

Ministry of Higher Education  
and Scientific Research  
Misan University  
College of Basic Education



**Misan Journal**  
**for Academic studies**  
**Applied sciences and humanities**

ISSN (Paper)- 1994-697X

(Online)- 2706-722X

Vol 21 Issue 42 Year 2022



# Misan Journal of Academic studies

Applied Sciences and Humanities

ISSN (Paper)-1994-697X  
(Online)-2706-722X

Vol. 21 Issue. 42 June 2022



OJS / PKP  
[www.misan-jas.com](http://www.misan-jas.com)

IRAQI  
Academic Scientific Journals



ORCID



TOGETHER WE REACH THE GOAL



OPEN ACCESS



<http://www.misan-jas.com/index.php/OJS>

 [journal.m.academy@uomisan.edu.iq](mailto:journal.m.academy@uomisan.edu.iq)

The Consignment Number at the Books and Documents House in Baghdad is 1326, 2009

ص	فهرس البحوث	ت
1	حامض السالسليك : خصائصه ودوره في تحفيز نظام الدفاع في النباتات ضد الممرضات الفطرية قصي خطاب ماضي      طلال حسين صالح      غسان مهدي داغر	1
15	عبد المطلب داود مهدي الحسيني الحلبي ودوره في النهضة الادبية والفكرية (1865-1920) نادية جاسم كاظم علي الشمري      هالة مهدي خيرى الدليمي	2
26	إرث المتبنى في الشريعة الاسلامية (دراسة في ضوء القرآن والسنة والمذاهب الإسلامية) سيد حسين آل طه      هيثم مظهر محي الساعدي	3
38	كاميرات المراقبة وأثرها في كف السلوك المنحرف من وجهة نظر المجتمع الأنباري (الفلوجة إنموذجا) دراسة تطبيقية ميدانية عبد الرزاق جاسم محمود العيساوي      احمد محمد مطلق المحمدي	4
59	تأثير معالجات عجز الري المنظم على الجودة الفيزيائية والكيميائية لثمار صنفين من نخيل التمر (الساير) و (الحلاوي) علي عبد الرحمن فاضل      عبدالكريم محمد عيد      عبد المنعم حسين علي	5
70	كفايات التعليم الالكتروني أحمد عبد المحسن كاظم      أسراء حسين عليوي	6
87	تقدير حجم الضائعات المائية في مشروع المحاصيل الصناعية الإرواني في قضاء العزيبية وسبل رفع كفاءته ناطق هاشم طوفان الشمري      نجاح علوان عويز الغشام	7
93	مهارات تدريس معلمي اللغة الانكليزية في المرحلة الابتدائية من وجهة نظرهم جمال نصيف العلوي	8
115	التصويب والتخطئة عند أهل السنة محمد رسول آهنگران حسين رجبى      مهدي نوروزي مهدي صداقت	9
132	التحليل الجغرافي لتكرار بقاء الأيام الممطرة لأكثر من يومين في محطات (بغداد والعمارة والحي) طالب عباس كريم      صدام رزاق عيود	10
145	التشكيل الصوري لخاتمة القصيدة في عهد بني الأحمر علي مطشر نعيمة      كريم قاسم جابر الربيعي	11
160	محددات الطلب على النقود في العراق (دراسة قياسية) حلمي إبراهيم منشد	12
170	التفاعل في التعليم الإلكتروني وعلاقته بالمعرفة الشخصية للطلبة من وجهة نظر أعضاء الهيئة التدريسية غسان كاظم جبر	13
186	السرد القصصي في كتاب عيون الأخبار لابن قتيبة هديل علي كاظم	14
198	دلالة الخبر عند أهل المعقول والمنقول، دراسة تحليلية نصير ثجيل داود	15

210	انعكاس خطاب الكراهية في القنوات الفضائية العراقية على الجمهور احمد كريم احمد	16
228	تحليل ظاهرة البطالة في العراق: ارث الماضي وتجليات الحاضر واستراتيجيات الحل حسين علي عبد	17
243	مباني تدارك الأضرار المعنوية في نظام الإيراني القانوني ناظرة إلى الإجراءات القضائية حميد ابهرى <sup>1</sup> مهدي طالقان غفارى <sup>1*</sup> مهرداد باكزاد <sup>1</sup> الياس يارى <sup>1</sup>	18
253	الاختلاف العقائدي في مسألة المعاد ومجال التسامح صادق كاظم مكلف	19
264	الازمة السورية و موقف جامعة الدول العربية منها 2011- 2018 حسن موات حسين هشام نعيم غليم الكعبي	20
276	الاضواء الداخلية في الاحواز 1913- 1925م حميد ابولول جبجاب	21
289	الزراعة في العصر الفاطمي 296-567هـ / 909-1171م علي فيصل عبد النبي العامري	22
308	أثر استراتيجية التعلم المستقل في تحصيل تلاميذ الصف الخامس الابتدائي في مادة العلوم حنان كاظم عبد	23
317	الدلالة الصوتية في الفاظ المثل القرآني ناصر حسن عبد علي	24
330	دور النظام المحاسبي الحكومي العراقي عند الانتقال من الموازنة التقليدية(البند والنفقات) الى موازنة البرامج والأداء " دراسة تطبيقية في امانة بغداد "	25
356	الحيوية الذاتية وعلاقتها بالإبداع الارشادي لدى المرشدين التربويين فاطمة عادل داخل	26
368	دراسة بيئية للملوثات العضوية في مياه شط البصرة سها وليد مصطفى	27
386	قياس اتجاهات الجمهور العراقي إزاء ممارسات العلاقات العامة للمؤسسات الديمقراطية ( دراسة ميدانية) علي جبار الشمري ليث صبار جابر	28
403	ظاهرة الانزياح في بانية عنتره بن شداد علي غانم فلحي	29
414	التنظير الفقهي للأحوال الشخصية بين القانون الجعفري والقانون المدني العراقي ( دراسة مقارنة ) هرمز اسدي كوه باد محمد هاشم كرم النوري	30
429	دراسة بيئية وتصنيفية لمستحاثات الفورانيفرا والايوستراكودا لاهوار جنوب العراق سرى اسعد سليم الشريدة رشاد عبد الستار كشيش العلي	31
441	Geomorphometric Analysis of Al -Teeb River Meanders Between Al-Sharhani Basin and Al-Sanaf Marsh, Eastern of Misan Governorate, Iraq Bashar F. Maaroo <sup>1</sup> and Hashim H. Kareem <sup>2</sup>	32

<b>456</b>	<b>Analyzing the Errors Made by Advanced Student on (Subject-Verb) Concord at Misan University</b> <b>Emad Jasem Mohamed</b>	<b>33</b>
<b>466</b>	<b>Types of Assimilation in English as Recognized by Iraqi EFL Learners at the University Level : A Perceptual Study</b> <b>Furqan Abdul-Ridha Kareem Altaie</b>	<b>34</b>
<b>477</b>	<b>The Impact of Active Learning Strategies on Developing EFL College Students' Self-efficacy and Academic Achievement</b> <b>Khansa Hassan Hussein Al-Bahadli</b>	<b>35</b>
<b>491</b>	<b>Improvement of the thermo Oxidation properties for low-density polyethylene using curcumin analogues</b> <b>Ali M. Al-Asadi , Salah Sh. AL-Luaibi*, Basil A. Saleh**</b>	<b>36</b>

## Improvement of the thermo Oxidation properties for low-density polyethylene using curcumin analogues

Ali M. Al-Asadi , Salah Sh. AL-Luaibi\*, Basil A. Saleh\*\*

Department of Chemistry, College of Science, University of Basrah, Basrah, Iraq

Correspond author: \* [salah.hashim@uobasrah.edu.iq](mailto:salah.hashim@uobasrah.edu.iq)

\*\* [alialasdi254@gmail.com](mailto:alialasdi254@gmail.com)

DOI /2022 10.54633/2333-021-042-037

### Abstract:

In this study, three analogs of curcumin were prepared and used as antioxidant for LDPE. The thermal oxidation inhibition was investigated using carbonyl index, TGA, and DSC as well as the antioxidant inhibition was evaluated using DPPH. The results showed that the curcumin analogs derived from 4-hydroxyl benzaldehyde, compound had high antioxidant efficiency for LDPE.

