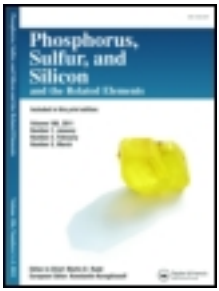

Phosphorus, Sulfur, and Silicon and the Related Elements

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Synthesis and Characterization of Some Novel 3-Bromo-2-acetylthiophene Chalcones and Biological Evaluation of Their Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate Derivatives

B. V. Ashalatha [a] , B. Narayana [a] & K. K. Vijaya Raj [a]

[a] Department of Post-Graduate Studies and Research in Chemistry, Mangalore University, Mangalagangotri, India

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Synthesis and Characterization of Some Novel 3-Bromo-2-acetylthiophene Chalcones and Biological Evaluation of Their Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate Derivatives

B. V. Ashalatha, B. Narayana, and K. K. Vijaya Raj
Department of Post-Graduate Studies and Research in Chemistry, Mangalore University, Mangalagangotri, India

Novel chalcones 1-(3-bromothien-2-yl)-3-(aryl)prop-2-en-1-ones derived from 3-bromo-2-acetylthiophene and their cyclization product with ethylacetoacetate such as 4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate derivatives were synthesized and studied by X-ray, analytical, and spectral methods. Compounds were screened for their anti-inflammatory, analgesic, and antimicrobial activities. The compound ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-propoxyphenyl) cyclohex-3-ene-1-carboxylate **5c** *exhibited promising anti-inflammatory, analgesic and antibacterial activities.*

Keywords Biological evaluation; 3-bromo-2-acetylthiophene chalcones; characterization; cyclohex-3-ene-1-carboxylate; synthesis

Chalcone and the corresponding heterocyclic analogs are valuable intermediates in organic synthesis[1]and exhibit a wide range of biological activities.[2,3] An important feature of chalcones is their ability to act as activated unsaturated systems in conjugated additions of carbanions in the presence of suitable basic catalysts.[4,5] For example, the Michael addition of ethylacetoacetate to chalcone yields 4,6-diaryl-2-oxo-cyclohex-3-ene-1-carboxylate derivatives, which are efficient synthons for building spiranic compounds.[6] Cyclohexenone derivatives are well known lead molecules for the treatment of inflammation and autoimmune diseases.[7–9] In the present work, synthesis and characterization of some novel 3-bromo-2-acetylthiophene chalcones and

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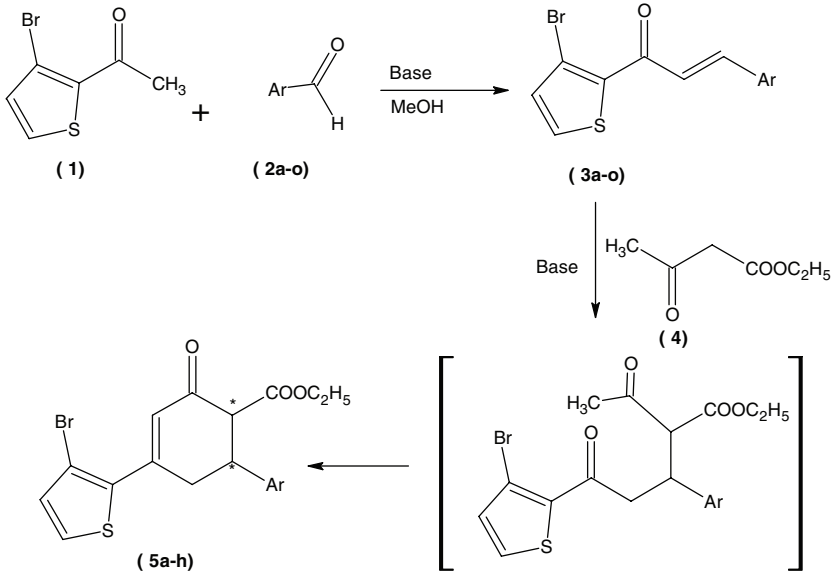
Address correspondence to B. Narayana, Department of Post-Graduate Studies and Research in Chemistry, Mangalore University, Mangalagangotri, 574 199, India. E-mail: nbadiadka@yahoo.co.uk

biological evaluation of their Michael addition products such as ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate derivatives are discussed.

