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New Chalcones Derivatives, Determine Their Chemical Structure Using 1D and 2D-NMR Spectroscopy

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Abstract

The complete ^{1}H and ^{13}C NMR assignment of new chalcones compounds has been obtained using one-and two-dimensional NMR techniques including COSY, HMQC, and HMBC experiments. The data deduced from this study show that the alkyl chain and the phenyl ring are in different planes compared to the chalcones ring.

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1. Introduction

Chalcones are the major component of the natural product, which consists of two aryl rings connect by an α, β-unsaturated ketone system. Chalcones are precursors for flavonoids [1-4]. Because of their large range of pharmacological characteristics such as anti-cancer [5-7], anti-inflammatory [8], anti-oxidant [9], and much other activity [10-13], chalcones and their derivatives have gotten a lot of interest. in recent years, the utilization of FT-NMR devices in undergraduate laboratories has expanded dramatically [14-16]. The two-dimensional NMR spectroscopy is a widely used and extremely powerful technique in the elucidation of the chemical structure of compounds [17-18]. 2D-NMR approaches allow the NMR experiment to shed light on molecular connection, making interpretation conceivable and easier [19]. Indeed, recently established the recording feasibility of 2D-NMR heteronuclear ^{1}H-^{15}N and ^{1}H-^{13}C correlation spectra in structure characterization of synthetic organic compounds [20,21]. This paper focuses on the synthesis of chalcone derivatives and studies their 1D- and 2D-NMR spectra. The 2D-NMR technique that has been used to structural elucidation are the homonuclear ^{1}H-^{1}H correlation spectroscopy (COSY), and the heteronuclear HMBC, and HMQC.

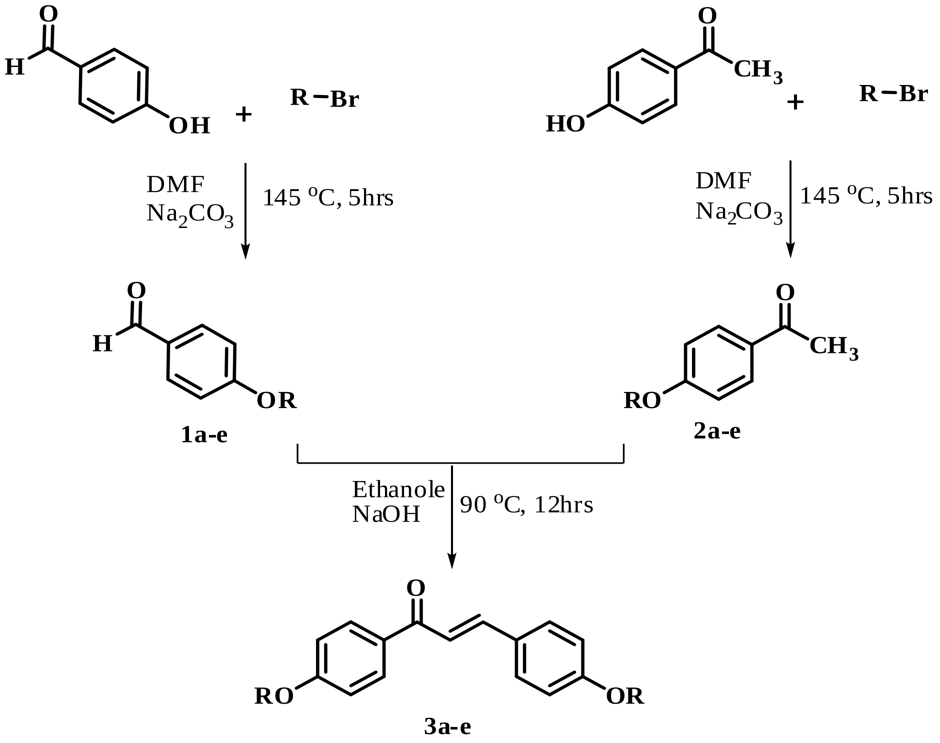
2. Experimental

2.1. Material

The p-hydroxybenzaldehyde, p-hydroxy acetophenone, bromoalkanes (C_6, C_8, C_{10}, C_{12}, C_{14}), DMF, Sigma-Aldrich supplied the materials. The NMR spectra were recorded in deuterated chloroform ($CDCl_3$) at 25 °C on a Bruker 400 MHz Ultrashied FT-NMR spectrometer. Internal tetramethylsilane (TMS) was used to reference chemical shifts. Standard Bruker pulse programs were used throughout the entire experiment.