**Keywords:** low-density polyethylene (LDPE), curcumin analogs, thermal antioxidant, Carbonyl index, TGA, DSC.

**الكلمات المفتاحية:** - البولي ايثيلين واطى الكثافة ، نظائر الكركمين ، مضادات الاكسدة الحرارية ، معامل الكربونيل ، التحليل الوزني الحراري ، المسح التفاضلي المسعري.

### 1. Introduction

The last few decades have seen a large usage for the low-density polyethylene, particularly in the agriculture and packaging operation and multiple

applications, because of the increasing consumption and production of plastic in the world. In 2019 alone, about 360 million tons (Mt) of plastics were produced globally<sup>1</sup>. So, plastics need to more of studies to protect the environment from the negative effects. The question is how long the properties of plastic materials can be maintained in outdoor environments<sup>2</sup>. The thermal degradation of polymers refers to the case where polymers at elevated temperatures start to undergo from a chemical change without the simultaneous involvement of another compound<sup>3</sup>. Thermal degradation of polymers is of paramount importance in developing a rational technology for polymer processing. By using the polymers at a higher temperature, it leads to understanding thermal decomposition

mechanisms for the synthesis of safe polymeric materials. Degradation of polymers includes all the changes in the chemical structure and physical properties of the polymers due to external chemical or physical stresses that caused by chemical reactions<sup>4</sup>. Polyethylene may be exposed to several stresses such as oxidation, therefore polymers can react with molecular oxygen in a process called spontaneous oxidation. This process occurs due to many of reasons, such as heat, ultraviolet light, mechanical stress, catalyst residue, or reaction with impurities, to form alkyl radicals<sup>5</sup>. Free radicals can be reacting with others to cause a polymer decomposition, then they resulting in embrittlement, instability of melt flow, loss of tensile properties and discoloration<sup>6</sup>. Oxidation can be slowed by chain-breaking antioxidants, to reduce the rate of diffusion, or protective antioxidants, which prevent the initial formation of free radicals<sup>6</sup>. LDPE is available as plastic bags and packaging films<sup>7</sup>, it is widely used in packaging due to its easy feedstock availability and processability, versatility, low cost and

recyclability<sup>8</sup>. Thermo oxidation degradation of polyethylene (PE) has an essential economic impact. It impacts polymers that exposure to heat and light, which is related to the lifetime of the manufactured product<sup>9</sup>. Several studies on the PE thermo oxidative have shown that hydroperoxides are formed and then decompose to form carboxyl and alcohol compounds, so the polymer chains are breakdown and decrease in molecular weight<sup>10-11</sup>. Antioxidants are molecules that can react and inhibit the initiation and propagation of oxidizing chain reaction produced by reactive free radical before polymers degradable<sup>12</sup>. Antioxidants can inhibit free radical reactivity through sundry mechanisms including the donation of hydrogen, radical scavenging, and singlet oxygen quenching<sup>13</sup>. Many techniques were used to evaluate of antioxidant efficiency such as IR spectrophotometer and thermal analysis (TGA, and DSC)<sup>14</sup> and assessed by DPPH-scavenging<sup>15</sup>.

## 2. Experimental

### 2.1 Materials

All starting material were purchased from Sigma-Aldrich and used without any further purification. The NMR spectra were measured in deuterated dimethyl sulfoxide DMSO-*6d* , Food grade LDPE 463 pellets were supplied from the state Company for Petrochemical of Basrah, Iraq (density 0.922 g/cm<sup>3</sup> and melt flow index 0.32 g/10min).

## 2.2 Preparation of curcumin analogues

A basic condition was used for synthesizing curcumin analogues<sup>14</sup>. A solution of para hydroxybenzaldehyde (0.02 mol) in ethanol (2.5 ml) was placed in one-neck round bottom flask under constant stirring at room temperature. Then appropriate ketone (cyclohexanone , cyclopentanone or acetone) (0.01 mol) was added to the solution and stirred vigorously, followed by dropwise addition of 20% NaOH (50 ml) with keeping the temperature below 40 °C. The stirring of the red mixture was kept for 24 hours. Then, distilled water (15 ml) was added to the mixture and then neutralized at acidic conditions (pH = 5.5) by adding (6N HCl)

where a yellow-colored precipitate was observed. The product then was filtered and dried. Scheme 2 shows the preparation reaction, and table (1) shows some of the physical properties of the prepared compounds.

## 2.3 Purification of LDPE

Commercial pellets of LDPE were purified using xylene solvent and refluxed under nitrogen atmosphere for 1 hour to remove any antioxidant traces. Then precipitate using cold methanol then filtered and dried at 70 °C for 1 hour<sup>15</sup>.

## 2.4 Fabrication of the films

Different wt % of curcumin analogue was mixed with LDPE using extrusion and carried out through a three-heating zone, the rotation speed was fixed at 64 rpm throughout the extrusion process. During the process, the temperature of the three heating zones was set at 145 °C, for 8 min<sup>16</sup>. The extruded filaments were subsequently pelletized, and the formed pellets were used for the fabrication of the films. After that, pure LDPE and (antioxidant/LDPE) were exposed to thermal oxidation at 200 °C for 1 hour<sup>17</sup> by using air oven after that, pure LDPE and (antioxidant/LDPE) composite films were produced by compression molding at 140 °C for 5 mins to get films with on



average thickness of 1 mm by using press Hydraulic.

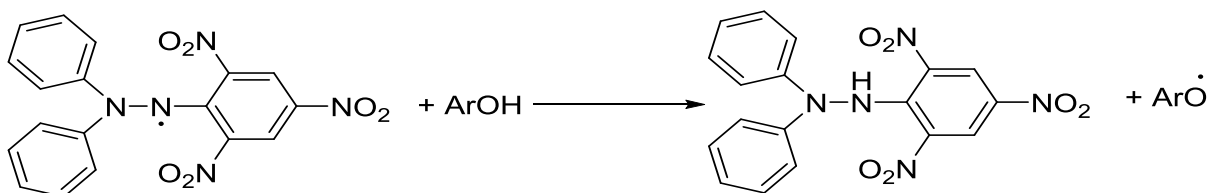
### 2.5 Carbonyl index study

The IR spectra of the films were recorded before and after the thermal oxidation using FT-IR Shimadzu 8400s. After that the carbonyl index<sup>18</sup> (CI) was obtained using equation (1)<sup>19</sup> We notice a significant change in the infrared spectrum with the increase in the absorption of the carbonyl group<sup>20</sup>.

$$CI = \frac{Abs_{1726\text{ cm}^{-1}}}{Abs_{1472\text{ cm}^{-1}}} \times 100\% \dots (1)$$

Where  $Abs_{1726\text{ cm}^{-1}}$  and  $Abs_{1472\text{ cm}^{-1}}$  are the absorption intensity of C=O and CH<sub>2</sub> peaks, respectively. The efficiency of antioxidant has been calculated according to equation<sup>21</sup> (2):

$$\%E = \frac{CI \text{ Before addition} - CI \text{ After addition}}{CI \text{ Before addition}} \times 100 \dots (2)$$



### 2.6 Radical scavenging activity

The 1,1-diphenyl-2-picrylhydrazyl DPPH is one of the few stable and commercially organic nitrogen radicals<sup>22</sup>. It is widely testified method for determination of antioxidant activity, the (DPPH•) radical (Figure 4) is characterized as a stable free radical because  $\pi$  electrons of the aromatic systems that present in the molecule which can compensate for the lack of an electron. DPPH• has a deep violet color led to absorption in solution at around 517 nm<sup>23</sup>. When a solution of DPPH• is in contact with a substance that can donate a hydrogen atom or with another radical (R•), the reduced form DPPH-H or DPPH-R is produced with the consequent loss of color and therefore the decrease or loss of absorbance (Figure 8). Consequently, the reduction of DPPH• provides an index to estimate the ability of the test compound to trap radicals.

