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SYNTHESIS OF 8-[4-METHYLSULPHONYL-BENZOYL] AND 8-[4-PHENYL-BENZOYL]-4H-FURO[2,3-H]ISOFLAVONES USING SUBSTITUTED PHENACYL HALIDES

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ABSTRACT:
The present investigation describes the condensation of 8-formyl-7-hydroxy isoflavones **2a-d** with phenacyl bromides (p-methylsulphonyl-phenacyl bromide **3**, p-phenyl-phenacyl bromide **4)** in 1,4-dioxane/K_2CO_3 medium which afforded 8-[4-methylsulfonyl-benzoyl] and 8-[4-phenyl-benzoyl]-4H-furo[2,3-h]isoflavones **5a-f** in good yields. The synthesized compounds were purified by column chromatography and characterized by IR, ^{1}H-NMR, ^{13}C-NMR and Mass spectrometry. These compounds were tested for their antibacterial and antifungal activities.

KEY WORDS: p-methylsulphonyl-phenacyl bromide, p-phenyl-phenacylbromide, 8-formyl-7-hydroxy-isoflavones, 1,4-dioxane/K_2CO_3.

INTRODUCTION

Isoflavones, 3-phenylchromene-4-ones constitute a subclass of flavonoids which are a large family of secondary plant metabolites. There are several natural sources of isoflavones but the most important one are soy-bean and red clover (Fabaceae family). Isoflavones remain the subject of many scientific studies as illustrated by the more than 1700 scientific publications mentioning isoflavones in their title or abstract. Most of these studies show that isoflavones have many health benefits. Genistein is a natural isoflavone occurring in many plants known to possess estrogen hormonal activity [1, 2]. Recent studies indicated that this isoflavone can also be considered as a drug for genetic diseases [3]. Talosin A and B, exhibited strong antifungal and anti-inflammatory activities [4]. Ipriflavone, is a synthetic isoflavone used for treatment of postmenopausal, senile osteoporosis [5] and also used to inhibit bone resorption [6]. In continuation of our interest in developing new biologically active heterocyclic compounds, new isoflavones with a furan ring fused at 7,8-positions are now designed and synthesized starting from 8-formyl-7-hydroxy flavones with p-methyl sulphonyl-phenacyl bromide **3,** p-phenyl-phenacylbromide **4** in 1,4-dioxane/K_2CO_3 medium.

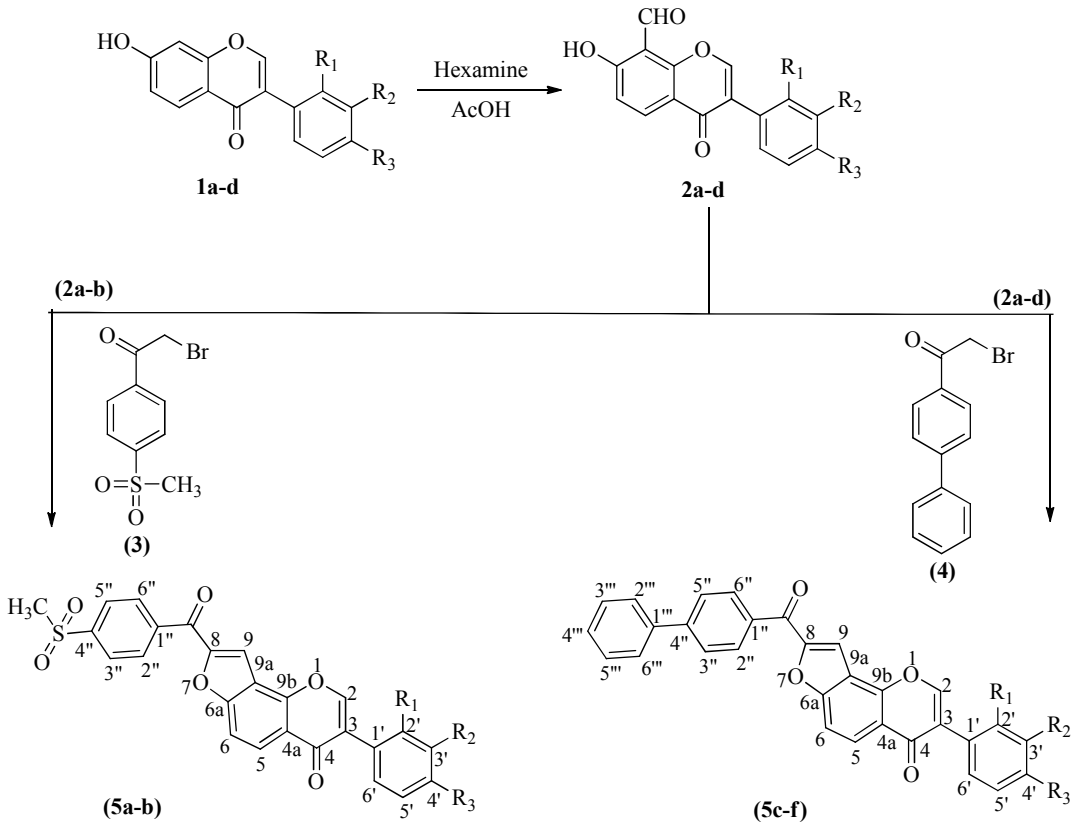
Additionally furo benzopyranones were widely distributed in nature and exhibit various

