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PRODUCTION OF LOW MOLECULAR WEIGHT FATTY ACIDS AND LIQUID FUEL FROM SPENT FRY OIL

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ABSTRACT

Waste fry oil was cracked in an autoclave with hydroquinone as a catalyst. The cracking process was conducted at different temperatures, in air blanket of 0.75 MPa for 30 min time of reaction. The feed oil and the obtained degraded oil at 425 °C were compared as petroleum crude oils via inspection of their physicochemical characteristics. Also the feed oil and the oils degraded (at different temperatures) were treated chemically for separating their liquid hydrocarbon and fatty acid constituents from each other. Moreover the obtained fatty acids were esterified to obtained their methyl esters. Meantime the prepared esters and the liquid hydrocarbons that extracted from the cracked oil at 425 °C were identified by gas chromatography technique.

INTRODUCTION

It is true that the highly advanced civilization of the recent century is supported by petroleum **[Abul-Hamayl (2002)]**. A switch from coal to petroleum which in other words is the liquefying revolution of energy has brought about many influences in the world. No doubt that the petroleum fuel is depletable and the hope of natural liquid fuel forever is restricted actually in the edible and nonedible oils. To realize this thought soon or later one must manage for increasing the field area of oil plants. Transferring these oils to petroleum fuel like, must be dealt chemically i.e. this must be the responsibility of chemists. Moreover tree and vegetable oils are good source of fatty acids **[Hussin, et al. (2001)]** .The predominant fatty acids molecules in these triglycerides oils are saturate and unsaturated molecules having only an even carbon number mainly of C_{16} and C_{18}. Low molecular weight fatty acid of even and odd

carbon number range from C_4 to C_{11} considered rare in nature **[Al-Amrousi & Ibrahim (2003)]**.

The previous concepts motivated us not only to tackle the disposal problem of used fry oil, but also to create a way for cracking to this waste liquids to produce low molecular weight fatty acids and to get a renewable liquid biofuel. The obtained nil sulphur and nitrogen content fuel maybe represent the solution for replacing the sour fossil fuels to meet the clean environment philosophy. The Chemical aspects of the applied process summarized in employing Oxygen gas and phenolic catalyst to play a role in degradation of used fry oil molecules. This may occurs by stripping the hydrogen atoms from these molecules, giving macroradicals and water via the shuttling motion of the phenoxy radical between **[Al-Amrousi & Ezat (2000)]** oxygenated hydrocarbon molecules and oxygen. The obtained radicals must be degraded according to β- fission rule to a lower molecular weight fry oil **[Al-Amrousi (1998)]**.

EXPERIMENTAL WORK

A-Materials:

Spent fry vegetable oil used in this study was obtained from Kentuky shop in Abass El-Akad Street, Cairo, Egypt as a liquid waste. The sample was heated to 60°C and filtrated under a pressure in press filter to get clear and clean spent fry oil. Physicochemical properties of this oil are shown Table (1).

B - Degradation Process.

Oxidative cracking of refused fry oil is carried out in an stainless steel autoclave model 4551 (3.7 liters) supplied by "Parr Instrument Company in U.S.A.". The reaction was achieved at temperatures ranged from 275 °C to 425 °C. In each experiment a 500g from spent fry oil (SFO) were charged inside the reactor, hydroquinone was added as a catalyst (0.6 wt% based on the oil weight. Then the reactor was sealed and charged by air (0.75 MP_a), the electrical heater and agitator were then turned on and after heated up for a period (30 –50 min), the system was held at the desired temperature for 30 minutes as a time of reaction. After this period the heater was turned off and the bomb was allowed to cool at room temperature then pressure was reduced. Reactor was opened, cracked oil was filtrated, char and liquid were weighted, and

evolved gases were estimated from the material balances (mass balance) by difference.

C- Extraction of fatty acids from the degraded oils as fatty acid methyl esters:

The feed, SFO, and its cracked oils produced from the four experiments which were performed at temperatures 275, 325, 375 and 425°C, respectively were subjected to the following esterification processes for extracting their fatty acids as a fatty acid methyl esters (FAMEs):

I- Extraction of fatty acids:

1-Saponification of these five oil samples by NaOH of 0.7 N solution were achieved according to the known saponification methods **[Snell (1958)]** to get the sodium salts of their hydrolyzed fatty acids.

2-The five alkaline solutions obtained were dissolved individually in excess of warm water (50°C), stirred for 15 min; the formed hydrocarbon layer was separated by using a separating funnel.

3-The extracted hydrocarbons were estimated and the hydrocarbon fraction of sample obtained at 425°C was studied by gas chromatography as mentioned latter.

4-The alkaline solutions obtained were extracted three times using normal hexane to remove the residual hydrocarbons.

5- A concentrated hydrochloric acid (34 wt %) was added drop wise to the alkaline solution till the solution became acidic

6-The produced solutions were shacked three times individually with diethyl ether and the ethereal layers containing the formed fatty acids were separated, washed with distilled water.

7-To dry the etheryel solutions, anhydrous Na_2SO_4 was added to each sample and left overnight.