#### Figure 4 DPPH• reduction by an antioxidant.

ArOH is an antioxidant that acts by donating hydrogen atoms, to obtain radicals with stable molecular structures that will stop the chain reaction<sup>24</sup>. The assay was carried out according to the modified method of Blois (1958)<sup>25</sup>. 1 mL of 0.1 mM solution of DPPH (Sigma Aldrich) in methanol was mixed with 2 mL of the aqueous extracts at different concentrations (50, 100, 150, 200, 250, 300, 350 and 400 µg/mL). The mixture was incubated at room temperature for (30-60) min in the dark. The control was prepared by mixing 1 mL of DPPH solution with 2 ml Methanol. The absorbance was measured against a blank

at 517 nm by using spectrophotometer. Lower absorbance of the reaction mixture indicates higher DPPH free radical scavenging activity. BHT was used as a standard, samples were prepared and measured in triplicates. The percentage of scavenging activity of each extract on DPPH radical was calculated as %inhibition of DPPH and a curve was drawn between the inhibition efficiency and concentration. The IC<sub>50</sub> was calculated by plotting the percentage of inhibition against different concentrations of the antioxidant sample. The IC<sub>50</sub> value indicates the concentration required to eliminate<sup>26</sup> 50% of the free radicals, low IC<sub>50</sub> values indicates a high radical uptake activity<sup>27, 28</sup>.

$$\text{DPPH inhibition (\%)} = \frac{A_{\text{Control}} - A_{\text{Sample}}}{A_{\text{Control}}} \times 100$$

Where A<sub>control</sub> is the absorption of control and A<sub>sample</sub> is the absorption of the tested sample solution

### 2.7- Thermal Analysis

The TGA and DSC of Pure LDPE and LDPE mixed with Curcumin analogues were investigated using (TGA technique SDT Q600 V20.9 Build 20 ( and DSC

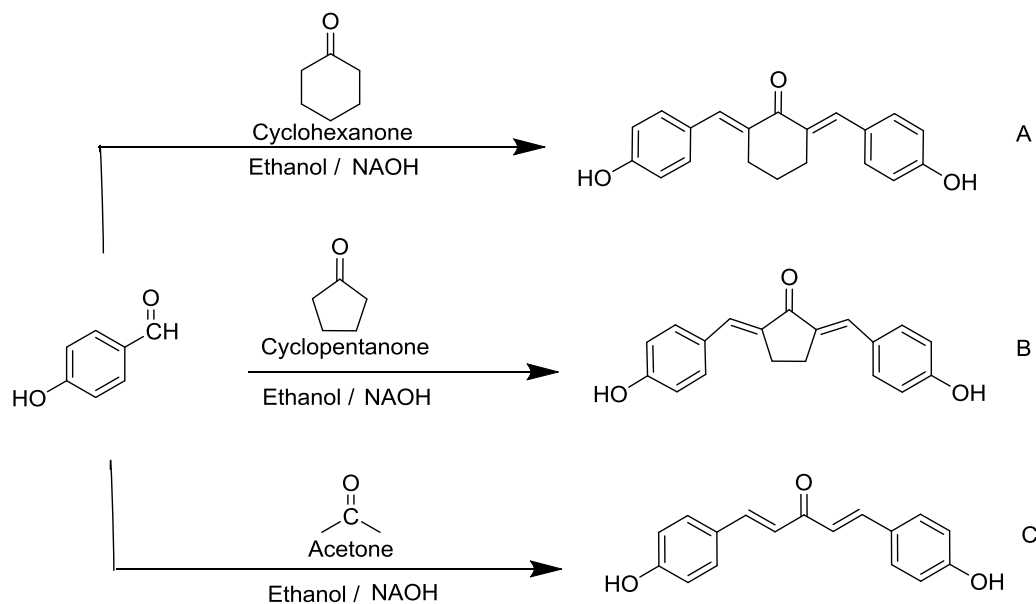
SDT Q600 V20.9 Build 20 ) under oxygen condition at heating rate 10C/min

## 3. Results and discussion

### 3.1 Synthesis of Curcumin analogues

Curcumin analogs (A-C) were synthesized according to literature<sup>15</sup>

protocols through condensation of appropriate ketone (cyclohexanone, cyclopentanone, or acetone) with a variety of aromatic aldehydes in basic conditions, in good to excellent yields. The structures of these analogs are



Scheme 1: Synthesis of curcumin analogues

**2,6-bis(4-Hydroxybenzylidene)  
cyclohexanone A.**

The product was recrystallized from ethanol, yellow crystals, Yield 60% m.p. > 300 °C. IR (cm<sup>-1</sup>): 3321, 3259, 2943, 1647, 1593, 1508, 1435, 1215, 1161, 968, 840. <sup>1</sup>H NMR (500 MHz, DMSO-*d*<sub>6</sub>) δ 9.93 (s, 2H, -OH), 7.54 (s, 2H, -CH=), 7.40 (d, *J* = 8.65 Hz, 4H, ArH), 6.84 (d, *J* = 8.65 Hz, 4H, ArH), 2.85 (t, *J* = 5.2 Hz,

4H, CH<sub>2</sub>), 1.70 (p, *J* = 6.4 Hz, 2H, -C-CH<sub>2</sub>-C-)

**2,5-bis(4-Hydroxybenzylidene)  
cyclopentanone B.**

The product was recrystallized from ethanol, yellow crystals, Yield 85 %, m.p. > 300 °C. IR (cm<sup>-1</sup>): 3321, 3171, 2960, 1666, 1597, 1512, 1431, 1257, 1165, 987, 837. <sup>1</sup>H NMR (500 MHz, DMSO-*d*<sub>6</sub>) δ 10.05 (s, 2H, -OH), 7.54 (d, *J* = 8.6 Hz,

4H, ArH), 7.33 (s, 2H, -CH=), 6.87 (d,  $J = 8.6$  Hz, 4H, ArH), 3.01 (s, 2H).

### **1,5-bis(4-Hydroxyphenyl)-1,4-pentadiene-3-one C.**

The product was recrystallized from ethanol, orange crystals, yield 86 %, m.p. 232–234 °C. IR ( $\text{cm}^{-1}$ ): 3506, 3120, 2827, 1643, 1589, 1516, 1442, 1172, 1114, 983, 829.  $^1\text{H}$  NMR (500 MHz,  $\text{DMSO-}d_6$ )  $\delta$  10.04 (s, 2H, -OH), 7.66 (d,  $J = 15.95$  Hz, 2H, -CH=), 7.62 (d,  $J = 8.7$  Hz, 4H, ArH), 7.10 (d,  $J = 15.95$  Hz, 2H), 6.83 (d,  $J = 8.65$  Hz, 4H, ArH).

### **3.2- The antioxidant activity of curcumin analogs**

In table 1 showed that the prepare curcumin analogs have a good antioxidant activity. The inhibition of the thermo oxidation for low density poly ethylene increased as the wt% increased from 0.5 to 6% . The best results were recorded for curcumin analogs derived from 4-Hydroxy benzaldehyde (A,B and C).

Among these three compounds, compound B has the highest inhibition of thermo oxidation which reached zero, and the lowest inhibition result was recorded for compound A. For a more convenient comparison, the antioxidant efficiency (%E) of the curcumin analog was calculated according to equation (2) and the results are summarized in Table 2. Again, compounds derived from 4-Hydroxy benzaldehyde namely (A, B, and C) as can be seen from the results in table 2, The high antioxidant efficiency of compounds (A, B, and C) as shown in Table 2, might be due to the extra two Hydroxy donor groups added to the benzene rings at meta position which make the free radical, generated through the oxidation process, more stable. The antioxidant efficiency of curcumin analogs toward LDPE oxidation appeared to increase with raise active functional groups.

**Table 1: Effect of concentration of curcumin analogs on %CI of LDPE**

Compound (w/w)%	CI					
	0	0.50%	1%	2%	4%	6%
LDPE+A	100	29.4	27.3	4.3	0	0
LDPE+B	100	20	5.2	3.3	0	0
LDPE+C	100	14.2	13.3	6.5	3.1	0

**Table 2: Antioxidant efficiency(%E) of curcumin analogs toward LDPE oxidation**

Compound (w/w)%	%E					
	0	0.5%	1%	2%	4%	6%
LDPE+A	0	70.6	72.7	95.7	100	100
LDPE+B	0	80	94.8	96.7	100	100
LDPE+C	0	85.8	86.7	93.5	96.9	100

### 3.3 DPPH Free Radical Scavenging

#### Activity A

In the DPPH assay, the antioxidant activity analysis is based on the inhibition of the dpph radical by the antioxidant. The optimal initial concentration of dpph was evaluated first to determine the assay sensitivity the violet color intensity increased rapidly with the dpph concentration from 1mM, but after adding antioxidants and comparing them with a standard compound such as BHT<sup>29</sup>, we

noticed the disappearance of the violet color, which indicates that the activity of antioxidants through absorption. A table was made that includes different concentrations, as shown in table (3). Compound B was more active than the rest in scavenging free radicals by giving a hydrogen atom through the value of IC<sub>50</sub>. It can be seen from the results in this table that compound B needs only (46,96 µg/ml) to scavenge half of the free radicals, while the compound A needs