RESULTS AND DISCUSSION

Chemistry

The reaction of chalcones with ethylacetoacetate is known to lead to three structurally diverse types of compounds, depending on the experimental conditions employed. The catalyst plays a major role in directing the reaction to different end products.[10–12] A strong Lewis acid such as BF_3.etherate generates pyrylium cations from the reaction of chalcones and acetoacetic esters, but a basic catalyst would turn the intermediate Michael addition product into cyclohexenones through the intramolecular cyclocondensation of the methyl group originating from acetoacetic acid ester and the ketone function of the initial chalcone. Thus in the presence of a base, bromothienyl-containing chalcones **3a–o** and ethyl acetoacetate **4** produce cyclohexenones **5a–h** by means of an intermediate Michael adduct, as given Scheme 1. 3-Bromo-2-acetylthiophene was synthesized from 3-bromothiophene

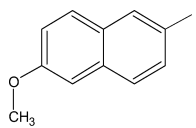
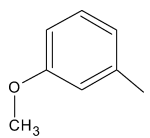
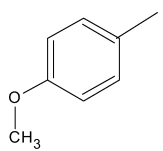
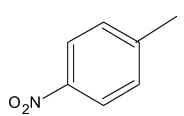
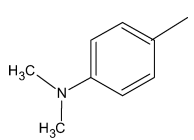


SCHEME 1 The reaction pathway.

by the acetylation of 3-bromothiophene with acetyl chloride in the presence of $SnCl_4$ in benzene as per the reported procedure.[13] (3-Bromothien-2-yl)-3-(aryl)prop-2-en-1-ones were prepared by the reaction of 2-acetyl-3-bromothiophene with aromatic aldehydes in the presence of sodium hydroxide and methanol as solvent. The newly synthesized chalcones were characterized by elemental and X-ray analysis. The resulting (3-bromothien-2-yl)-3-(aryl)prop-2-en-1-ones upon treatment with ethyl acetoacetate in the presence of sodium hydroxide in ethanol proceeded the reaction through Michael addition product intermediate yielded 4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate by intramolecular cyclocondensation of the methyl group originating from acetoacetic acid ester and the ketone function of initial chalcone. The target ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates were characterized by elemental, single crystal X-ray, and spectral data. The characterization data of each compound are presented in Tables I and II. The spectral data are given in the Experimental section. The structures of chalcones and ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates were confirmed by single crystal X-ray study.[14–19]

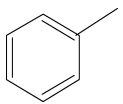
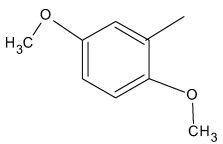
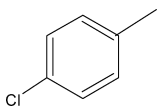
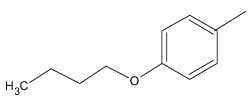
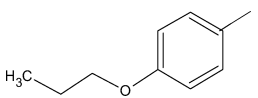
The structure of ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(1,3-benzodioxol-5-yl)cyclohex-3-ene-1-carboxylate **5b** was confirmed by ^{1}H-NMR, ^{13}C-NMR, and FAB mass spectral analysis. The ^{1}H-NMR spectrum displayed a triplet that appeared at δ 1.10 integrated for three protons of CH_3 and a quartet at 4.08 integrated for two protons of the CH_2 of the ethyl ester side chain. A multiplet appeared at δ 2.95–3.14, which are due to two single CH protons and another multiplet at δ 3.66–3.73 are for CH_2 protons of the of the cyclohexenone ring. A singlet seen at δ 5.95 is due to methylene dioxide protons, and another singlet seen at δ 6.76 is due to H-3 of cyclohexenone ring. The benzene ring protons appeared as a singlet at δ 6.80 and a doublet at δ 6.82 ($J = 2.4$Hz). The thiophene protons appeared as two doublets at δ 7.07 ($J = 5.4$Hz) and 7.38 ($J = 5.4$Hz). The ^{13}C-NMR spectrum displayed peaks at δ 14.01 (CH_3), 38.06 (CH_2), 43.76 (CH), 38.10 (CH_2), 59.78 (CH), 61.04 (CH_2), 101.13 (-OCH_2O-), 107.55 (CH), 108.55 (CH), 125.63 (=CH), 127.81 (CH), 133.44 (CH), 134.41, 135.33, 135.41, 146.88, 147.87, 150.68, 168.99 (C=O ester), and 193.40 (C=O ring) accounts for 20 carbon atoms in the molecule. The FAB mass spectrum gave molecular ion peak at m/z 449 (100%) and an isotopic peak at 451 (90%). The other prominent peaks are m/z 403 (48%, M- CH_3CH_2OH), 405 (46%, (M-(CH_3CH_2OH+2), 375 (55%, M-OCHOEt), and 377 (58%, (M-OCHOEt)+2) respectively. The fragmentation pattern of **5b** is given in Scheme 2.