biological properties. Khellin, a furobenzopyranone isolated from *Ammi visnaga* (L) is useful in the treatment of angina pectoris, bronchial asthma and as a coronary vasodilator and was also employed for the photochemotheraphy or vitilago [7]. We also reported the synthesis of 2'-methyl furano/pyrano fused coumarins, chromones, flavones and isoflavones starting from their corresponding 7-proprgyloxy derivatives by carrying out Claisen rearrangement [8-11].

In the present study, we have developed a simple and efficient route for the synthesis of some novel angular 2-methyl furoisoflavones and benzyl furoisoflavones with p-methyl sulphonyl-phenacyl bromide **3**, p-phenyl-phenacylbromide **4** in 1,4-dioxane/K_2CO_3 medium.

RESUTS AND DISCUSSION

The synthesis of new 8-[4-methylsulfonyl-benzoyl]isoflavones **5a-b** and 8-[4-phenyl-benzoyl]-4H-furo[2,3-h]isoflavones **5c-f,** by the condensation reaction of 7-hydroxy-8-formyl isoflavones **2a-b** with p-methyl sulphonyl-phenacylbromide **3** and p-phenyl-phen acylbromide **4** is reported in this study. 7-Hydroxy isoflavones **1a-f** were prepared by reported methods [12-14]. The Duff reaction [15-16] of **1a-f** with hexamethylenetetramine (HMTA) in glacial acetic acid gave 8-formyl-hydroxy isoflavones **2a-d** in 43-57% yields.
8-Formyl-7-hydroxy flavones **2a-b**, on reaction with p-methyl sulphonyl-phenacylbromide **3,** in 1,4-dioxane and anhydrous K_2CO_3 on heating for 24 hrs afforded new 8-[4-methylsulfonyl-benzoyl]isoflavones **5a-b** in quantitative yields (Scheme-1). The compound **5a** was characterized by spectral data. In the IR spectrum of 8-[4-methylsulfonyl-benzoyl]-4H-furo[2,3-h]isoflavones **5a**, the C=O of isoflavone appeared at 1600 cm^{-1} and benzoyl carbonyl appeared at 1623 cm^{-1}. In the UV spectrum of **5a,** bands appeared at 246 nm (log ϵ 5.6), 286 nm (log ϵ 5.6). ^{1}H NMR (300 MHz, $CDCl_3$) spectrum of **5a** indicates furan ring fused at 7,8-position of the isoflavone and the aroyl group is at 8-position. Furan H-9 appeared at δ 8.12 as a singlet, the SO_2-CH_3 appeared at δ 3.15 as a singlet, H-3",5" appeared as doublet δ 8.28 with (*J* = 8.4 Hz) and H-2",6" at δ 8.18 doublet with (*J* = 8.4Hz), H-5 resonated at δ 8.48, as doublet (*J* = 8.0 Hz) and H-6 appeared at δ 7.70 as doublet (*J* = 8.0Hz). H-2 appeared at δ 7.94 as singlet. The isoflavone ring aromatic protons H-3',4',5' appeared as multiplet at δ 7.45-7.47 and the H-2',6' resonated at δ 7.60 as a multiplet. In ^{13}C-NMR (75.5MHz, $CDCl_3$) spectrum of **5a,** SO_2-CH_3 resonated at δ 43.29. The signals due to the furan ring appeared at 114.21 (C-9), 139.93 (C-8), 145.0 (C-1"), 130.07 (C-2",6"), 128.79 (C-3",5"), 145.10 (C-4"), 181.0 (C=O). The signals due to the isoflavone ring system are assigned as follows 174.68 (C-4), 160.09 (C-6a), 128.98 (C-4'), 153.54 (C-2), 155.32 (C-9b), 130.78 (C-2',6'), 132.06 (C-1'), 125.69 (C-5), 123.26 (C-3), 114.21 (C-6), 128.98 (C-3',5'), 114.32 (C-9a), 116.71 (C-4a). The EIMS of **5a** showed $[M+H]^+$ ion peak at m/z 445.