(57.78  $\mu\text{g/ml}$ ) and compound C needs more active and stable the antioxidants. (63.24  $\mu\text{g/ml}$ ), the lower of the  $\text{IC}_{50}$  value

**Table 3:** Assay radical scavenging activity towards DPPH for antioxidant.

[conc] $\mu\text{g/ml}$	<i>Inhibition Free Radical Scavenging Activity%</i>			
	BHT	A	B	C
0	0	0	0	0
50	70	51.5	55.4	49.9
100	80.5	57.2	60.6	55.4
150	86.6	63.6	67.2	61.2
200	87.3	71.7	78.4	68.1
300	90.1	79.9	80.5	77.6
350	94	82.3	85.3	80
400	94.5	86.9	90.1	83.4
$\text{IC}_{50}$ $\mu\text{g/ml}$	20.13	57.78	46.96	63.24

### 3-4 Thermal Analysis

TA can be used in laboratories as quality control method for the development of new polymeric materials<sup>30</sup>, that explain the connection between temperature and specific physical properties of materials<sup>31</sup>.

(TGA) is a method of thermal analysis in which changes in physical and chemical properties of materials are being observed as a result of increase in temperature<sup>32</sup>. The thermo oxidation temperatures of LDPE mixed with the prepared compounds Figures (7-11) were summarized in Table

#### 3-4-1 Thermo gravimetric analysis

##### TGA

**Table 4 :** The values of LDPE Decomposition temperatures in the presence and absence of compounds prepared under an atmosphere of oxygen.

Compounds	1 <sup>st</sup> stage Decomposition temp. $^{\circ}\text{C}$	2 <sup>nd</sup> stage Decomposition temp. $^{\circ}\text{C}$
LDPE	383	430
LDPE/A	416	452

LDPE/B	413	482
LDPE/C	410	435

It showed that the decomposition temperatures of two stages increased for LDPE/ Curcumin analogs (A,B and C) compared with decomposition temperatures of pure LDPE.

### 3-4-2 Differential scanning calorimetric (DSC)

The DSC of LDPE was investigated under oxygen atmosphere figure (12-15) and show that an endothermic peak<sup>33</sup> appears at 126 °C with a heat absorption capacity of 70.95 J/g attributed to melt of LDPE. The method involves introducing

heat energy into a sample cell and a reference cell simultaneously while identically increasing the temperature of both cells over time<sup>34,35</sup>, After that, a number of exothermal peaks appears that correspond to the decomposition of LDPE which corresponding with TGA, and the total energy of decomposition 4229 J / g to ldpe but after antioxidants (compounds prepare) mixer with ldpe , the Energy decomposition reached 8445 J/g. On the other hand, the decomposition energy of (LDPE/curcumin analogs) higher than LDPE alone because have hydroxyl group<sup>36</sup> were summarized in Table 5.

Table: 5 Dissociation energy of LDPE and LDPE/curcumin analogs.

Compounds	LDPE	LDPEL/A	LDPE/B	LDPE/C
Dissociation Energy J/g	4229	4644	8445	5578

## 4. Conclusion

This study has shown that the antioxidant efficiency of (A, B and C) compounds for LDPE falls between very

good to excellent. Compounds derived from para-hydroxybenzaldehyde have the highest efficiency which might be due to the extra donor hydroxyl group attached in meta position which stabilizes the free

radicals produced during the oxidation process. Compound (B) had the highest antioxidant activity, while compound C had the lowest.

### References

- 1- Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., and Vara Prasad, P. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, 13(17), 9963..
- 2- Grause, G., Chien, M. F., & Inoue, C. (2020). Changes during the weathering of polyolefins. *Polymer Degradation and Stability*, 181, 109364.
- 3- Kerber, R. (1983). *W. Schnabel: Polymer Degradation, Principles and Practical Applications*. Carl Hanser Verlag, München 1981. 227 Seiten, Preis: DM 68.
- 4- Ilie, S. and R. Senetscu (2009). Polymeric materials review on oxidation, stabilization and evaluation using CL and DSC methods. TE-Note-2009-004.
- 5- Yüksel, E., A. Bilici, İ. H. Geçibesler and İ. J. C. J. o. C. Kaya (2020). Synthesis and antioxidant activities of phenolic Schiff base monomers and polymers. *98(3): 151-157*.
- 6- Murphy, J. (2001). *Additives for plastics handbook*, Elsevier.
- 7- Saikrishnan, S., D. Jubinville, C. Tzoganakis, T. H. J. P. D. Mekonnen and Stability (2020). Thermo-mechanical degradation of polypropylene (PP) and low-density polyethylene (LDPE) blends exposed to simulated recycling. **182:** 109390.
- 8- Zia, J., U. C. Paul, J. A. Heredia-Guerrero, A. Athanassiou and D. J. P. Fragouli (2019). Low-density polyethylene/curcumin melt extruded composites with enhanced water vapor barrier and antioxidant properties for active food packaging. **175:** 137-145.
- 9- Crompton, T. R. , Thomas R. (2010), Thermo-Oxidative Degradation of Polymers.
- 10- Baum, B. (1959). *The mechanism of polyethylene oxidation. Journal of*



Applied Polymer Science, 2(6), 281–288.  
doi:10.1002/app.1959.070020604

**11-** Zweifel, H. (1998). Principles of Oxidative Degradation. Stabilization of Polymeric Materials, 1–40.  
doi:10.1007/978-3-642-80305-5\_1 .

**12-** Menczel, Joseph D, and R Bruce Prime. 2009. Thermal analysis of polymers: fundamentals and applications (John Wiley & Sons)

**13-** Shang, Y. J., Jin, X. L., Shang, X. L., Tang, J. J., Liu, G. Y., Dai, F., and Zhou, B. (2010). Antioxidant capacity of curcumin-directed analogues: Structure–activity relationship and influence of microenvironment. Food Chemistry, 119(4), 1435-1442.

**14-** Alariqi, Sameh A. S.; Al-Areqi, Niyazi A. S.; Alaghbari, Elyas Sadeq; Singh, R. P. (2017). Stabilization of  $\gamma$ -sterilized low-density polyethylene by synergistic mixtures of food-contact approval stabilizers. International Journal of Industrial Chemistry, 8(2), 145–156.  
doi:10.1007/s40090-017-0117-0.

**15-** Amol A. Nagargoje, Satish V.

Akolkar, Madiha M. Siddiqui, | Aditi V. Bagade, | Kisan M. Kodam, Jaiprakash N. Sangshetti, Manoj G. Damale, | Bapurao B. Shingate. (2019). Synthesis and evaluation of pyrazole-incorporated monocarbonylcurcumin analogues as antiproliferative and antioxidant agents.  
DOI: 10.1002/jccs.201800405

**16-** Zia J., Paul U.C., Heredia-Guerrero J.A., Athanassiou A., Fragouli D.J.P. (2019) Low-density polyethylene/curcumin melt extruded composites with enhanced water vapor barrier and antioxidant properties for active food packaging 175:137-145.  
<https://doi.org/10.1016/J.POLYMER.2019.05.012>.

**17-** Kirschweg, B., Tátraaljai, D., Földes, E., & Pukánszky, B. (2015). Efficiency of curcumin, a natural antioxidant, in the processing stabilization of PE: concentration effects. Polymer Degradation and Stability, 118, 17-23.

**18-** M.K.J.AL-Rubeai, M.SC thesis, Basrah University. (2003).

**19-** Rouba, N., T. Sadoun, N. Boutagrabet, D. Kerrouche, S. Zadi, N. J. I. J. o. C. Mimi and C. Engineering (2015). "Thermo-oxidation and biodegradation study of low-density polyethylene/starch films by IR spectroscopy." 34(4): 69-78.

<https://doi.org/10.30492/IJCCE.2015.1>

[5458](#)

20- S.A.W.Niema, Ph. D thesis, Basrah University. (2004).

21- Cao, Dongxu, Maobing Tu, Rui Xie, Jing Li, Yonnie Wu, Sushil %J Journal of agricultural Adhikari, and food chemistry. 2014. 'Inhibitory activity of carbonyl compounds on alcoholic fermentation by Saccharomyces cerevisiae', 62: 918-26.

