palm oil sample

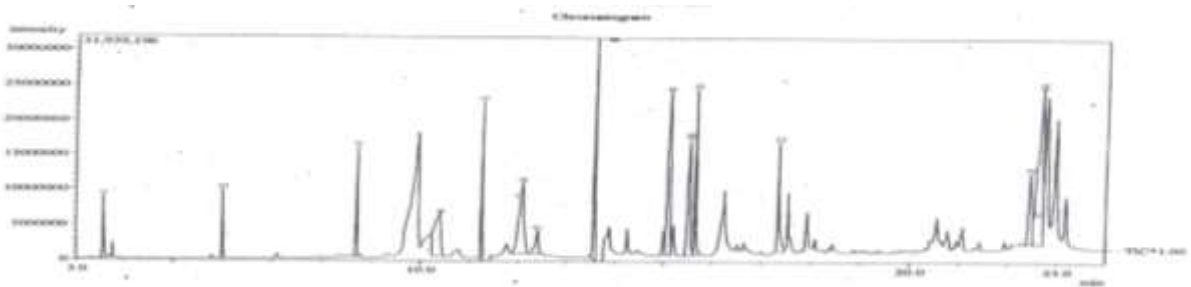


Figure 7: GC-MS result of the thermal cracked palm oil sample

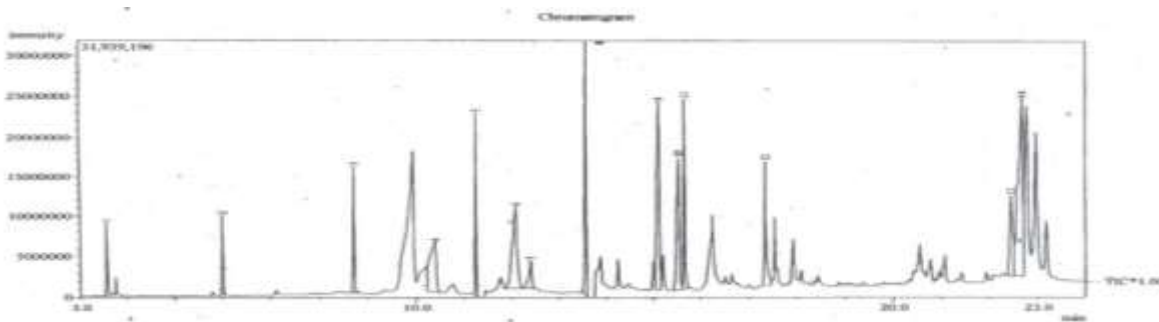


Figure. 8: GC-MS result of the catalytic cracked palm oil sample

## CONCLUSION

The evaluation of products involved FTIR, GC-MS, and Effects of process parameters (Temperature, Time and catalyst weight) on acid value, density and kinematic viscosity. Viscosity, acid value and density of the liquid condensates fall within the accepted limit of the oleochemical standard, and this shows that triglyceride molecules in the palm oil were broken down to light molecules. The research also shows that Catalytic cracking of palm oil (at a much lower temperature levels) with the aid of clay catalyst yielded better oleochemicals to that obtained from thermal cracking of oil at a very high temperature. This work also showed that this is a good process that can be used industrially in obtaining oleochemicals.

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