8- Decantation and distillation were carried out for removing Na_2SO_4 and diethyl ether respectively from the extracted fatty acids of different samples then the produced fatty acids were weighted.

II-Esterification of extracted fatty acids:

Five samples of extracted fatty acids (2g) were charged individually inside the reflux reactor with methyl alcohol (100 g) and para - toluene sulphonic acid which employed as a catalyst. The reaction was performed in a glass reactor immersed in water bath and fitted with

reflux side tube (like Dean Strak apparatus) **[Nehal (1996)]** This side tube containing a very small amount from anhydrous Na_2SO_4 in its bottom for adsorbing the formed water. After one-hour time of reaction the reactor left to cool and the formed ester have been extracted by caking the reaction mixture with diethyl ether. The ethereal layer was separated, washed by distilled water, separated again by separating funnel **[El-Bassoussi et al., (1988)]**, dried overnight with anhydrous Na_2SO_4 and then heated on a water bath (at 50-60°C) to get the prepared fatty acid methyl esters .

D- Gas chromatographic analysis:

i- Fatty acid methyl esters obtained in this study were dissolved in diethyl ether as a proper solvent and analyzed by using Agilent 6890 plus HP gas chromatograph equipped with flame ionization detector (FID) using the fused silica capillary column Hp-50 of 30 meter in length and 0.35 mm internal diameter **[El-Fadly et al. (1988)]**. The elution of the injected samples was achieved at temperature programming from 80°C to 300°C with an increasing rate of 5°C min^{-1}. Nitrogen was used as a carrier gas at flow rate 2 ml min^{-1}. The injector and detector temperatures were 250 and 300°C respectively. Degradation was estimated by integration of the area under the resolved chromatographic peaks, using the HP computer of software chemstation. The components of the prepared FAMES prepared were identified qualitatively by comparing their retention time with those of standard n -hexadecanoic acid (C_{16}) methyl ester and n-octadecanoic acid (C_{18}) methyl ester, samples. The prepared esters samples and the known esters were injected in the gas chromatogram (GC) at the same conditions that mentioned above.

ii - Hydrocarbon fraction extracted from the oil degraded at 425°C was analyzed without any solvent using capillary column AT-1 of length 60 m and 0.35 mm internal diameter **[Al-Amrousi et al., (2002)]**. Temperature programming from 60 °C to 300 °C at 30 °C min^{-1}, with the same carrier gas (N_2) at flow rate 6 ml min^{-1} and also the injector and detector are the same temperatures of the first case. The components of extracted hydrocarbon compounds were identified qualitatively by comparing their retention time with a paraffinic hydrocarbons mixture from dodecane (C_{12}) , tetradecane (C_{14}) and hexadecane (C_{16}) . Both the extracted hydrocarbon sample and the known paraffinic sample were injected in the gas chromatogram at the same conditions illustrated above.

E- Evaluation of the feed oil and its cracked oil at 425°C as a petroleum crude oil:

The feed oil and its oil cracked at 425°C has been evaluated as a petroleum crude oil according to ASTM test methods **[Joanl & Poula (2000)]** viscosity (D 445), calorific value (D240), flash point (D 93), carbon residue (D 189), density (D 1298), pour point (D 97), ASTM distillation (D 86), copper strip test (D 130)and (D 1552) sulphur content. The molecular weights of the degraded products was determined by an automatic cryoscopic method through the cryettic apparatus (D2505).

F- The SFO and its degraded oil at (425°C) were analyzed using FTIR (Perkin Elmar Model 598) Maston infinity Bench tap941, Model 960 M 0009 combined with computer unit Acer 6500 .

RESULTS AND DISCUSSION

Properties of the SFO and its corresponding cracked oil at 425 °C were evaluated as petroleum crude oils and the results are shown in Table (1). It is obvious from ASTM (boiling range D86) **[Joanl & Poula (2000)]** that the degraded oil is distinguished by pronounced occurrence of the lighter fractions. This may related to the strong free radical (since the oxidation is a free radical reaction) catalytic cracking. The decrease in molecular weight, specific gravity, viscosity, flash point, pour point etc. of cracked oil with respect to the feedstock, oil also could be considered as the result of steady cracking occurring in the molecules of the virgin oil by increasing the reaction temperature. Moreover, one can observe that the calorific value has been increased than that of feedstock SFO. This may be due to two factors: The first self or in – situ hydrogenation ie. saturation occurs in some degraded molecules in expense of collapsing of other molecules to form char which was considered as one of the by-products in this experiment. As set in Table (1) this char was formed as a result of break down of some hydrocarbon molecules to carbon after stripping of their hydrogen by phenoxy radicals via the catalytic hydrogen disproportionation process. The mechanism of the applied reaction have been mention in details elsewhere **[Al-Amrousi (1997)]**.