2.2. Synthesis of target compound 3a-e

sThe intermediate compounds (4-alkyloxy)benzaldehyde **1a-1e** and (4-alkyloxy)acetophenone **2a-2e** were prepared according to the method described in the literature [22-23]. The final compounds have been synthesized by the aldol condensation reaction of **1a-1e** and **2a-2e**. The synthetic method of compound **3e** is described here as an example. An equimolar mixture of ((4-tetradecyloxy)phenyl)ethanon (10 mmol) and (4-tetradecyloxy)benzaldehyde (10 mmol) were dissolved in absolute ethanol 35 ml. NaOH (36 mmol) was dissolved in ethanol, which was then poured into the reaction mixture. The reaction mixture has been stirred and refluxed for 12 hours, the separated product was filtered and dried. Chalcones were recrystallized from ethanol. Figure 1 shown the scheme of the synthesis of target compounds.



Series **3a-e**, **3a**: R = C_6H_{13}, **3b**: R = C_8H_{17}, **3c**: R = $C_{10}H_{21}$
3d: R = $C_{12}H_{25}$, **3e**: R = $C_{14}H_{29}$

Fig.1: Scheme of synthesis of compounds 3a-e.

3. Results and Discussion

The ^{1}H-NMR data for prepared compounds in $CDCl_3$ solution are tableted in Table 1.

3.1. 1D-NMR Spectral Assignment

The sample compound **3e** can be used to provide a full assignment for the target compounds, as shown in Fig. 2. The ^{1}H-NMR of compounds **3e** shows the aromatic protons are observed at δ =8.04-8.02 ppm was assigned for phenyl protons (H11and H12). The appearing doublet at δ

=7.79-7.76 ppm has arisen from the β-proton of the olefinic group (H7). The two doublets at the chemical shift δ =7.62-7.60 ppm and δ =7.65-7.62 ppm were assigned for phenyl protons (H4 and H5), respectively. While the α-proton of the olefinic group (H8) is observed at δ =7.45-7.42 ppm. The phenyl ring protons of the (H2, H3, and H13, H14) were given a four doublet signal at δ =7.01-6.92 ppm. While the (-OCH$_2$) peak was observed in the region of δ =4.06-4.03 ppm. In all **3a-3e** chain compounds, the protons in ((-CH$_2$)n) reside were observed as multiples at the range of δ =1.95-1.28 ppm. In the same way, the observed triplets at δ =0.90-0.81 ppm were assigned to the methyl group (-CH$_3$) of alkyl side chains, as shown in Fig. 3.

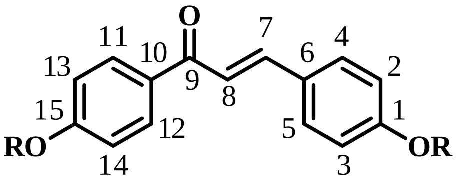


Figure 2: Chemical structures of series 3a-e with numbering.