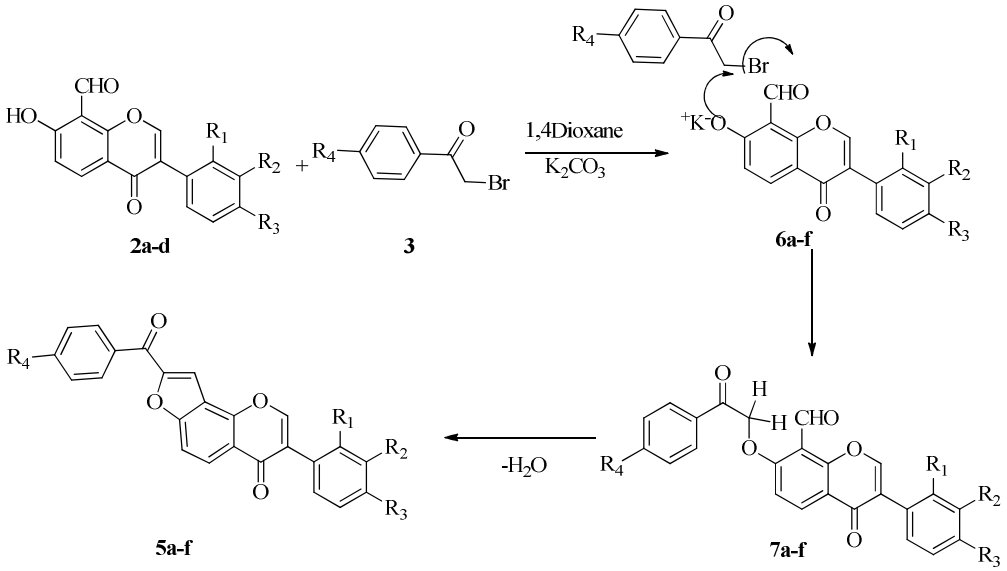


5a) R_1=H, R_2=H, R_3=H. **5b)** R_1=H , R_2=H ,R_3=OCH_3.
5c) R_1=H, R_2=H, R_3=H. **5d)** R_1=H, R_2=H, R_3=OCH_3
5e) R_1=Cl, R_2=H, R_3=Cl. **5f)** R_1=H, R_2=Cl, R_3=H.

Scheme-1: Synthesis of 8-[4-methylsulfonyl-benzoyl] and 8-[4-phenyl-benzoyl]-4H-furo[2,3-h] isoflavones **5a** and **5c.**

Mechanism of the formation of 8-[4-ph/SO_2CH_3-aroyl]-4H-furo[2,3-h]isoflavones 5a-f

The base catalyzed reaction of *o*-hydroxy aldehydes with phenacylbromides gives 2-benzoylbenzofurans[17-20]. The nucleophilic attack of phenoxide ion at the methylene group of phenacylbromide gives the phenacylderivative **6a-f**. Intramolecular condensation of the carbonyl and active methylene group of **7a-f** leads to the formation of benzofurans **5a-f** as shown in Scheme-2.