Table (1): physicochemical characteristics of the spent fry oil and its oil cracked at 425 C°

Characteristic	Spent fry oil	Cracked oil at 425°C	Characteristic	Spent fry oil	Cracked oil at 425°C
Distillation vol.%, °C			Density at 15.5°C	0.9273	0.8195
IBP	143	45	Specific gravity	0.9282	0.8276
10	167	88	API gravity	20.95	39.58
20	209	163	Kinematics viscosity at 21 °C (st)	(19.6 at 60 °C)	6.43
30	275	199	Total sulphur content (wt%)	Nil	Nil
40	308	223	Copper strip test (50 °C)	1	1
50	321	269	Calorific value (Kcal/g)	9.365	9.568
60	344	291	Carbon residue (wt%)	2.15	4.01
70	-	329	Pour point (°C)	12	<-31
80	-	358	Molecular weight	675	189
90	-	-	Pyrolysis products		
Recovered%	61%	81	Char wt %	-	6
Residue	35%	16	Liquid wt%	-	83
loss	4	3	Gases wt %	-	11

The second factor the calorific value of vegetable oils is lower than the pure hydrocarbon due to its high oxygen content. Meanwhile the degraded oil has low oxygen content as mention in a previous work. From this context the degraded oil have higher calorific value with respect to its original oil. Finally the increase in carbon residue of degraded oil (4.0 wt %) than that in its original SFO (2.15) may be due to the carbon black formed can function as a radical trap by capturing these formed free radicals at the completion of the reaction. Small portion of the carbon black is occupied by high active sites where physicochemical adsorption may occur between these active sites and the formed hydrocarbon free radicals of the obtained oil . This mechanism also was discussed in details elsewhere **[Al-Amrousi (1997)]**.

Infrared study:

The Fouriered Transform Infrared Spectral analysis of cracked oil and the feed SFO (Figure (1,a and b) indicated week peak at the olefin region (1640-1610) **[Borrego (1996)]** and show a height difference comparable with this peak at spectra (a) and (b). The weakness of the olefin peak of degraded oil may be accounted for the partial saturation occurring in olefinic bonds during the degradation process as mentioned in a previous publications **[Gullions et al., (1990)]**. Also one can see the

ratio between the peak height in spectrum (a) of the carbonyl group (at 1744 cm^{-1}) in the original SFO and its CH_2 + CH_3 peak height (at 2950-2853 cm^{-1}) and the ratio between the peak heights in spectrum (b) of the carbonyl group (at 1705 cm^{-1}) and its CH_3 - CH_2 peak height (at 2950-2853 cm^{-1}). It is obvious that the first ratio is more than the second this may be attributed to the reduction occurs in the amount of carboxylic ester group in the oil degraded. Moreover carbonyl group of ester can restricted frequency have a range from 1750-1730 cm^{-1} as shown in spectrum (a) of original sample whereas the peak of carbonyl group of degraded oil appeared at 1709 cm^{-1} which characterized by ketone carbonyl group. Furthermore the medium intensity absorption near 1300 to 1000 cm^{-1} is characterized the C-O bond of hydroxyl group in ester. The reduction of this peak in spectrum (b) of degraded sample at the region near 1300 -1000 cm^{-1} give the evidence to the obvious reduction occurs in the oxygenated content in the degraded oil.

Quantitative and qualitative analysis of prepared fatty acid methyl esters by gas chromatography :

It is worth to mention that the weight percentage of fatty acids extracted from the feed and the cracked oils in this study were 81 wt% in case of feed SFO and for degraded oils were 75, 61, 46 and 28 wt% obtained at 275, 325, 375 and 425°C, respectively. Therefore corresponding remainder represent the weight percentage of each hydrocarbon fraction in each sample. The extracted fatty acids were esterificatied to their corresponding methyl esters. The five fatty acid methyl esters (FAMEs) samples derived from both spent fry oil and its four cracked samples were subjected to gas chromatographic analysis to investigate their FAMEs constituents and distribution. The chromatograms could be considered as the fingerprints **[El-Fadly et al., (1988)]** of different FAMEs samples. The representative models are given in Figures (2,3). The carbon number distribution of C_4 up to C_{24} of FAMEs fraction of each sample was calculated in terms of weight percent by the aid of normalizing peak area technique. The results of carbon number distribution of five samples are given in Table (2). From the chromatograms and Table (2) one can realize the following:

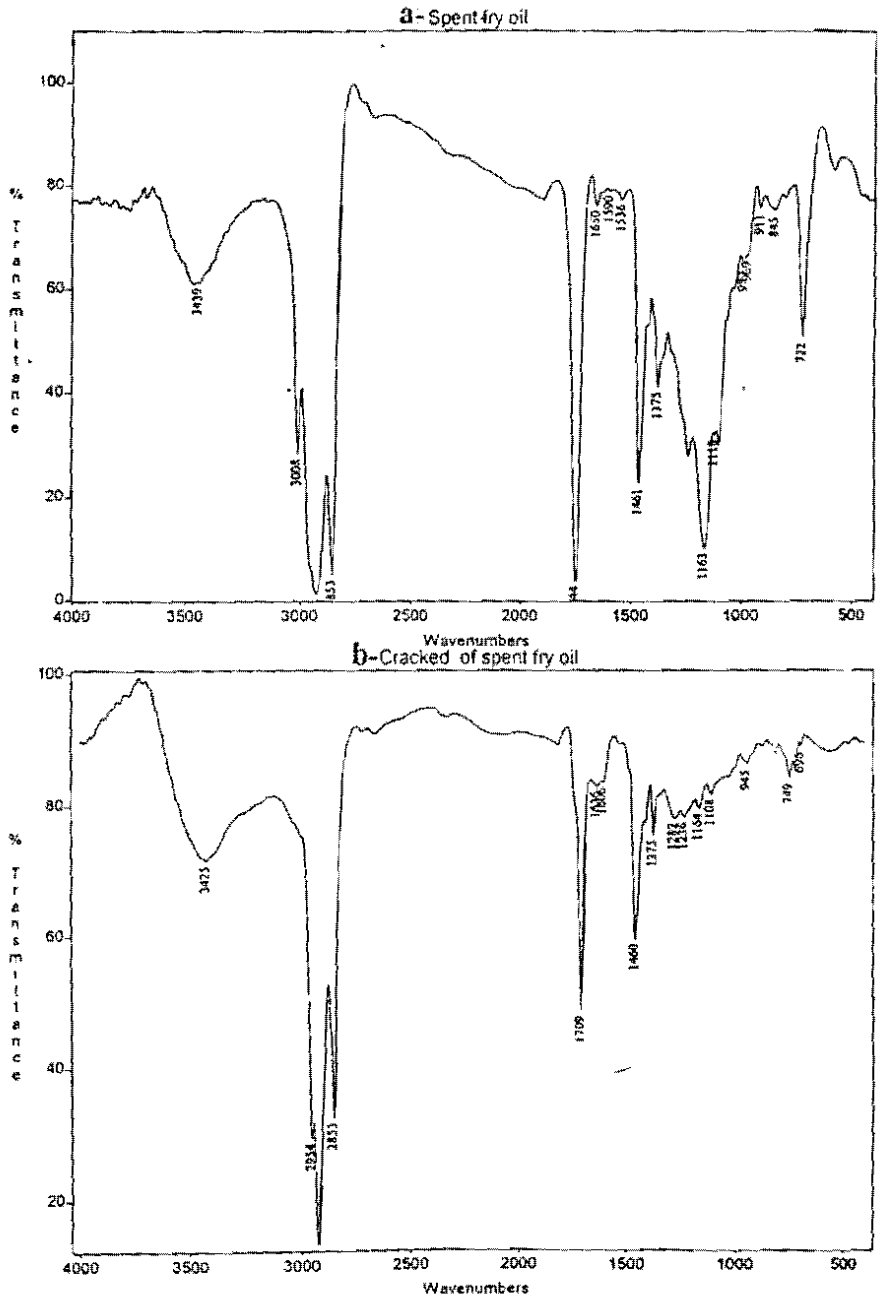

Figure (1) : Infrared of spent fry oil (a) and its cracked oil at 425C°(b) .