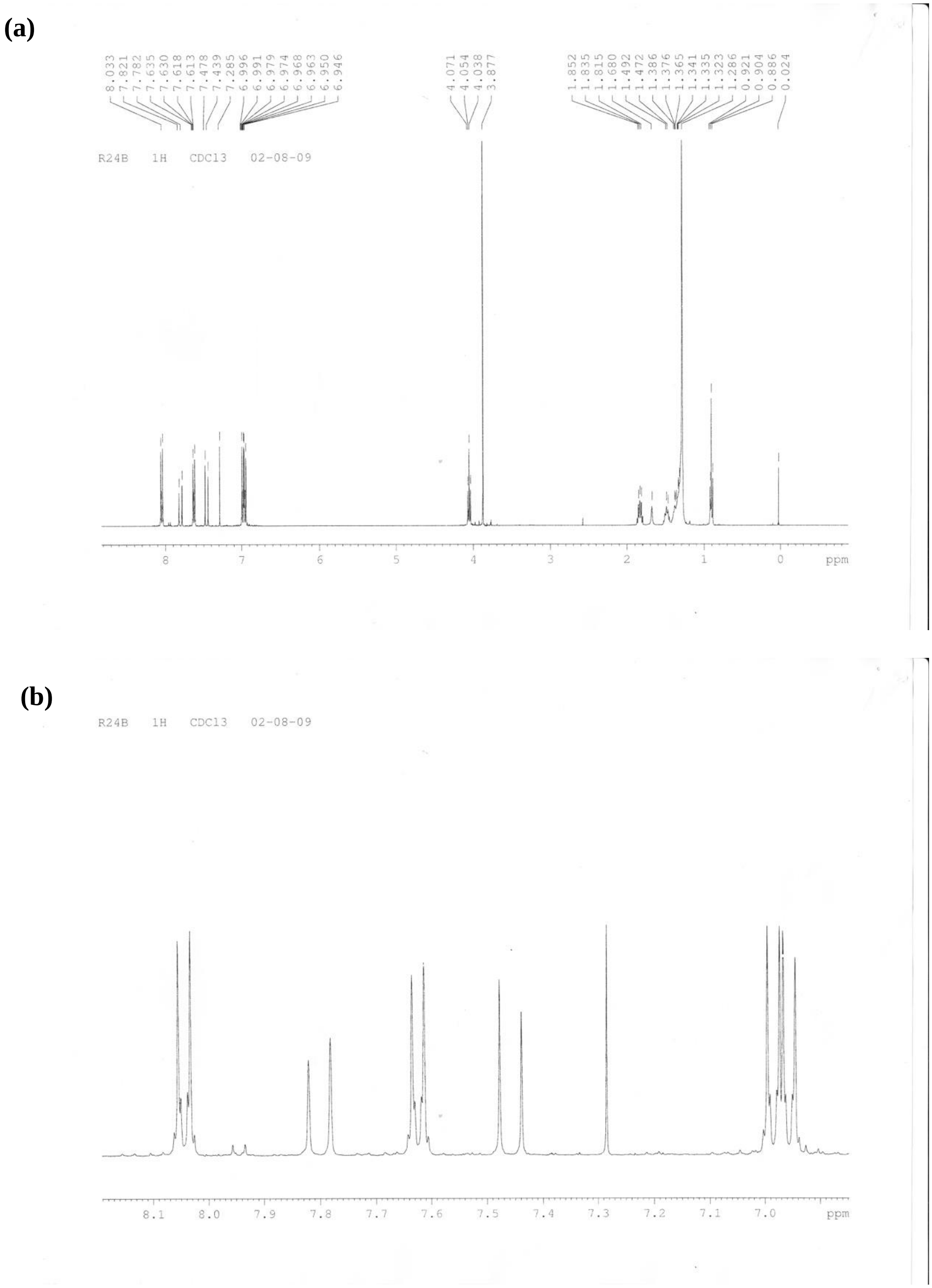


Figure 3: (a) ^{1}H-NMR spectrum of compound 3e. (b) expansion of ^{1}H-NMR of compound 3e.

Table 1: The ^{1}H-NMR data of compounds **3a-e**.

	Chemical shift (ppm)				
Atom	**3a**	**3b**	**3c**	**3d**	**3e**
$-CH_3$	0.82	0.81	0.86	0.84	0.90
$-(CH_2)n$	1.26-1.86	1.25-1.83	1.29-1.85	1.27-1.86	1.28-1.85
$-OCH_2$	4.04	4.03	4.06	4.03	4.05
H2	6.92	6.93	6.95	6.94	6.94
H3	6.96	6.97	6.98	6.99	6.96
H13	6.97	6.98	6.99	6.97	6.97
H14	6.98	7.00	7.01	6.98	6.99
H8	7.42	7.43	7.45	7.44	7.43
H4	7.61	7.60	7.62	7.60	7.61
H5	7.63	7.62	7.65	7.64	7.63
H7	7.78	7.77	7.78	7.79	7.78
H11 &H12	8.02	8.04	8.03	8.01	8.03

The ^{13}C-NMR data for prepared compounds are tableted in Table 2. The ^{13}C-NMR spectra show that the carbonyl groups peak (C=O) appeared in the ^{13}C-NMR chemical shift δ =189.16-188.94 ppm. The aromatic quaternary carbon atoms resonate in the region δ =163.34-163.08 ppm and δ =161.88-160.98 ppm which is assigned to (C15 and C1), respectively. The peaks of olefinic carbons were observed at the region 144.21-144.11 assigned to (C-β), while (C-α) were observed at the lower chemical shift δ =120.79-120.02 ppm. The signals in the range of δ =131.51-131.43 ppm corresponding to the aromatic carbon (C10). While, the signals in the region δ =131.11-131.09 ppm were assigned to aromatic carbons (C11 and C12). The aromatic carbons (C4 and C5) given signals at the chemical shift δ =130.49-130.36 ppm. The signals of aromatic carbons (C6) appearing at δ =128.27-127.22 ppm. The observed signals at δ = 114.65-114.58 ppm were attributed to (C13, C14, and C2, C3). The signals at the chemical shifts δ =68.51-68.43 ppm were assigned to the ($-OCH_2$) group. while the signals in the region. The peaks of the aliphatic methylene carbons were observed at δ =22.53-32.97 ppm, which are corresponding to ((-CH_2)n), and at δ=14.52-14.24 ppm can be attributed to the terminal methyl carbon of the alkyl chains (-CH_3). Figure 5 shows the ^{13}C-NMR of compound **3e**.