Scheme-2: Mechanism of the formation of 8-[4-ph/SO_2CH_3-aroyl]-4H-furo [2,3-h] isoflavones **5a-f** .

EXPERIMENTAL

All melting points are uncorrected and were determined on a Polmon instrument (model MP 96). IR spectra were recorded on a Fourier transform (FT)-IR spectrometer (Perkin-Elmer model 337), and UV spectra were recorded on a Schimadzu UV-vis 1601 spectrophotometer. The ^{1}H-NMR (300 MHz) and ^{13}C-NMR (75.5 MHz) spectra were recorded on a Varian Gemini spectrometer using $CDCl_3$ solvent with Tetramethylsilane (TMS) as internal standard (chemical shifts in ppm). The mass spectra were recorded on a VG Micromass 7070-H instrument and VG Autospec mass spectrometer.

All the prepared compounds were further tested for their antifungal and antibacterial activity using paper disc method against Gram-positive, and Gram-negative strains of bacteria and on selected fungal strains. The investigation of antifungal screening data (Table-1) revealed that two compounds showed moderate to good fungal activity. The activity is expressed as three categories, (+) mark indicates that the compound is more active, (±) mark indicates that the compound has moderate activity and (–) mark indicates that the compound has no activity. Among the compounds screened 7-hydroxy-8-formylisoflavones **2b and 2c** showed good inhibition against antifungal activity at lower concentration towards both the strains *Aspergillus niger* and *Rhizoctonia solani* , species at 200,100,50,25,12.5,6.25 μg/mL concentrations. The **2 a,d** and **5 a,b,c,d,e,f** did not show good inhibition against antifungal activity towards both the strains *Aspergillus niger* and *Rhizoctonia solani.*

The antibacterial screening data **(Table-2**) showed that four compounds exhibited moderate activity. Among the screened compounds, **5a and 5b** showed good inhibition against the bacterial strain especially *Escheria coli*. Compounds **2c** and **5a** showed moderate activity against *Pseudomonas putida* at all concentrations. The **2b,d** and **5d,e,f** did not show good inhibition against the bacterial strains, *Pseudomonas putida* and *Escheria coli.* It can be concluded that four compounds (**2a, 2c, 5a** and **5b**) were showing activity against *E.coli* but only two compounds (**2c** and **5a**) were showing activity against *P.putida*. In antifungal activity, **2b** and **2c** were showing activity whereas other compounds were not showing any activity.

Table-1: Antifungal activity

Compound	*Aspergillus niger* (conc. µg/ml)						*Rhizoctonia solani* (conc. µg/ml)					
	200	100	50	25	12.5	6.25	200	100	50	25	12.5	6.25
2a	-	-	-	-	-	-	-	-	-	-	-	-
2b	+	+	+	+	+	+	+	+	+	+	+	+
2c	±	±	+	+	+	+	+	+	+	+	+	+
2d	-	-	-	-	-	-	-	-	-	-	-	-
5a	-	-	-	-	-	-	-	-	-	-	-	-
5b	-	-	-	-	-	-	-	-	-	-	-	-
5c	-	-	-	-	-	-	-	-	-	-	-	-
5d	-	-	-	-	-	-	-	-	-	-	-	-
5e	-	-	-	-	-	-	-	-	-	-	-	-
5f	-	-	-	-	-	-	-	-	-	-	-	

Table-2: Antibacterial activity

compound	*Pseudomonas putida* (conc. µg/ml)						*Escherichia coli* (conc. µg/ml)					
	200	100	50	25	12.5	6.25	200	100	50	25	12.5	6.25
2a	-	-	-	-	-	-	±	±	±	-	±	-
2b	-	-	-	-	-	-	-	-	-	-	-	-
2c	±	-	±	-	±	±	±	±	±	-	-	-
2d	-	-	-	-	-	-	-	-	-	-	-	
5a	±	±	±	±	±	±	+	+	+	+	+	+
5b	-	-	-	-	-	±	+	+	+	+	+	+
5c	-	-	-	-	-	-	-	-	-	-	-	-
5d	-	-	-	-	-	-	-	-	-	-	-	-
5e	-	-	-	-	-	-	-	-	-	-	-	-
5f	-	-	-	-	-	-	-	-	-	-	-	-

General procedure for the synthesis of 8-Formyl-7-Hydroxy isoflavone 2a-d.