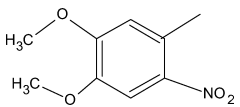
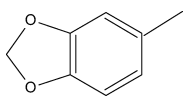
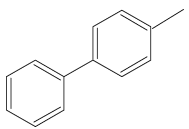
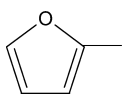
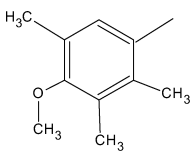
TABLE I Characterization Data of (3-Bromothien-2-yl)-3-(aryl) prop-2-en-1-ones 3a–o

Compound no.	Ar	Yield* %	Melting point°C	Nature of products	Elemental analysis % Found (Calculated)			
					C	H	N	S
3a		85	152–154	Yellow crystal	57.75 (57.92)	3.36 (3.51)	–	8.52 (8.59)
3b		62	80	Yellow powder	52.01 (52.03)	3.32 (3.43)	–	9.87 (9.92)
3c		89	117–119	Off yellow crystal	51.98 (52.03)	3.40 (3.43)	–	9.88 (9.92)
3d		78	179–181	Yellow needles	46.02 (46.17)	2.25 (2.38)	4.05 (4.14)	9.36 (9.48)
3e		82	96–98	Red crystal	53.39 (53.58)	4.12 (4.20)	4.08 (4.17)	9.46 (9.54)

(Continued on next page)

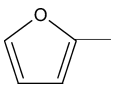
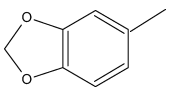
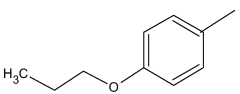
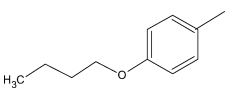
TABLE I Characterization Data of (3-Bromothien-2-yl)-3-(aryl) prop-2-en-1-ones 3a–o *(Continued)*

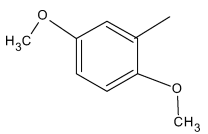
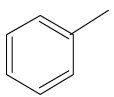
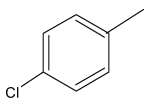
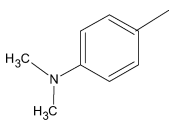
Compound no.	Ar	Yield* %	Melting point°C	Nature of products	Elemental analysis % Found (Calculated) C	H	N	S
3f		80	64–66	Yellow crystal	53.10 (53.26)	3.04 (3.09)	–	10.90 (10.94)
3g		75	102–104	Yellow powder	49.95 (51.00)	3.65 (3.71)	–	9.02 (9.08)
3h		72	139–141	Cream powder	47.33 (47.66)	2.40 (2.46)	–	9.87 (9.79)
3i		84	74–76	Yellow crystal	55.74 (55.90)	4.58 (4.69)	–	8.68 (8.78)
3j		81	81–83	Yellow crystal	54.69 (54.71)	4.25 (4.30)	–	9.05 (9.13)