Table 2: The ^{13}C-NMR data of compounds **3a-e**.

	Chemical shift (ppm)				
Atom	**3a**	**3b**	**3c**	**3d**	**3e**
-CH_3	14.29	14.43	14.24	14.48	14.52
-(CH_2)n	22.84-32.67	22.53-32.33	23.03-32-97	22.98-32.48	23.10-32.33
-OCH_2	68.43	68.47	68.49	68.51	68.44
C2, C3 & C13, C14	114.61	114.59	114.65	114.58	114.65
C8	120.44	120.20	120.63	120.79	120.02
C6	127.60	127.22	128.10	127.93	128.27
C4 & C5	130.39	130.37	130.48	130.44	130.49
C11& C12	131.09	131.09	131.11	131.10	131.09
C10	131.50	131.43	131.51	131.48	131.51
C7	144.12	144.18	144.21	144.18	144.11
C15	161.91	161.88	161.97	161.94	161.98
C1	163.08	163.13	163.31	163.23	163.34
C9	188.98	189.04	188.94	189.88	189.16

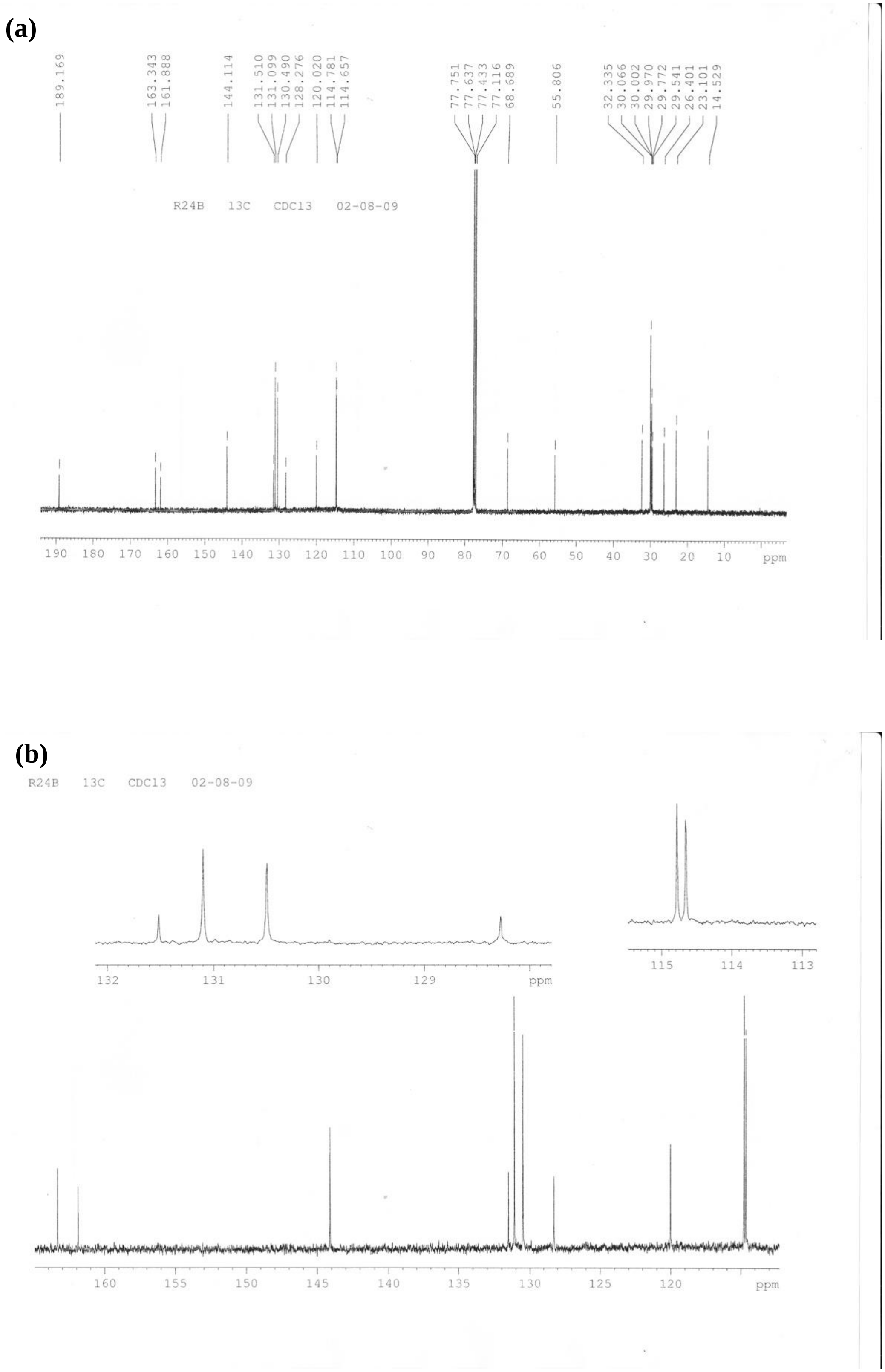


Figure 4: (a) ^{13}C-NMR spectrum of compound 3e. (b) expansion of ^{13}C-NMR of compound 3e.

3.1 2D-NMR Spectroscopy:

The correlation spectroscopy (COSY) experiments verified the connection between analogous proton pairs and neighboring protons. When the cross peak generated by these correlations would seem in the same area. The representative COSY spectrum of compound **3e** is shown in Figure 6. The COSY spectrum showed three areas, the aromatic and unsaturated area, the aliphatic oxygenated area, and the aliphatic side chains area. At the aromatic and unsaturated area, the H11 and H12 were correlated with H13 and H14 in the aromatic ring which was observed at δ = 8.03 ppm and δ = 6.97 ppm, respectively. likewise, the signals of protons H4 and H5 which appear as two doublets at δ = 7.61 was correlated with H1 and H2. The COSY spectrum also shows that the β-proton H7 of the α,β-unsaturated group that reported at δ = 7.78 ppm was connected with α-proton H8 at δ = 7.43 ppm. In the aliphatic oxygenated area, the COSY spectrum showed the correlation between $–OCH_2$ groups that were reported as a triplet signal at δ = 4.05 ppm and its nearby methylene groups $–CH_2$ in aliphatic side chains at δ = 1.83 ppm. The aliphatic area exhibit a complex COSY correlation in the area δ =1.68-1.28 ppm which reveals the correlation between the methylene groups $-CH_2$ in the aliphatic side chains. Moreover, the $-CH_3$ group in the terminal side chains has appeared at δ = 0.90 ppm was connected with its nearby methylene group at δ = 1.28 ppm.

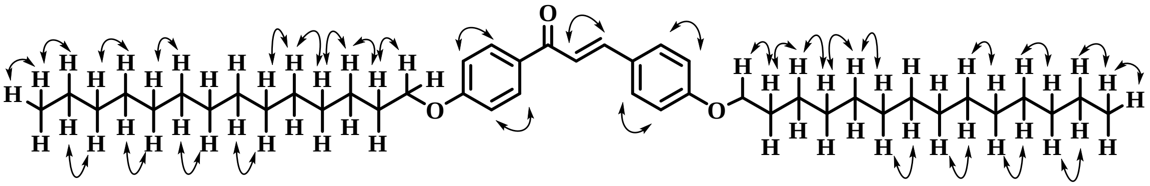


Figure 5: ^{1}H-^{1}H correlation in COSY spectrum of compound 3e.