To a solution of 7-hydroxyisoflavone **1a** (2.7g, 10.0mmol) dissolved in glacial acetic acid (50 ml), hexamethylenetetramine (HMTA) (8.0g, 57.1mmol) was added and heated on water bath for 6-8 hrs. The solution was treated with dil. HCl (1:1) and further heated for 30 min. -and was diluted with water (500 ml) and left overnight in a refrigerator. The reaction mixture was then extracted with ether and the ethereal solution was then washed with sodium

bicarbonate solution (10%) and water. Concentration of the ether extract furnished crude 7-hydroxy 8-formylisoflavone. The crude product was purified by column chromatography over 60-120mesh using silica gel and was eluted with ethyl acetate and hexane to give **2a** in 54% yield. Similar protocol was followed for the preparation of **2b-d**.

i. ***7-Hydroxy -8-formylisoflavone*** **2a.** Recrystallized from chloroform. white crystals. Yield:54%. mp.186 ^{0}C. IR (KBr): 1650cm^{-1}(C=O), 1642 cm^{-1}(CHO). UV (MeOH): 218 nm (log ε 4.3), 249 (log ε3.8) ^{1}H NMR : (300MHz, $CDCl_3$) : δ 12.47 (s, OH-7), 10.55 (s, CHO), 8.14 (d, *J* = 9.0 Hz, H-5), 7.94 (s, H-2), 7.56-7.53 (m, H-2',6'), 7.48-7.38 (m, H-3',4',5'), 7.02(d, *J* = 9.0Hz, H-6).^{13}C-NMR (75.5 MHz, $CDCl_3$) : δ 191.85 (CHO), 174.08 (C-4), 167.16 (C-7), 157.70 (C-8a), 151.39 (C-2), 135.27 (C-5), 126.33 (C-3), 130.68 (C-1'), 128.40 (C-2',6'), 128.69 (C-3',5'), 128.40 (C-4'), 116.49 (C-4a), 116.30 (C-6), 108.42 (C-8). EIMS: $M^{+\cdot}$ m/z 266 (100%).

ii. ***7-Hydroxy-8-formyl-4'-methoxyisoflavone*** **2b.** Recrystallized from chloroform. white crystals. Yield:57%. mp.176^{o}C. IR (KBr): 1635 cm^{-1} (C=O),1640 cm^{-1}(CHO).UV(MeOH): 218 nm (log ε 4.3), 230 nm (log ε 3.6). H^{1}NMR (300 MHz, $CDCl_3$): δ 12.43 (s, OH-7), 10.52 (s, CHO), 8.38 (d, *J* = 9.03 Hz, H-5), 7.94 (s, H-2), 7.46 (d, *J* = 8.4Hz, H-2',6'), 6.93-7.0 (m, H-3',5',6), 3.82 (s, 4'-OCH_3).^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 191.86 (CHO), 174.33 (C-4), 159.66 (C-4'), 157.70 (C-8a), 150.79 (C-2), 129.88 (C-2',6'), 125.93 (C-3), 116.74 (C-4a), 135.30 (C-5), 122.91 (C-1'), 116.18 (C-6), 167.11 (C-7), 108.42 (C-8), 113.90 (C-3',5'), 55.27 (OCH_3). EIMS: $M^{+\cdot}$ m/z 296 (100%).