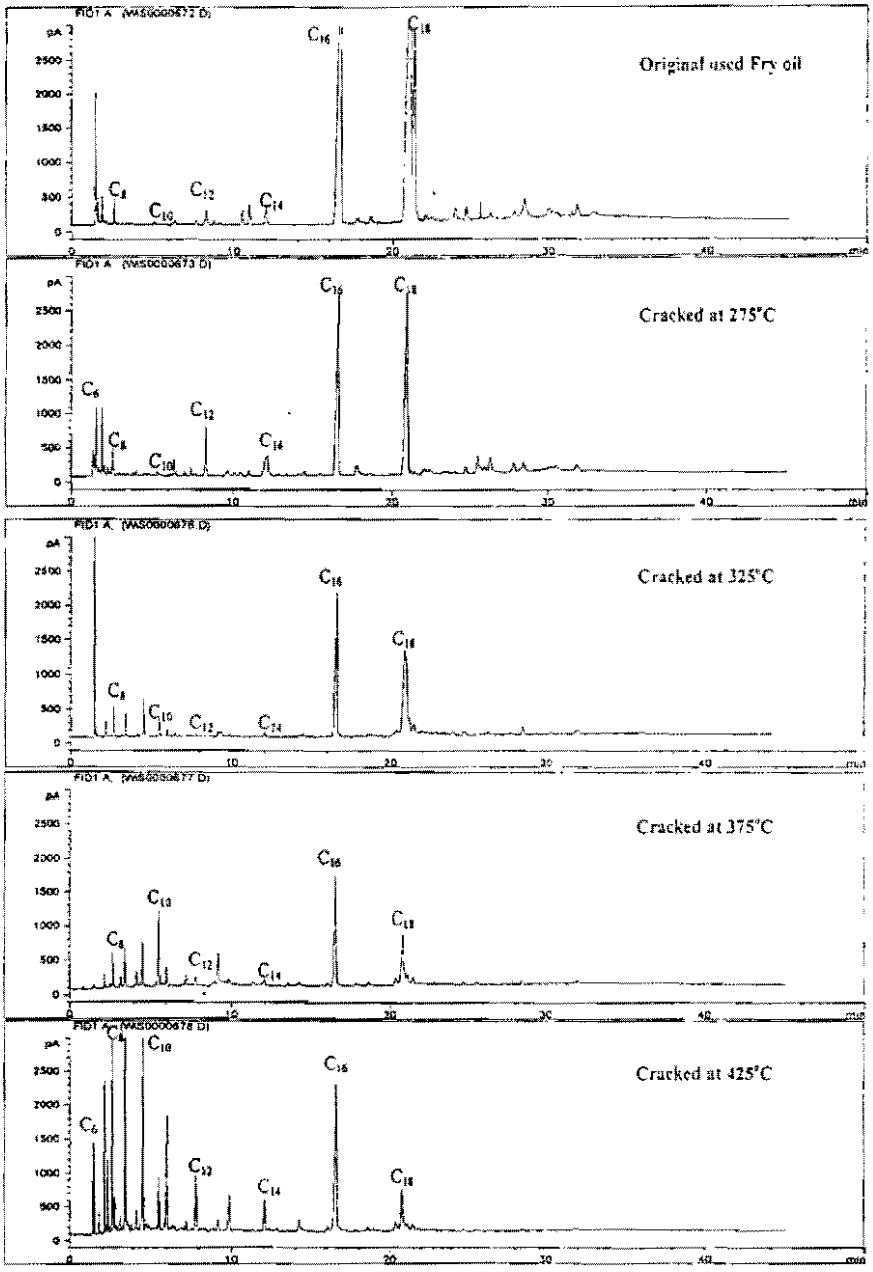

Fig. (2) Gas chromatographic analysis of the extracted fatty acid methyl esters of spent Fry oil and degraded oils at 275, 325, 375 and 425°C

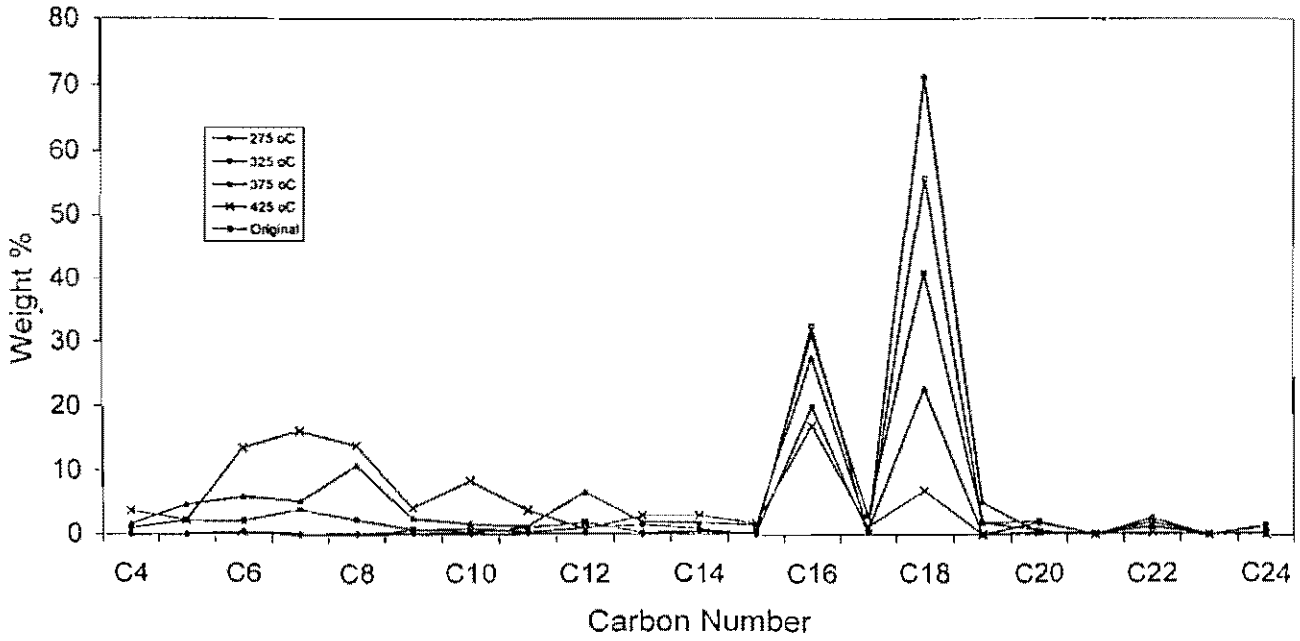

Fig.(3) distribution of fatty acid methyl ester of original and degraded fry oil at different temperatures

A- Gas chromatographic analysis of FAMEs extract from feed oil (SFO) only.

Carbon number distribution of the FAMEs, which extracted from the SFO are ranged between C_6 and C_{24} as shown in Table (2). From the Table we can see that the methyl ester of hexadecanoic acid and octadecanoic acids have the percentages 32.5 and 55.8 wt% respectively. This means that the abundances in extracted FAMEs (88 wt%) in this sample are restricted in both C_{16} and C_{18} fractions. Where upon the remainder which approximately 12 wt% represents the fractions of C_5 – C_{14} and C_{19} –C_{24} ranges. These low molecular weight FAMEs of SFO may be formed due to the thermal oxidative degradation of some molecules in the virgin vegetable oil during the frying process of food cooking. Whereas the high molecular weight belongs to its virgin oil .