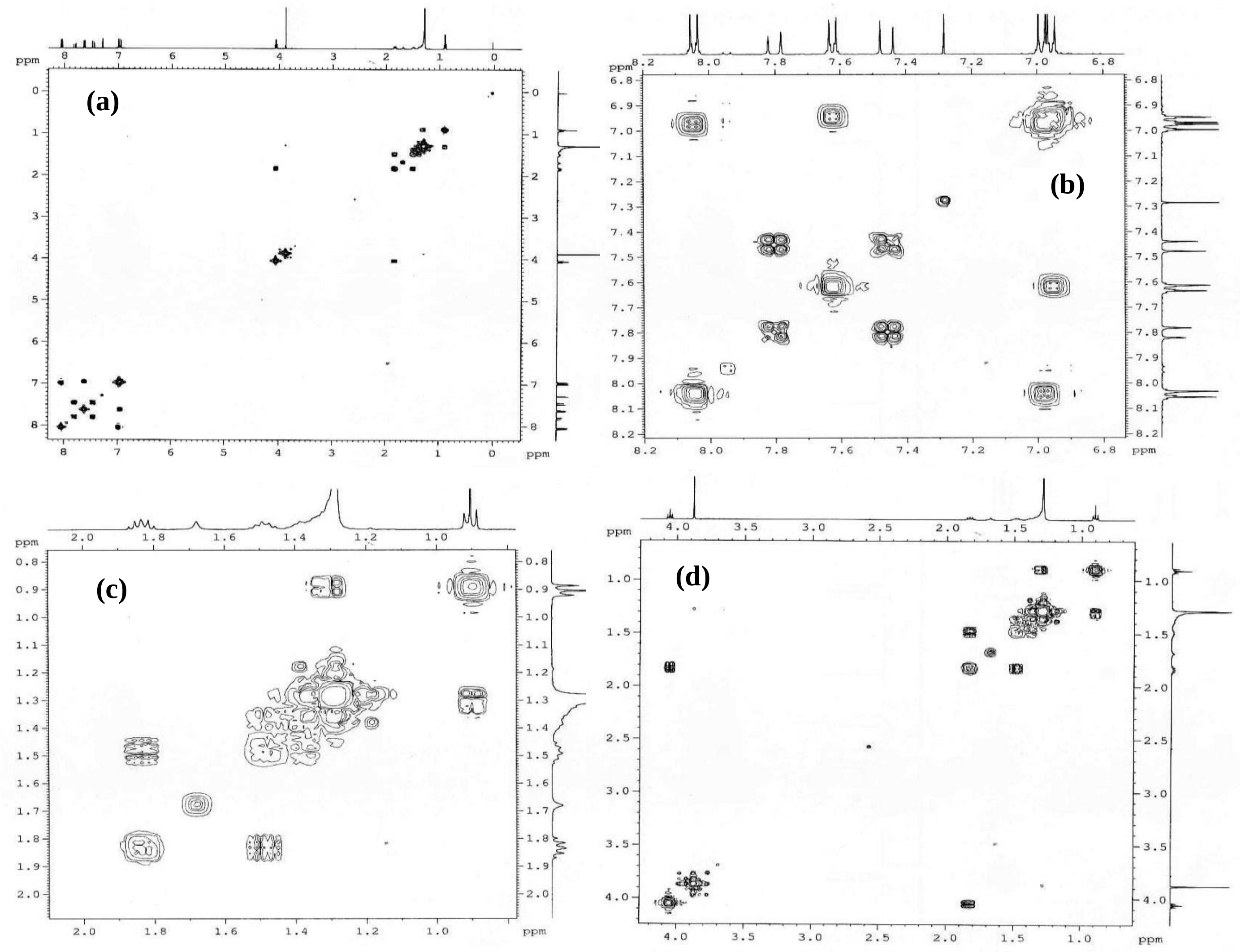


Figure 6: The COSY spectrum of compound 3e. (a) completely COSY spectra. (b) Expansion of aromatic protons. (c), (d) Expansion of aliphatic protons.

The HMQC spectra reveal the direct bond between protons and carbon atoms to which they are directly linked. The HMQC spectrum of all prepared compounds and the representative HMQC of compound **3e** was explained here, and it is shown in Figure 7. The HMQC spectrum shows that the appearing doublet at δ = 8.03 ppm has been connected with the signal at δ = 131.09 ppm, while, the appearing doublet at δ = 7.78 ppm was connected with the α,β-unsaturated group carbon atoms signal observed at δ = 144.21 ppm. The doublet appears at δ = 7.61 ppm was connected with the signal at δ = 130.49 ppm, while, the appearing doublet at δ = 7.43 ppm with the signal of α,β-unsaturated group carbon atoms at δ = 120.02 ppm. Also, the observed doublets at δ = 6.99 ppm, and δ = 6.97 ppm was connected with the signal appearing at δ = 114.78 ppm, while the two doublets observed at δ = 6.96 ppm and δ = 6.94 ppm with the signal at δ = 114.65 ppm. Moreover, the triplet observed at δ = 4.05 ppm was connected with ether group $–OCH_2$ at δ = 68.68 ppm. In addition, the multiple at δ = 1.83 ppm connection with the signal at δ = 32.33 ppm. The complex signals appearing at 1.68-1.28 ppm which assignment to the protons of methylene group $–CH_2$ was connected with the signals at δ = 30.06-23.10 ppm. The triplet observed at δ = 0.90 ppm was connected with a methyl group at δ = 14.52 ppm.