3k		68	170–172	Dark brown crystal	45.14 (45.24)	3.00 (3.04)	3.49 (3.52)	8.02 (8.05)
3l		67	146–148	Yellow crystal	49.85 (49.87)	2.56 (2.69)	–	9.47 (9.51)
3m		74	131–133	Yellow crystal	61.59 (61.80)	3.59 (3.55)	–	8.57 (8.68)
3n		83	86–88	Brown crystals	46.58 (46.66)	2.39 (2.49)	–	11.25 (11.33)
3o		86	129–131	Yellow crystal	55.87 (55.90)	4.56 (4.69)	–	8.82 (8.78)

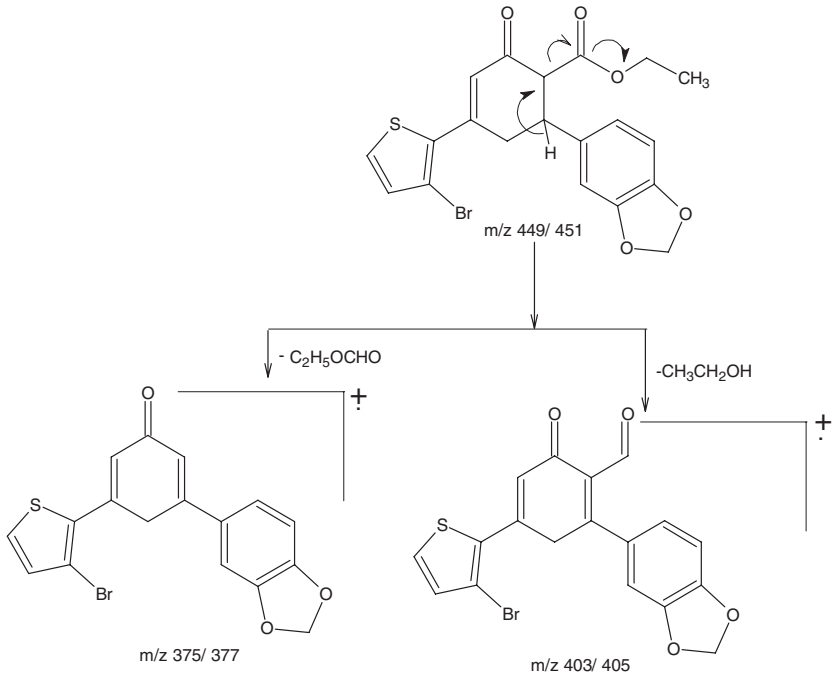
*All the yields are on an isolated basis.

TABLE II Characterization Data of Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl) cyclohex-3-ene-1-carboxylates 5a–h

Compound no.	-R	Yield* %	Melting point°C	Nature of products	Elemental analysis % Found (Calculated)			
					C	H	N	S
5a		62	96–98	Light brown crystals	51.59 (51.66)	3.80 (3.83)	–	8.05 (8.11)
5b		58	118–120	Cream crystals	53.42 (53.46)	3.78 (3.81)	–	7.09 (7.14)
5c		78	76–78	Cream crystals	56.97 (57.02)	4.96 (5.00)	–	6.88 (6.92)
5d		75	89–91	Cream crystals	57.56 (57.86)	5.30 (5.28)	–	6.69 (6.72)

5e		77	88–90	Cream crystals	54.08 (54.20)	4.37 (4.55)	–	6.84 (6.89)
5f		68	64–66	Cream crystals	56.19 (56.30)	4.15 (4.23)	–	7.87 (7.91)
5g		62	116–118	Cream crystals	51.69 (51.89)	3.59 (3.67)	–	7.06 (7.29)
5h		60	114–116	Cream crystals	56.18 (56.25)	4.90 (4.95)	3.07 (3.12)	7.04 (7.15)

*All the yields are on isolated basis.



SCHEME 2 Mass fragmentation pattern of **5b**.