B- Effect of temperature on the carbon number distribution and in the weight percent of FAMEs extracted from degraded oils:

I- Fatty acid esters of degraded oil obtained at 275 °C:

The GC analysis of the FAMEs extracted from oil degraded at 275 °C was represented at Figures (2 and 3). The result mentioned in Table (2) indicated a quite different than the fatty acid ester extracted from the spent fry oil feed stock. From these data one can find that hexadecanoic acid ester (C_{16}) exhibits slightly decrease during the thermal degradation at 275 °C, whereas, octadecanoic acid decreases from 55.8 to 36.7 wt %. In fact the decrease in the weight percent in this heavy fatty acid ester was converted to two type of fractions. The first type as heavier fatty acid ester about 10 wt % and the second type as lighter fatty acid ester as indicated in Table (2) by 10 wt% also if compared with those extracted from the original sample. This attributed to degradation of octadecanoic acid, which may have two path ways. The first is the dissociation of the acid in order to give low molecular weight fatty acids. The second may be occurs during the degradation via the association of high molecular weight free radicals forming fatty

Table (2): Carbon number distributions of fatty acid esters extracted from SFO and from its oils degraded at different temperatures.

Carbon number	Type of fatty acid of ester	Wt % of fatty acid esters extracted from				
		Used fry oil	Oil degraded at			
			275 °C	325 °C	375 °C	425 °C
C_4	Tetranoc acid	-	-	0.995	1.602	3.703
C_5	pentanoic acid	-	-	2.143	4.644	2.216
C_6	n-hexanoic acid	0.503	1.206	2.111	5.942	13.436
C_7	n-heptanoic acid	0.075	0.099	3.917	5.269	16.128
C_8	n-octanoic acid	0.085	0.779	2.302	10.747	13.777
C_9	n-nonnoic acid	0.692	0.343	0.831	2.482	4.247
C_{10}	n-decanoic acid	0.927	1.563	0.357	1.687	8.424
C_{11}	n-undecanoic acid	0.403	0.709	1.139	1.341	3.816
C_{12}	n-dodecanoic acid	1.057	4.596	1.944	6.708	0.918
C_{13}	n-tridecanoic acid	1.559	1.505	0.292	1.934	2.956
C_{14}	n-tetradecanoic acid	0.921	5.210	0.628	1.896	3.009
C_{15}	n-pentadecanoic acid	-	0.495	0.38	1.516	1.753
C_{16}	n-hexadecanoic acid	32.511	31.452	31.117	27.662	16.925
C_{17}	n-heptadecanoic acid	0.436	2.909	2.909	0.729	1.238
C_{18}	n-octadecanoic acid	55.875	36.654	40.875	22.723	6.845
C_{19}	n-nonadecanoic acid	1.806	1.914	1.85	-	-
C_{20}	n-eicosanoic acid	0.608	6.836	2.006	1.822	0.328
C_{21}	n-heneicosanoic acid	-	-	-	-	-
C_{22}	n-docosanoic acid	2.483	5.168	1.897	1.296	0.289
C_{23}	n-tricosanoic acid	-	-	-	-	-
C_{24}	n-tetracosanoic acid	1.522	1.192	1.101	-	-
Total	-	100	100	100	100	100

acids esters having higher molecular weight than the original octadecanoic acid (C_{18}). Association and dissociation of esters fragments in this stage (275 °C) may be due to the effect of oxygen gas of air atmosphere in the reaction medium when variety of free radicals engendered at this low temperature and interact to give stable molecules at the end of reaction since the oxidation is a free radical reaction **[Al-Amrousi (1997)]**.

2- The fatty acid methyl ester of oil degraded at 325°C:

The extracted esters are distinguished by the increase in wt % of low molecular weight fatty acids from C_4 to C_{15}. This may be as a result to dissociation occurs in all fatty acids from C_{18} to C_{24}. From Table (2) one can notice the decrease in weight percent of these fatty acids from 62 to 48. Meanwhile the hexadecanoic acid have no noticeable change in its weight percent if compared with its value in the fatty acid esters formed from the spent fry oil.