We can supplement the HMQC by using HMBC spectroscopy. The HMBC allows to determine the quaternary carbons atoms and their correlation with the nearby proton. As shown in the HMBC spectrum of compound **3e,** Figure 8. The appearing doublet at δ = 8.03 ppm connected with signals that appearing at δ = 114.78 ppm, δ = 163.34 ppm, and δ = 189.16 ppm. The observed doublet at δ = 7.78 ppm was connected with α-unsaturated carbon atom at δ = 120.02 and with carbon atoms at δ = 128.27 ppm and δ = 189.16 ppm. The proton that gives a signal at δ = 7.61 ppm was connected with carbons at δ = 114.65 ppm, δ = 120.02, δ = 144.11ppm, also connected with the quartet carbon atom of the aromatic ring at δ = 163.34 ppm. Likewise, the signals of α-proton of the α,β-unsaturated connected with the quartet aromatic carbon atom δ = 128.27 ppm, also correlated with carbons at δ = 130.49 ppm, and δ = 189.16 ppm. The two doublet appearing at δ = 6.99 ppm and δ = 6.97 ppm correlated with 131.09, and δ = 163.34 ppm, while the two doublet at δ = 6.96 ppm and δ = 6.94 ppm correlated with carbons at δ = 130.49 ppm, and δ = 161.88 ppm. The signal of protons at δ = 4.05 ppm correlated with carbon atoms of the ether groups at δ = 163.34 ppm and δ = 161.88 ppm.