Biological Activity

Anti-Inflammatory Activity (Carrageenan Induced Acute Paw Edema Test)

Six of the newly synthesized compounds **5b**, **5c**, **5d**, **5e**, **5f**, and **5h** were evaluated for their anti-inflammatory activity against carrageenan-induced acute paw edema in rats weighing 150–200g.[20] Albino rats of Wistar strain (150–200 g) and Swiss albino mice (25–30 g) were used for the experiment. They were housed in standard polypropylene cages and kept under room temperature ($24 \pm 2^{\circ}$C), relative humidity (60–70%) in a 12 h light–dark cycle. The animals were given a standard laboratory diet and water ad libitum. Food was withdrawn 12 h before and during experimental hours. Institutional ethics committee approved all the experiments.

The results are shown in Table III. The rats were divided in to eight groups of one each, as group 1 received 10 mL/kg of 2% gum acacia, group 2 received Indomethacin at a dose of 2 mg/kg. The 3rd, 4th, 5th, 6th, 7th, and 8th group were administered the test compounds **5b**, **5c**, **5d**, **5e**, **5f**, and **5h**, respectively, at a dose of 50 mg/kg suspended in

TABLE III Anti-Inflammatory Activity of Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates 5a-h by Carrageenan-Induced Acute Paw Edema Method

Drug/compound no.	Dose (mg/kg, p.o)	Increase in paw edema volume in mL	% Inhibition of paw edema
2% Gum acacia (Control)	10 mL/kg	0.63	–
Indomethacin (Standard drug)	2	0.27	57.14
5b	50	1.8	–185.71
5c	50	0.09	85.71
5d	50	1.53	–142.86
5e	50	0.36	42.85
5f	50	0.45	28.57
5h	50	0.36	42.85

10ml/kg of 2% gum acacia orally by gavage feeding. Acute inflammation was produced by subplantar injection of 0.1 mL of 1% suspension of carrageenan with gum acacia in normal saline in the left hind paw of the rats, 1 h after oral administration of the drugs.[20] The paw volume was measured plethysmometrically (Ugo Basile, Italy) at 0 h and 3 h after carrageenan injection. The difference between the two readings was taken as the volume of edema, and the percentage anti-inflammatory activity was calculated using the formula, % Of edema inhibition = $100 - (V_{test}/V_{control}) \times 100$

Where, $V_{control}$ = Volume of paw edema in control group

V_{test} = Volume of paw edema in drug treated group

The results were expressed as % inhibition of edema over the untreated control group. Table III shows anti-inflammatory activity of ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates **5a–h**. The percentage of inhibition was compared with that of standard drug Indomethacin (2.0 mg/kg). The most active compound was ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-propoxyphenyl)cyclohex-3-ene-1-carboxylate **5c**. A dose of 50 mg/kg p.o decreased the carrageenan-induced edema by 85.71%, while the Indomethacin in a dose 2 mg/kg p.o used as standard drug decreased carrageenan induced edema by 57.14%. The compounds ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(2,5-dimethoxyphenyl)cyclohex-3-ene-1-carboxylate **5e** and ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-(N,N-dimethylamino)phenyl)cyclohex-3-ene-1-carboxylate **5h** decreased the carrageenan induced edema by 42.85%.

Compounds ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(1,3-benzodioxol-5-yl) cyclohex-3-ene-1-carboxylate **5b** and ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-butoxyphenyl)cyclohex-3-ene-1-carboxylate **5d** aggravated the inflammation. The compound **5c** can be considered as the most active amongst the tested compounds.

Analgesic Activity (Hot Plate Test)

Six of the newly synthesized compounds **5b**, **5c**, **5d**, **5e**, **5f**, and **5h** were evaluated for their analgesic activity by the hot plate test. Male albino mice weighing 18–26 g were used for the experiment. They were housed in clean polypropylene cages and kept under room temperature (24 ± 2°C), relative humidity 60–70% in a 12 h light-dark cycle. The animals were fed a standard laboratory diet and water ad libitum. Each experimental group consisted of six animals/dose, and all the animals were used only once. The experiment was conducted after obtaining approval from the institutional animal ethics committee.