22- Huang, D., Ou, B., & Prior, R. L. (2005). The chemistry behind antioxidant capacity assays. Journal of agricultural and food chemistry, 53(6), 1841-1856.

23- Musa, Khalid Hamid, Aminah Abdullah, Bambang Kuswandi, and M Amrun %J Food chemistry Hidayat. 2013. 'A novel high throughput method based on the DPPH dry reagent array for determination of antioxidant activity', 141: 4102-06.

24- Santos-Sánchez, N. F., Salas-Coronado, R., Villanueva-Cañongo, C., and Hernández-Carlos, B. (2019). Antioxidant compounds and their antioxidant mechanism. Antioxidants, 10, 1-29.

25 - Blois, M. S. J. N. (1958). "Antioxidant determinations by the use of a stable free radical." **181**(4617): 1199-1200.

26- Brand-Williams, W., Cuvelier, M. E., and Berset, C. L. W. T. (1995). Use of a free radical method to evaluate

antioxidant activity. LWT-Food science and Technology, 28(1), 25-30.

27- Nagarajan, Subhalakshmi, Ramaswamy Nagarajan, Jayant Kumar, Adele Salemme, Anna Rita Togna, Luciano Saso, and Ferdinando %J Polymers Bruno. 2020. 'Antioxidant activity of synthetic polymers of phenolic compounds', 12: 1646.

28- Valantina, Rubalya S, P %J Research Journal of Chemistry Neelamegam, and Environment. 2012. 'Antioxidant potential in vegetable oil', 16: 87-94.

29- K.A.J.Jawad, M.SC thesis, Basrah University (1983).

30- Rezakazemi, Mashallah, Mohtada Sadrzadeh, Takeshi %J Progress in Energy Matsuura, and Combustion Science. 2018. 'Thermally stable polymers for advanced high-performance gas separation membranes', 66: 1-41.

31- Menczel, Joseph D, and R Bruce Prime. 2009. Thermal analysis of polymers: fundamentals and applications (John Wiley & Sons).

32-Sarfraz, Amina, Asif Hassan Raza, Mojtaba Mirzaeian, Qaisar Abbas, and Rizwan Raza. 2019. '11742 Electrode Materials for Fuel Cells'.

33-Fortunato, A. (2013). Drug–Biomembrane Interaction Studies || DSC: history, instruments and devices., 169 212. doi:10.1533/9781908818348.169.

34- Gill, P., Moghadam, T.T., and Ranjbar, B. Differential scanning

calorimetry techniques: applications in biology and nanoscience. *J. Biomol. Tech.* **21** (4), 167-193 (2010).

35- Durowoju, Ibrahim B.; Bhandal, Kamaljit S.; Hu, Jian; Carpick, Bruce; Kirkitadze, Marina (2017). *Differential Scanning Calorimetry &#8212; A Method for Assessing the Thermal Stability and*

*Conformation of Protein Antigen. Journal of Visualized Experiments, (121), –. doi:10.3791/55262.*

36- Al-Rikabi, Ali Khudair; Extracting phenolic compounds from wheat bran, their effectiveness as antioxidants; *Polymer Research Journal; Issue 33 Part Two 8-15-118); (2007).*