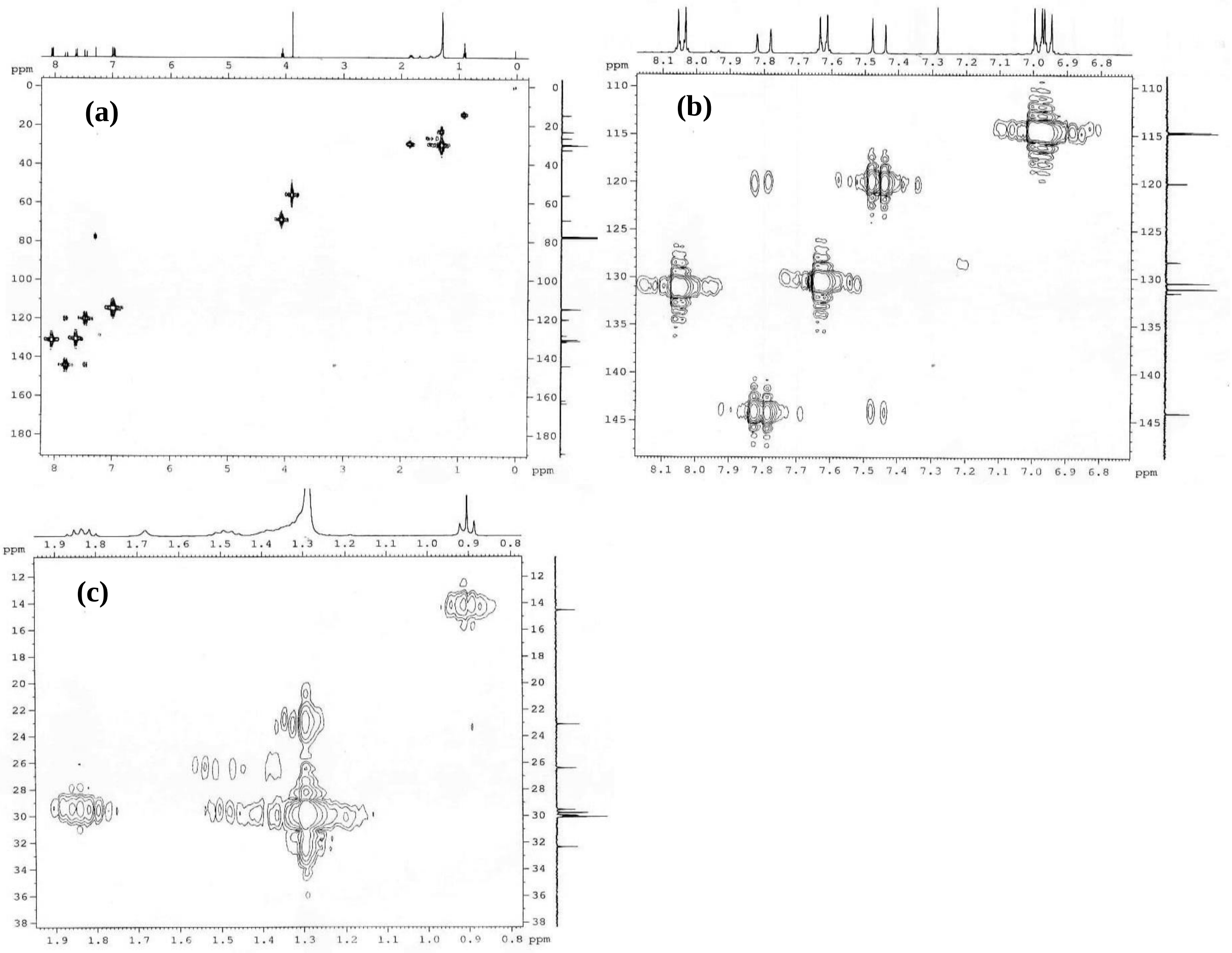


Figure 7: The HMQC spectrum of compound 3e. (a) The completely HMQC spectrum. (b) Expansion of aromatic region. (c) Expansion of aliphatic region.

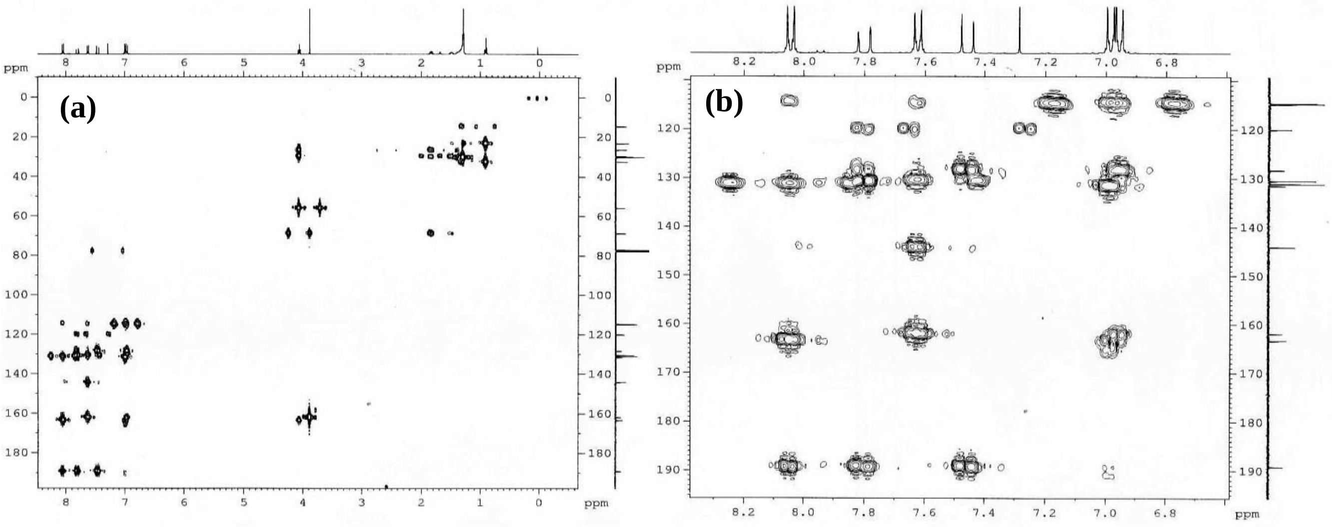


Figure 8: the HMBC spectrum of compound 3e. (a) the completely HMBC spectrum. (b) Expansion of aromatic region.

4. Conclusions

In this work new substation chalcones have been synthesized and structure elucidation of the prepared chalcones derivatives **3a are**. Complete NMR assignments have been studied in detail by 1D-NMR (^{1}H-NMR and ^{13}C-NMR) and 2D-NMR (COSY, HMQC, and HMBC). The results indicated it is possible to make accurate chemical shift assignments of prepared chalcones by utilizing the 2D-NMR (COSY, HMQC, and HMBC). Moreover, the correlation of methylene groups has been solved clearly by using 2D-NMR.

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مشتقات جالكون جديدة, وتحديد تركيبها الكيميائي باستخدام الرنين النووي المغناطيسي الاحادي و الثنائي البعد

وهج رائد عباس محمد عبد الكريم طلك

قسم الكيمياء- كليه العلوم- جامعة الانبار- الانبار- العراق

المستخلص

في هذا البحث تم تحديد ^{1}H و ^{13}C-NMR بشكل كامل لمشتقات الجالكون المحضرة وباستخدام تقنية الرنين النووي المغناطيسي الاحادي و الثنائي البعد و التي تضمنت قياس COSY و HMQC و HMBC. اظهرت البيانات التي تم الحصول عليها من هذه الدراسة ان سلاسل الاكيل والحلقات الاروماتية تقع في مستويات مختلفة بالنسبة لحلقة الجالكون.