iii.*7-Hydroxy-8-formyl-2',4'-dichloroisoflavone* **2c**. Recrystallized from chloroform. white crystals. Yield:48%. mp. 188^{o}C. IR (KBr): 1636cm^{-1}(C=O), 1640cm^{-1}(CHO). UV(MeOH): 222 nm (log ε 5.2), 280 nm (log ε 4.7). ^{1}H-NMR (300MHz, $CDCl_3$): δ12.48 (s, OH-7), 10.55 (s, CHO), 8.38 (d *J* = 9.0Hz, H-5), 7.94 (s, H-2), 7.51 (d, *J* = 2.1Hz, H-3'), 7.24-7.34 (m, H-5',6'), 7.03 (d, *J* = 9.0Hz, H-6). ^{13}C-NMR (75.5MHz, $CDCl_3$): δ 191.75 (CHO), 173.16 (C-4), 167.33 (C-7), 157.87 (C-8a), 152.91 (C-2), 135.28 (C-2'), 135.11 (C-5), 134.92 (C-4'), 132.61 (C-5'), 129.61 (C-6'), 127.77 (C-3'), 127.04 (C-3), 116.52 (C-4a), 124.14 (C-1'), 116.61 (C-6), 108.49 (C-8). EIMS: $[M+H]^+$ m/z 335,309,240.

iv.***7-Hydroxy-8-formyl-3'-chloroisoflavone*** **2d .** Recrystallized from chloroform. Yield:43%. mp. 78^{o}C. IR (KBr): 1661cm^{-1} (C=O). UV (MeOH): 234 nm (logε 4.8).^{1}H-NMR (300MHz, $CDCl_3$): δ 12.45 (s, OH-7), 10.50 (s ,CHO), 8.40 (d, *J* = 9.30Hz, H-5), 8.00 (s, H-2), 7.00 (d, *J* = 9.0Hz, H-6), 7.60-7.20 (m, H-4',6',2',5'). ^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 192.05 (CHO), 173.98 (C-4), 167.49 (C-7), 157.90 (C-8a), 151.63 (C-2), 132.06 (C-1'), 130.40 (C-2'), 130.81 (C-4'), 135.40 (C-5), 135.33 (C-3'), 129.97 (C-5'), 125.48 (C-3), 122.88 (C-6'), 116.78 (C-6), 108.52 (C-8), 116.70 (C-4a).

General procedure for synthesis of 8-[4-Methylsulphonyl-benzoyl]-4H-furo[2,3-h] isoflavones (6a-b)and 8-[4-phenyl-benzoyl]-4H-furo[2,3-h]isoflavones (5a-b).

A mixture of 8-formyl-7-hydroxy-4'-methoxyisoflavone **2a** (2.7g, 10mmol) and p-methyl sulphonyl-phenacylbromide **3** (0.2g, 0.72mmols), in dry 1,4-dioxane and anhydrous potassium carbonate (6.0 g) was refluxed for 24 hrs. The reaction mixture was allowed to cool to room temperature and the contents were poured over crushed ice and left overnight in a refrigerator. The crude solid which separated was filtered, washed with water and recrystallized from methanol to afford **5a** as colorless crystals.

i. *8-[4-Methylsulfonyl-benzoyl]-4H-furo[2,3-h]isoflavone* **5a.**

Recrystallized from methanol. Yield:57%. mp.210^{o}C. IR (KBr): 1600cm^{-1}isoflavone (C =O), 1623cm^{-1} aroylcarbonyl (C=O). UV (MeOH): 246nm (logε 5.6), 286nm (logε 5.6). ^{1}H-NMR (300 MHz, $CDCl_3$): δ 8.48 (d, *J* = 8.0 Hz, H-5), 8.28 (d, *J* = 8.4Hz, H-3",5"), 8.18 (d, *J* = 8.4Hz, H-2",6"), 8.13 (s, H-2), 7.94 (s, H-9), 7.70 (d, *J* = 8.0Hz, H-6), 7.60 (m, H-2',6'),

7.45-7.47 (m, H-3',4',5'), 3.15 (s, SO_2-CH_3). ^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 181.0 (C=O), 174.68 (C-4), 160.09 (C-6a), 155.32 (C-9b), 153.54 (C-2), 145.0 (C-1"), 145.1 (C-4"), 139.93 (C-8), 132.06 (C-1'), 130.78 (2',6'), 130.07 (C-2",6"), 128.98 (C-3',5'), 128,79 (C-3",5"), 128.98 (C-4'), 125.69 (C-5), 123.26 (C-3), 116.71 (C-4a), 114.21 (C-6), 114.21 (C-9), 114.32 (C-9a), 43.29 (SO_2-CH_3). EIMS: $[M+H]^+$ m/z 445.