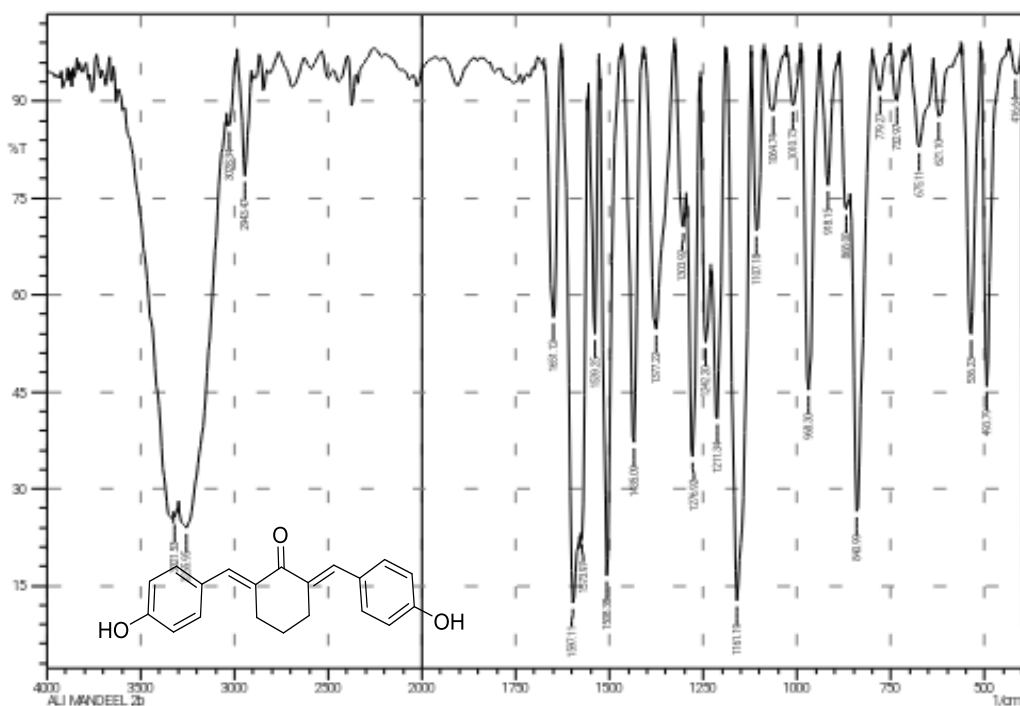


Figure (1) IR SPECTRA for compound A

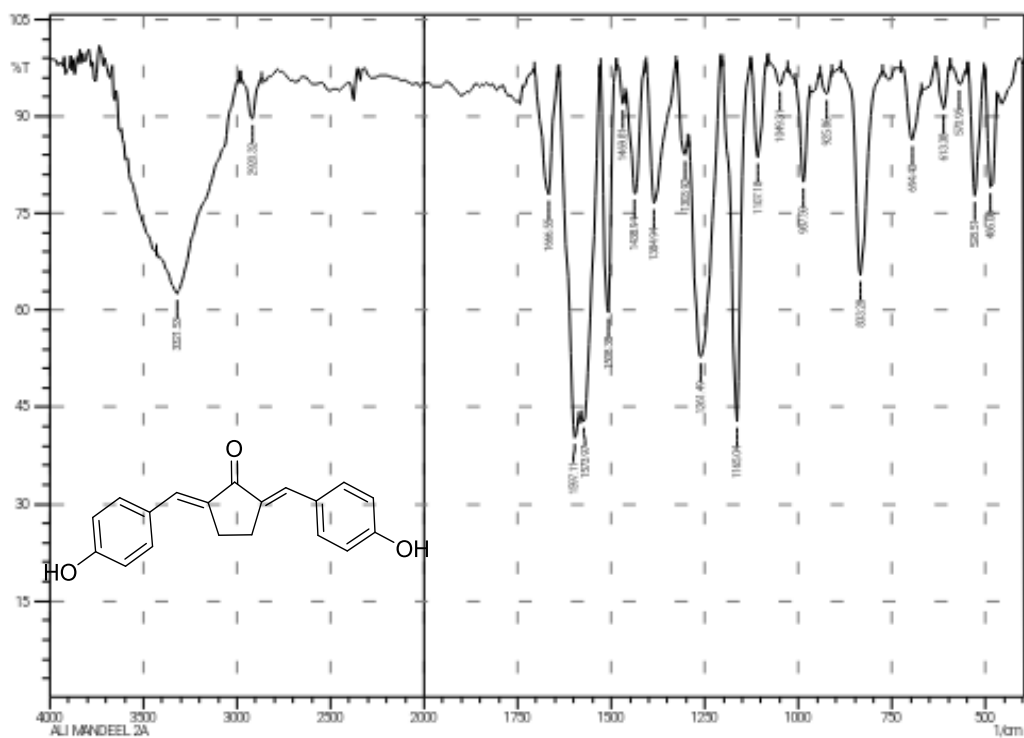


Figure (2) IR SPECTRA for compound B

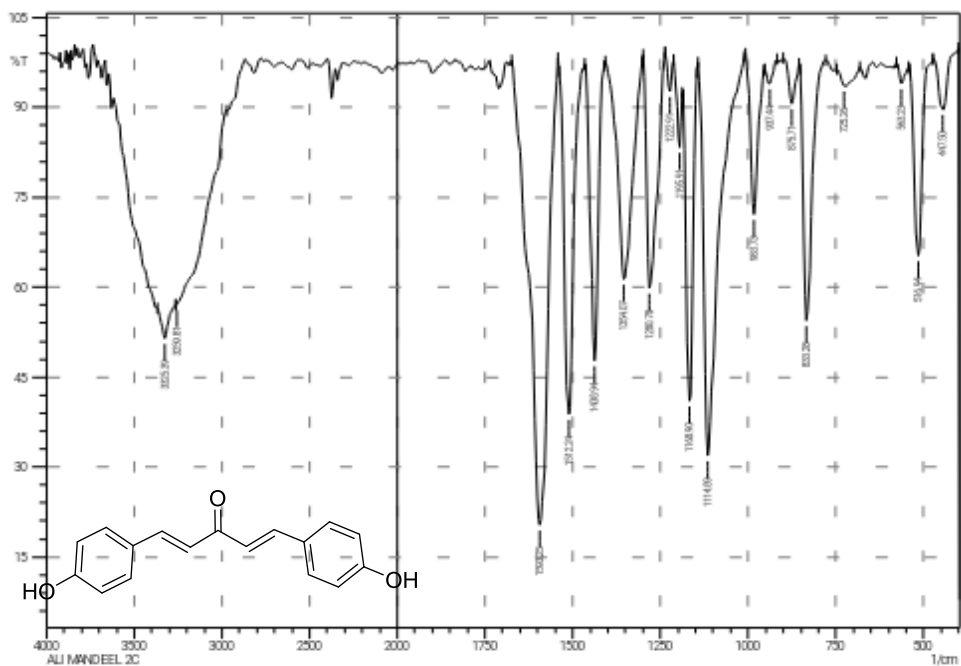


Figure (3) IR spectra for compound C



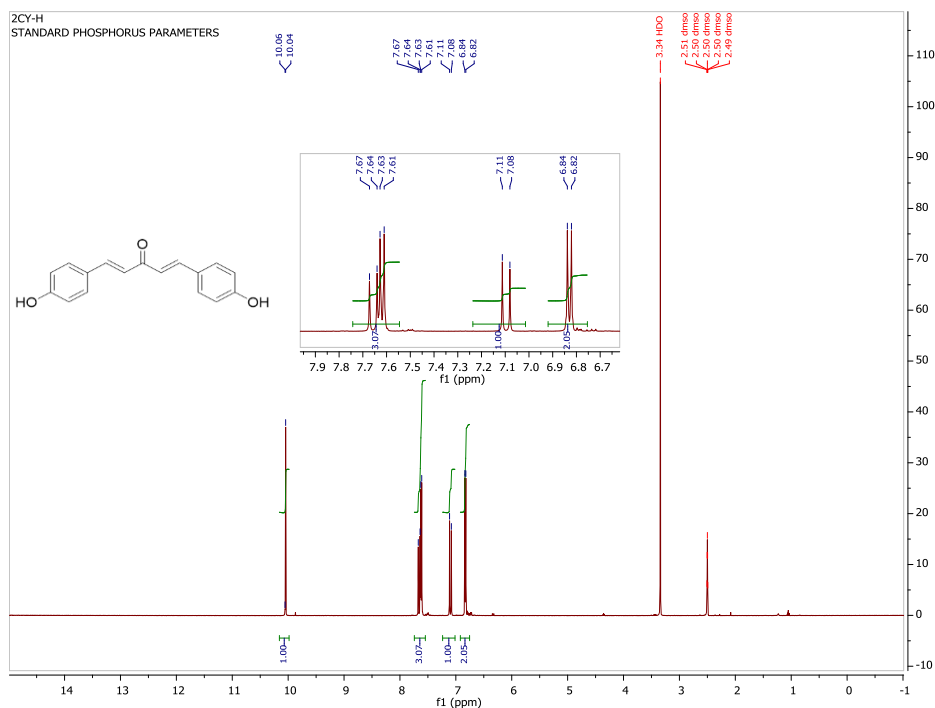


Figure (6)  $^1\text{H}$ NMR FOR COMPOUND C

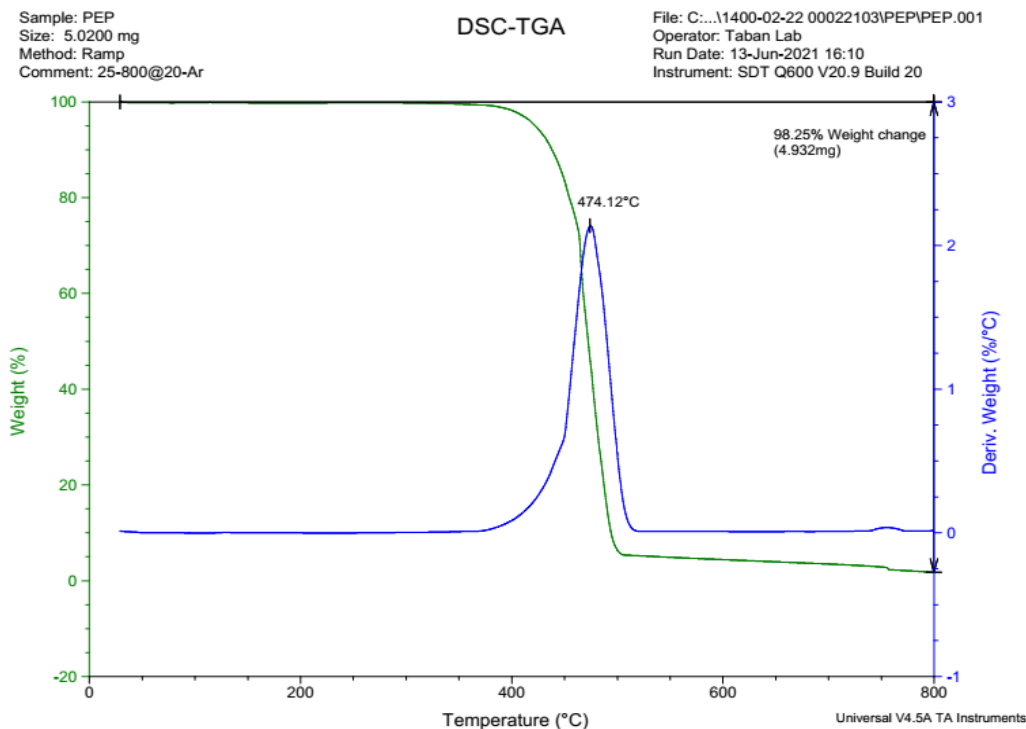


Figure (7) curve TGA to LDPE Under argon atmosphere