The hot plate test was conducted according to the procedure described by Eddy and Leinbatch.[21] In this test, reaction of mice to painful stimulus was measured. Mice were placed on the metal plate heated to 55 ± 0.4°C and covered with a glass cylinder (25 cm high, 15 cm diameter). The time(s) elapsing the first pain response (licking or jumping) was determined by a stop watch, and then recorded as response latency, prior to, and 60 and 180 min following the p.o administration of the investigated compounds. The results are given in Table IV.

Pethidine was used as standard drug in the present study. Compounds ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-propoxyphenyl)cyclohex-3-ene-1-carboxylate **5c** has shown highest activity at a dose of

TABLE IV Analgesic Activity of Eethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates 5a-h in the Hot Plate Test

Drug/compound no.	Dose (mg/kg)	Time of reaction to pain stimulus at time (h) [s] ± SEM		
		0	1	3
Control	10 mL/kg	8.25	8.2	8.8
Pethidine (Standard drug)	5	8.5	16.4	14.3
5b	50	8.51	11.1	10.2
5c	50	7.9	14.2	13.9
5d	50	8.6	8.9	9.1
5e	50	9.4	9.2	9.9
5f	50	8.24	10.4	11.1
5h	50	8.3	9.1	9.2

TABLE V Antibacterial and Antifungal Activity of Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates 5a–h

	Antibacterial activity (MIC in μg/ml)				Antifungal activity(MIC in μg/ml)			
Compd. No.	Escherichia coli	Staphyllococcus aureus	Psuedomonus aeruginosa	Klebsiella pneumoniae	Aspergilus flavus	Aspergilus fumigatus	Penicillium marneffei	Trichophyton mentagrophytes
5a	–	–	–	–	25	25	–	–
5b	12.5	12.5	12.5	12.5	–	25	–	–
5c	12.5	12.5	12.5	12.5	–	–	–	–
5d	–	–	–	–	–	–	–	–
5e	–	–	–	–	25	25	–	–
5f	12.5	12.5	12.5	12.5	25	–	–	–
5g	–	–	–	–	25	–	–	–
5h	12.5	12.5	12.5	12.5	–	–	–	–
Nitrofurazone	6.0	12.5	>100	–	–	–	–	–
Itraconazole	–	–	–	–	<16	<16	<16	<16

50 mg/kg, which is comparable to that of the standard drug Pethidine, while compound ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(1,3-benzodioxol-5-yl)cyclohex-3-ene-1-carboxylate **5b** has shown moderate activity. The rest of the compounds did not show analgesic activity in the model used. This inference is based on a pilot study in a small number of animals only. Further studies using larger samples have to be done to obtain conclusive data. The compound **5c** exhibited promising anti-inflammatory and analgesic activity, which can be recommended for further studies.

Antibacterial and Antifungal Activities

All the newly synthesized ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl) cyclohex-3-ene-1-carboxylates **5a–h** were screened for their antibacterial activity against *Escherichia coli*, *Staphyllococcus aureus* (Smith), *Psuedomonus aeruginosa* (Gessard), and *Klebsiella pneumoniae* (Friedlander) bacterial strains by the disc diffusion method.[22–24] The compounds were also screened for their antifungal activity against *Aspergilus flavus* (NCIM No.524), *Aspergilus fumigatus* (NCIM No.902), *Penicillium marneffei* (recultured), and *Trichophyton mentagrophytes* (recultured) in DMSO by the serial plate dilution method.[22–24] The results are given in Table V. Nitrofurazone was used as the standard antibacterial drug and Itraconozole was used as the standard antifungal drug.

It can be seen from the studies that the compounds ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(1,3-benzodioxol-5-yl)cyclohex-3-ene-1-carboxylate **5b**, ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-propoxyphenyl) cyclohex-3-ene-1-carboxylate **5c**, ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(phenyl) cyclohex-3-ene-1-carboxylate **5f**, and ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-(N,N-dimethylamino)phenyl)cyclohex-3-ene-1-carboxylate **5h** exhibited comparable activity with the standard drug Nitrofurazone. None of the compounds exhibited considerable antifungal activity.