3- Fatty acid esters of degraded oil at 365 and 425°C:

The percentage of FAMEs extracted from both degraded oils at these last temperatures as listed in Table (2) and shown in Figures (2,3) one can find the followings :

a- The FAMEs wt % of $C_4 - C_5$ rage seem to be increased gradually through the two last reaction temperatures (275, 350 °C) This may reveal the effect of reaction temperature, catalytic activity and the severity of oxidative reaction. Mechanism of this reaction was mentioned in details elsewhere **[Al-Amrousi & Ibrahim (2003) and Al-Amrousi (1997)]**.

b- Really the increasing in ester wt % of $C_4 - C_{15}$ range was associated with a gradual decrease in the weight percentage of both C_{16} and C_{18} fraction of esters which finally were reduced to 16.9 and 6.8 wt%, respectively in the last reaction (at 425°C). From these results one can find that the more abundances at lower range ($C_4 - C_{15}$) of FAMEs can be fulfilled by increasing the reaction temperature up to 425°C. Vice versa more abundances at higher range C_{16} - C_{24} of FAMEs can be formed at a low reaction temperature. On the other hand, increasing in the reaction temperature more than 425°C reduces the amount of liquid obtained and give unfavorable char and undesired gases **[Al-Amrousi & El-Naggar (1999)]**.

c - During this study one can obtain a variety of fatty acids of different uses ,such as $C_4 - C_6$ fraction that is suitable for fatty alcohols and plasticizer manufacture. $C_7 - C_9$ fraction for fatty alcohol production, $C_{10} - C_{16}$ fraction is used for toilet soap and varnishes. This fraction of ester can also be used as an economic substitute for diesel fuel as biodiesel fuel **[Reed et al., (1992)]**, $C_{17} - C_{20}$ fraction is suitable for high grade household soaps. The C_{21} and higher fractions are suitable for the manufacture of some plasticizers.

Analysis of the separated hydrocarbon fraction by gas liquid chromatography.

The pyrolysis products of SFO that degraded at 425°C as mentioned in Table (1) are char, liquid oil and gases. The type of these obtained gases was studied elsewhere **[Al-Amrousi & El-Naggar (1999)].** But the liquid obtained was divided to two main fractions included FAMEs and hydrocarbon fraction. This hydrocarbon fraction derived from the degradation of triglyceride during thermo catalytic oxidative reaction gives short chain hydrocarbons through a free radical reaction as previously mentioned **[Al-Amrousi (1997)]**. Moreover some of hydrocarbons obtained due to the formation of RCOO• acidic radicals and subsequent loss of carbon dioxide forming n-paraffins, isoparaffins and olefins. Each molecule would have one carbon atom less than the original degraded fatty acid or giving dimer molecules **[Sonntag (1979)]**. These hydrocarbon samples were subjected to gas chromatographic analysis **[Al-Amrousi et al., (2002)]** in order to investigate their paraffinic hydrocarbon constituents.

Table (3): Carbon number distribution (wt %) of C_{14}- C^{+}_{29} range of hydrocarbon oil extracted from degraded oil at 425C°.

Carbon number	Wt % of paraffin and UCM	Petroleum fraction like wt %	Carbon number	Wt % of paraffin and UCM	Petroleum fraction like wt %
C_{12}	-	Kerosene like	C_{21}	2.14	Residue
C_{13}	-	36.94 wt%	C_{22}	1.72	9.77 wt%
C_{14}	2.42	(biokerosene)	C_{23}	1.44	
C_{15}	34.5		C_{24}	1.29	
C_{16}	12.89	Gas oil like	C_{25}	0.84	
C_{17}	21.50	53.29 wt%	C_{26}	0.54	
C_{18}	7.00	(biodiesel)	C_{27}	0.44	
C_{19}	8.06		C_{28}	0.43	
C_{20}	3.84		C^{+}_{29}	0.93	

The unresolved complex mixture (UCM) represent 70.95 wt %which represent the hump was distributed in all corresponding fractions.

It is obvious from the Figure (4) and Table (3), the carbon number distribution was ranged between C_{14} and C^{+}_{29} with the maximum at C_{15} and C_{17} and can be divided in to four zones .

- The first zone range between C_{14} and C_{15} which corresponding to kerosene petroleum fraction and represented about 36.94 wt % from the total wt% of hydrocarbon and unresolved complex mixture (UCM) .
- The second zone in the chromatogram curve ranges between C_{16} and C_{20} (i.e. the carbon number distribution range of petroleum gas oil) having 53.29 wt % . This abundances may be attributed to the main fatty acids of triglycerides in oil which mainly restricted in C_{18} fatty acid carbon number (octadecanoic acid). It is worth to mention that the paraffinic hydrocarbon of this zone associated with isoparffinic and olefinic and all UCM fraction may be derived from octadecanoic and higher fatty acids present in feedstock triglycerides. This confirmed by the decreases in the C_{18} fraction from 55 to 16 wt% in the extracted esters from SFO and degraded sample at 425°C, respectively.
- The third zone was characterized by low abundances in the carbon number ranges from C_{21} to $> C^{+}_{29}$ which represented the high boiling point fraction in sample (>350 °C) fraction of this zone corresponding to heavy residue and represent 9.77 wt % from the total weight of hydrocarbon sample .
- The fourth zone in the chromatogram exhibits only one predominant hump due to the polar compounds such as oxygenated aromatics, alcohols, and phosphoric compounds etc .These compounds are known as unresolved complex mixture (UCM) **[El-Naggar & El-Adly (2002)]**. The amount of these classes in the hydrocarbon fraction was listed in Table (3) seems to be have high weight percent (70.95 wt %). This amount actually was distributed to three fractions weight as divided in the chromatogram (Figure 4). The oxygenated and unsaturated compounds of this hump may be related to the degradation of triglycerides esters. In this context 452 C^{o} is more preferable reaction temperature. At this condition the obtained biodiesel represents a maximum percent (50 wt % in the extracted hydrocarbon). This was associated with more abundances in the fatty acid esters in the range of $C_4 - C_{15}$ that were formed during the cracking process or formed during the use of the feedstock oil in fraying . This was confirmed by FTIR of the degraded oil at 425C^{o} as