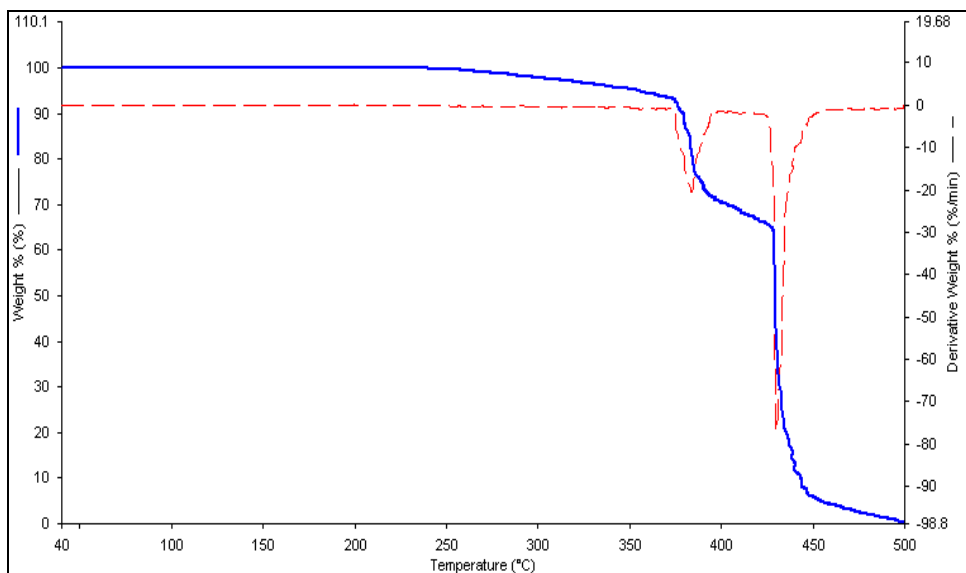


Figure (8) curve TGA to LDPE Under oxygen atmosphere

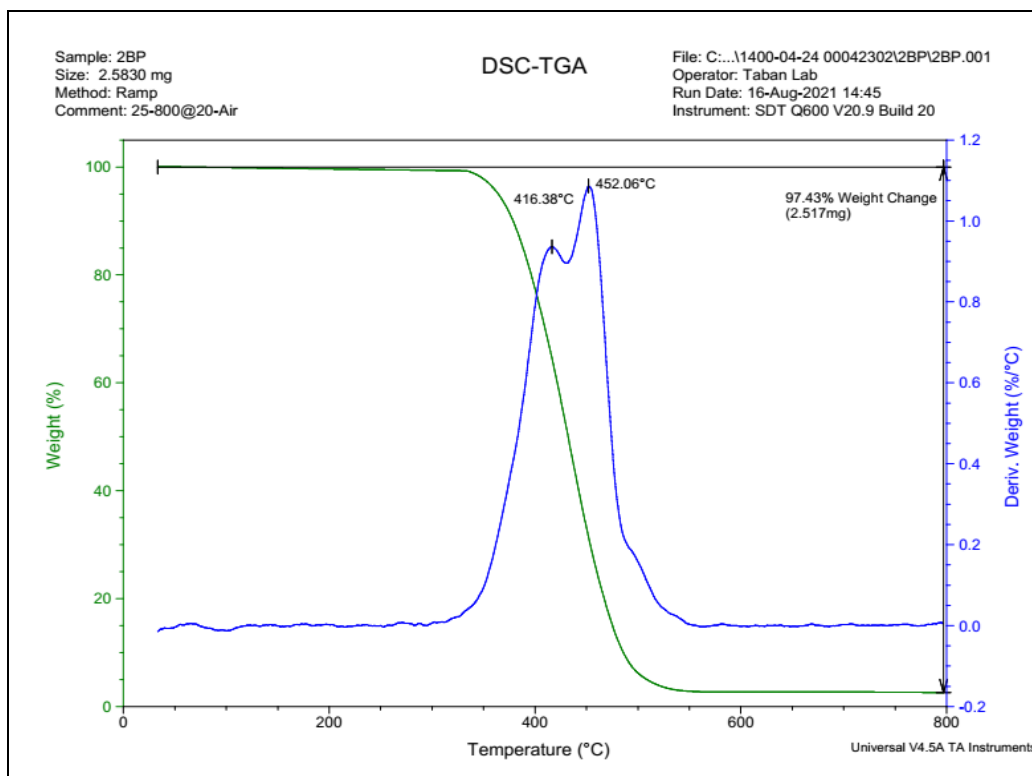


Figure (9) curve TGA of compound (LDPE/ A 6% )under oxygen

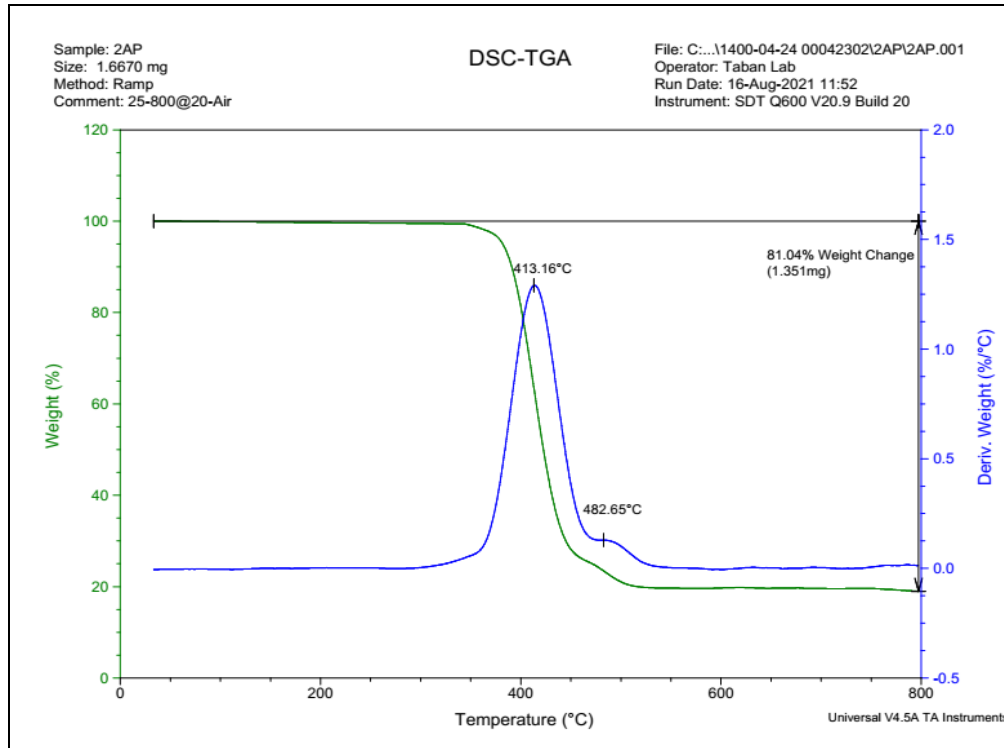


Figure (10) curve TGA to compound (LDPE/ B 6% ) under oxygen

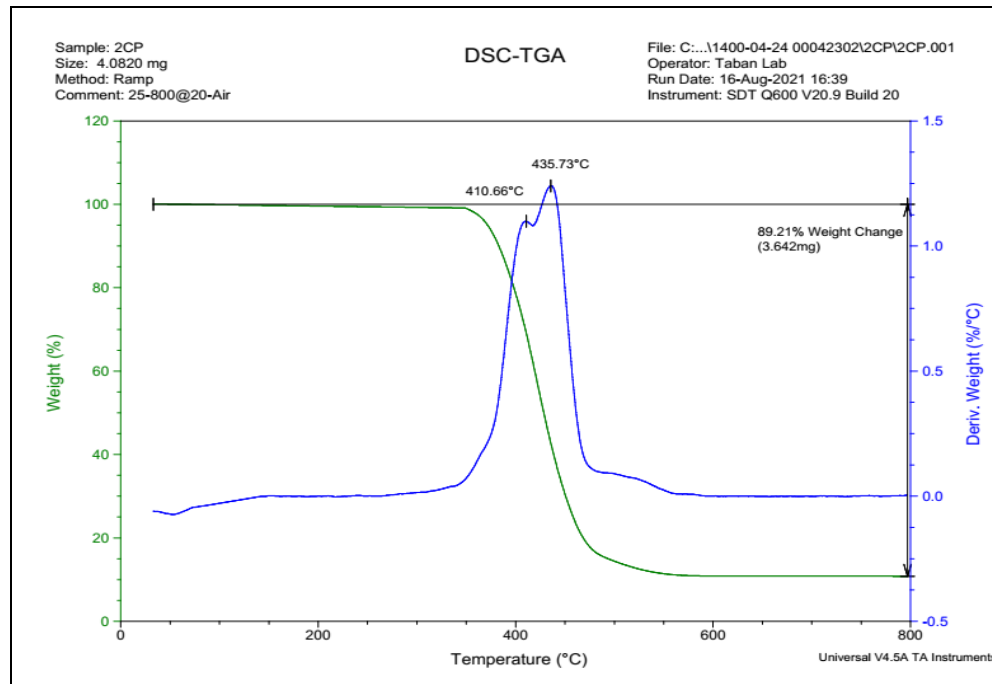


Figure (11) curve TGA to compound (LDPE/C 6% ) under oxygen