CONCLUSION

A few novel chalcones such as 1-(3-bromothien-2-yl)-3-(aryl)prop-2-en-1-ones derived from 3-bromo-2-acetylthiophene and their cyclized products with ethyl acetoacetate, such as 4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylate derivatives, were synthesized and evaluated for anti-inflammatory, analgesic, and antimicrobial activities. The compound ethyl 4-(3-bromothien-2-yl)-2-oxo-6-(4-

propoxyphenyl)cyclohex-3-ene-1-carboxylate **5c** emerged as a promising anti-inflammatory, analgesic, and antibacterial agent.

EXPERIMENTAL

Melting points were taken in open capillary tubes and are uncorrected. The purity of the compounds was confirmed by thin layer chromatography using Merck silica gel 60 F_{254} coated aluminium plates. IR spectra were recorded on Shimadzu-FTIR Infrared spectrometer in KBr (ν_{max} in cm^{-1}). ^1H NMR spectra were recorded in $CDCl_3$ and in DMSO-d_6 on a Varian (300 MHz) spectrometer using TMS as internal standard, and ^{13}C NMR spectra were recorded in $CDCl_3$ and in DMSO-d_6 on a Varian (75 MHz) spectrometer. FABMS spectra were recorded on a JEOL SX 102/DA-6000 mass spectrometer using argon/xenon (6kv, 10 mA) as the FAB gas. The starting material 3-bromo-2-acetylthiophene was synthesized by the acetylation of 3-bromothiophene with acetylchloride in presence of $SnCl_4$ in benzene as per the reported procedure.[13]

^1H-NMR (300 MHz): δ 2.69 (s, 3H, $COCH_3$), 7.10 (d ($J = 5.1$ Hz) 1H, ArH), 7.52 (d ($J = 5.1$ Hz) 1H, ArH).

General Procedure for the Synthesis of (3-Bromothien-2-yl)-3-(aryl)prop-2-en-1-ones 3a–o

2-Acetyl-3-bromothiophene (0.01 mol) and aryl aldehydes (0.01 mol) were taken in methanol (25 mL), and 5 mL of 10% sodium hydroxide solution was slowly added to it under stirring at 15–20°C. Stirring continued for 2 h at the same temperature. Progress of the reaction was monitored by TLC. The solid that separated was filtered out and washed with cold methanol. Recystallization from methanol yielded the pure compounds in 62–89% yields.

General Procedure for the Synthesis of Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(aryl)cyclohex-3-ene-1-carboxylates 5a–h

The chalcones (3-bromothien-2-yl)-3-(aryl)prop-2-en-1-ones (0.03 mol) and ethyl acetoacetate (0.03 mol) were refluxed in 15 mL ethanol for 2 h in the presence of 0.5 mL 10% sodium hydroxide. The reaction mixture was kept overnight. The solid that separated was filtered out and recrystallized from ethanol to yield the required material as an isomeric mixture in 58–78% yield.

Spectral Data

Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(1,3-benzodioxol-5-yl)cyclohex-3-ene-1-carboxylate

IR (KBr, cm^{-1}): 1650 ($\nu_{c=o\,Ketone}$), 1742 ($\nu_{c=o\,Ester}$); ^{1}H-NMR (300 MHz): δ 1.10 (t, 3H, CH_3), 2.95–3.14 (m, 2H, -CH-CH-Ar), 3.66–3.73 (m, 2H, CH_2CHAr), 4.08 (q, 2H, -OCH_2), 5.95 (s, 2H, -OCH_2O), 6.76 (s, 1H, =CH), 6.80 (s, 1H, ArH), 6.82 (d (J = 2.4 Hz) 1H, ArH), 7.07 (d (J = 5.4Hz) 2H, ArH), 7.38 (d (J = 5.4Hz) 1H, ArH); ^{13}C-NMR (75 MHz): δ 14.01(CH_3), 38.06 (CH_2), 43.76 (CH), 38.10 (CH_2), 59.78 (CH), 61.04 (CH_2), 101.13 (-OCH_2O-), 107.55 (CH), 108.55 (CH), 125.63 (=CH), 127.81 (CH), 133.44 (CH), 134.41, 135.33, 135.41, 146.88, 147.87, 150.68, 168.99 (C=O), 193.40 (C=O); FABMS: 443 (100%, M^+), 451 (90%, M+2), 403 (48%, M- CH_3CH_2OH), 405 (46%, (M-(CH_3CH_2OH+2), 375 (55%, M-OCHOEt), 377 (58%, (M-OCHOEt)+2).

Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(4-propoxyphenyl)cyclohex-3-ene-1-carboxylate

IR (KBr, cm^{-1}): 1643 ($\nu_{c=o\,Ketone}$), 1727 ($\nu_{c=o\,Ester}$); ^{1}H-NMR (300 MHz): δ 1.03 (t, 3H, CH_3), 1.06 (t, 3H, CH_3), 1.80 (sextet, 2H, CH_2), 3.05–3.09(m, 2H, -CH-CH-Ar), 3.72–3.75 (m, 2H, CH_2CHAr), 3.90 (t, 2H, -OCH_2), 4.05 (q, 2H, -OCH_2), 6.837(s, 1H, =CH), 6.87 (d (J = 9.0 Hz) 2H, ArH), 7.07 (d(J = 5.4 Hz) 1H, ArH), 7.22 (d (J = 9.0 Hz) 2H, ArH),7.38 (d (J = 5.4Hz) 1H, ArH); ^{13}C-NMR (75 MHz): δ 10.46 (CH_3), 13.95 (CH_3), 22.52 (CH_2), 38.10 (CH_2), 43.29 (CH), 59.84 (CH), 60.93 (OCH_2), 69.47 (OCH_2), 111.08, 114.69 (CH), 125.63 (=CH), 127.71(CH), 128.29 (CH), 132.37, 133.39 (CH), 135.41, 150.76, 158.43, 169.09 (C=O), 193.61(C=O); FABMS: 463 (100%, M+), 465 (100%, M+2), 389 (48%, M-OCHOEt), 417 (30%, M-CH_3 CH_2OH).

Ethyl-4-(3-bromothien-2-yl)-2-oxo-6-(2,5-dimethoxyphenyl)cyclohex-3-ene-1-carboxylate

IR (KBr, cm^{-1}): 1660 ($\nu_{c=o\,Ketone}$), 1726 ($\nu_{c=o\,Ester}$); ^{1}H-NMR (300 MHz): δ 1.08 (t, 3H, CH_3), 3.04–3.26 (m, 2H, -CH-CH-Ar), 3.75 (s, 3H, -OCH_3) 3.82 (s, 3H, -OCH_3), 3.96-4.03 (m, 2H, CH_2CHAr), 4.06 (q, 2H, -OCH_2), 5.95 (s, 2H, -OCH_2O), 6.78 (s, 1H, =CH), 6.83 (d (J = 3.6 Hz), 1H, ArH), 6.84 (d (J = 3.6 Hz), 2H, ArH), 7.06 (d (J = 5.1 Hz) 2H, ArH), 7.38 (d (J = 5.4 Hz) 1H, ArH); ^{13}C-NMR (75 MHz): δ 13.92 (CH_3), 35.50 (CH_2), 40.12 (CH), 55.68 (OCH_3), 55.91 (OCH_3), 57.33 (CH), 60.75 (CH_2), 110.87, 112.19, 112.65, 115.11, 125.38 (=CH), 127.57 (CH), 129.26, 133.32, 135.56, 151.32, 151.65, 153.47, 169.23 (C=O), 194.17 (C=O); FABMS: m/z 485 (98%, M^+), 466 (100%, M+1), 467 (98%, M+2), 419 (40%, M-CH_3CH_2OH), 421 (38%, (M-(CH_3CH_2OH+2).

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