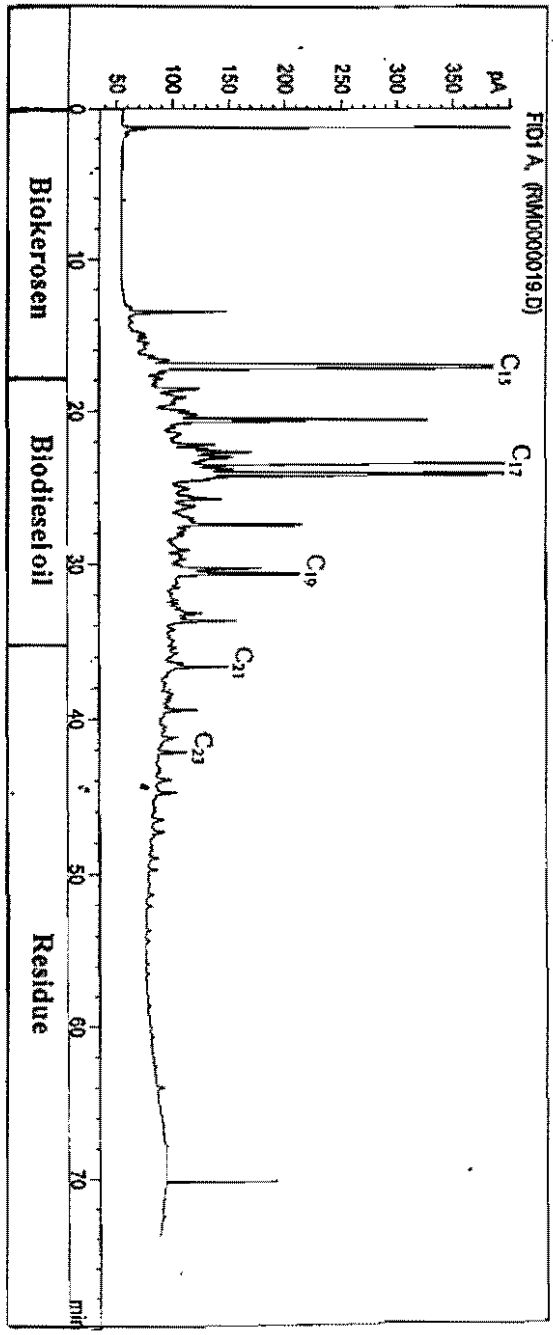

Fig. (4) Gas chromatographic analysis of hydrocarbon fractions extracted from degraded SFO at 425 °C.

• in Figure (1-b) which emphasize the presence of carbonyl and hydroxyl groups in this oil.

CONCLUSION

- Gas chromatographic analysis indicated that different molecular weight fatty acids can be produced according to the applied reaction temperature.
- The oxidation process applied in this study is considered as a novel process for producing low molecular weight fatty acids which have even and odd carbon numbers which rare in nature .
- The degraded spent fry oil at 425 °C has the advantages to be used as a substituted fossil fuels and as renewable energy sources.
- Infrared and chemical analysis indicated a noticeable reduction occurring in the amount of triglyceride groups of the last cracked oil.
- Using hydroquinone as a catalyst with air in the oxidative degradation reaction of refused fry oils gave a good result.

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إنتاج وقود سائل وأحماض دهنيه منخفضة الوزن الجزيئي من زيت القلي المستعمل

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تـم وضـع زيت الطعام المستعمل في فرن حابك وتم استخدام الهيدروكينون كعامل مسـاعد. تمت عملية تكسير الزيت عند درجات حرارة مختلفة في وجود الهواء تحت ضغط ٧,٥ ضـغط جوي وكان زمن التفاعل ٣٠ دقيقه ، تم مقارنة الزيت المستعمل وكذلك الزيت الـذي تـم تكسيره عند درجة ٤٢٥ °م كزيت البترول الخام و ذلك بدراسة الخواص الفيزيقية والكيميائية لكل منهم. كذلك تمت المعالجة الكيميائية للزيت الخام و الزيوت التي تم تكسيرها عـند درجـات حـرارة مختلفة بهدف فصل الأحماض الدهنية عن الهيدروكربونات الناتجة. وكذلـك تم تحويل هذه الأحماض إلى إسترات المثيل وتم التعرف علي هذه الإسترات الناتجة كماً وكيفاً باستخدام كروماتوجرافيا الغاز. وأخيرا تم تحليل الهيدروكربونات للزيت الناتج من التكسـير عـند درجة ٤٢٥°م كزيت خام بترولي بواسطة كروماتوجرافيا الغاز للتعرف على مكوناتها البرافينية.