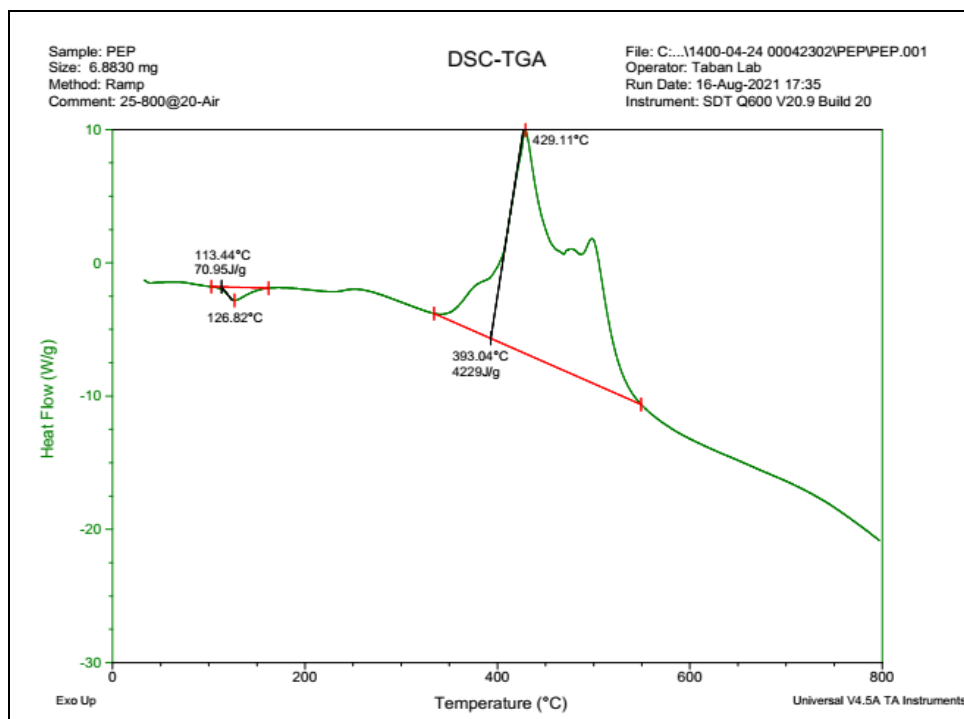


Figure (12) curve DSC to LDPE under oxygen

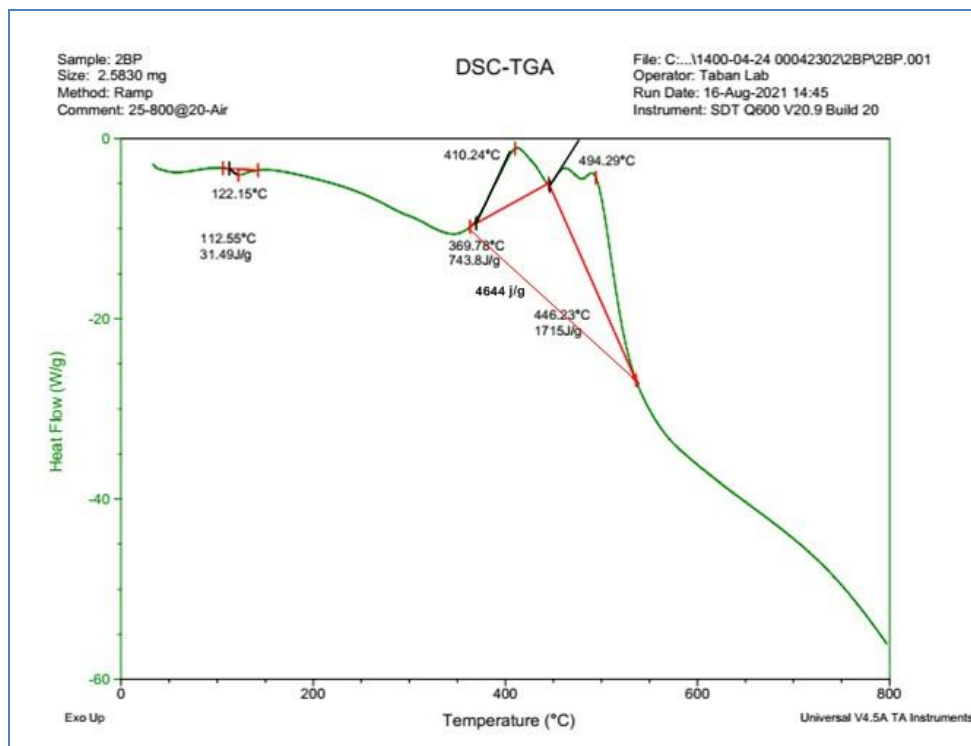


Figure (13) curve DSC to compound (LDPE/ A 6% )under oxygen

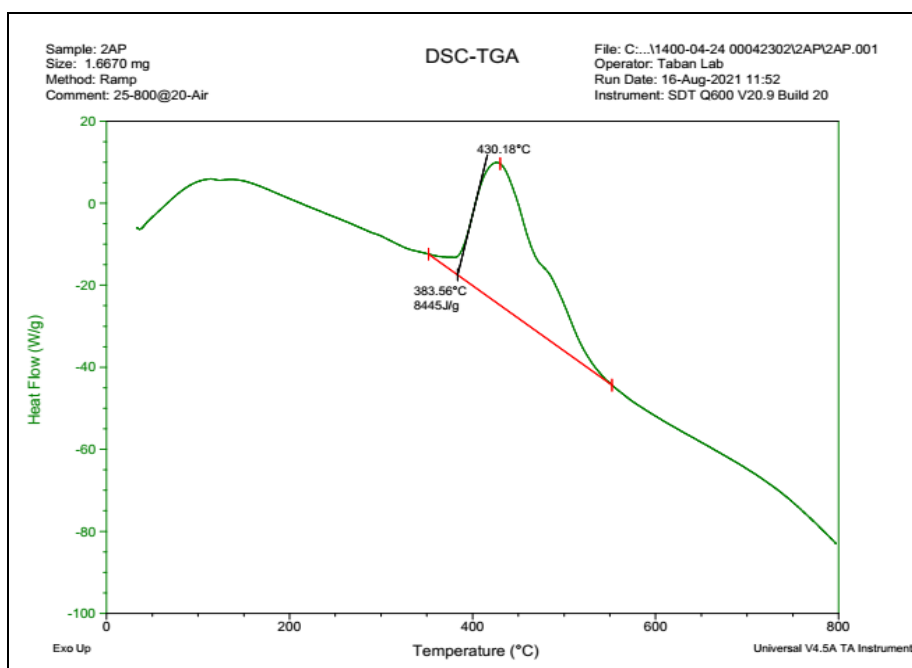


Figure 14 curve DSC to compound (LDPE/ B 6% )under oxygen

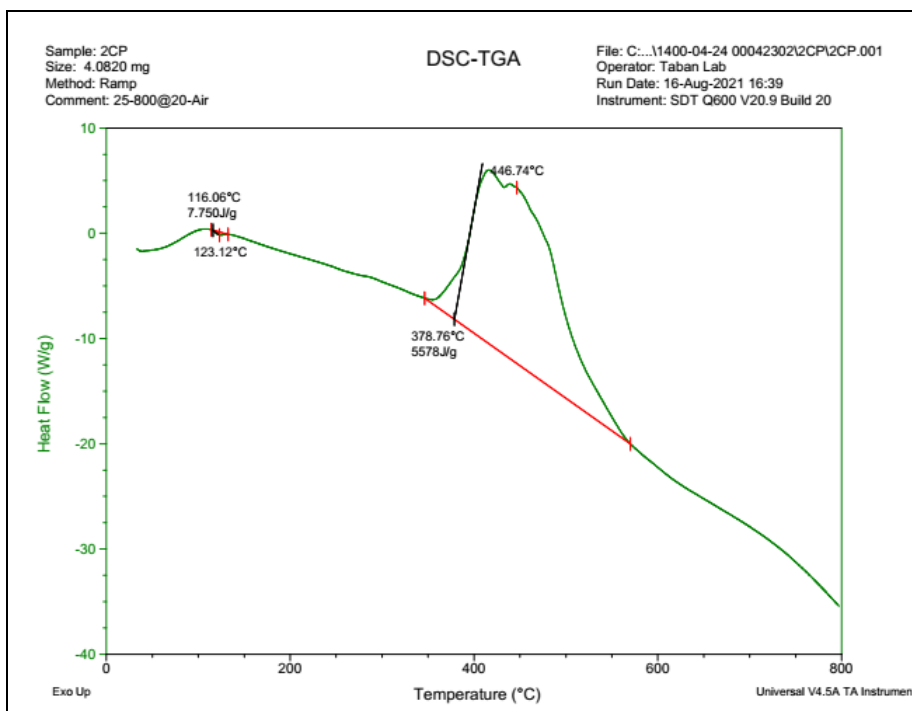


Figure 15 curve DSC to compound (LDPE/ C 6% )under oxygen