ii. *8-[4-Methylsulfonyl-benzoyl]-4H-furo[2,3-h]-4'-methoxyisoflavone* **5b**

Recrystallized from methanol. Yield:60%. mp. 255^{o}C. IR (KBr) : 1608cm^{-1} isoflavone (C =O), 1642cm^{-1} (C=O) aroylcarbonyl. UV (MeOH): 212nm (logε 5.3), 236nm (logε 5.4). ^{1}H-NMR (300MHz, $CDCl_3$) : δ 8.48 (d, *J* = 8.0Hz, H-5), 8.28 (d, *J* = 8.4Hz, H-2",6"), 8.18 (d, *J* = 8.4Hz, H-3",5"), 8.09 (s, H-2), 7.94 (s, H-9), 7.68 (d, *J* = 8.0Hz, H-6), 7.54 (m, H-2',6'), 7.01 (d, *J* = 8.0Hz, H-3',5'), 3.15 (s, SO_2-CH_3), 3.86 (4'-OCH_3).^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 182.0 (C=O), 175.52 (C-4), 159.33 (C-6a), 158.77 (C-4'), 152.34 (C-9b), 151.45 (C-2), 144.24 (C-1"), 144.24 (C-4"), 140.83 (C-8), 130.23 (C-2",5"), 130.10 (2',6'), 127.75 (C-3",5"), 127.28 (C-1'), 126.32 (C-5), 123.32 (C-3), 117.05 (C-4a), 110.73 (C-6), 110.73 (C-9), 114.02 (C-9a), 113.93 (C-3',5'), 55.28 (4'-OCH_3), 44.28 (SO_2-CH_3). EIMS: $[M+H]^+$ m/z 475.

iii. *8-[4-Phenyl-benzoyl]-4H-furo[2,3-h]isoflavone* **5c**

A mixture of 8-formyl-7-hydroxyisoflavone **2a** (2.5g, 10mmol) and p-phenyl-phenacyl bromide **4** (0.2g, 0.72 mmols), in dry 1,4-dioxane and anhydrous potassium carbonate (6.0 g) was added and refluxed for 24hrs. The reaction mixture was allowed to cool to room temperature and the contents were poured over crushed ice and left overnight in a refrigerator. The crude solid which separated was filtered, washed with water and recrystallized from methanol to afford **5c** as colorless crystals.

Recrystallized from methanol. Yield:47%. mp.198^{o}C. IR(KBr): 1631cm^{-1} isoflavone(C=O), 1684cm^{-1} aroyl carbonyl (C =O). UV (MeOH): 216nm (logε 5.6), 237nm (log ε 5.5). ^{1}H-NMR (300MHz, $CDCl_3$): δ 8.46 (d, *J* = 8.0Hz, H-5), 8.21 (d, *J* = 8.4Hz, H-2",6"), 8.12 (s, H-2), 7.92 (s, H-9), 7.81 (d, *J* = 8.4Hz, H-3",5"), 7.74-7.30 (m, 11-H, H-2',3',4',5',6',2"',3"',4"',5"',6"' and H-6). ^{13}C-NMR (75.5 MHz, $CDCl_3$) : δ 182.84 (C=O), 175.41 (C-4), 153.29 (C-9b), 158.66 (C-6a), 152.04 (C-2), 151.67 (C-4"), 146.16 (C-8), 139.64 (C-1"), 135.19 (C-1"'), 131.31 (C-4"'), 130.14 (C-2",6"), 128.51 (C-3",5"), 128.96 (C-2"',6"'), 128.43 (C-3',5'), 128.38 (C-2',6'), 127.30 (C-3"',5"'), 127.25 (C-4'), 126.43 (C-5), 120.63 (C-3), 117.17 (C-4a), 110.89 (C-9), 112.70 (C-9a), 110.89 (C-6), 126.59 (C-1'). EIMS : $[M+H]^+$ m/z 443.

iv. *8-[4-Phenyl-benzoyl]-4H-furo[2,3-h]-4'-methoxyisoflavone* **5d**

Recrystallized from methanol. Yield:54%. mp. 214^{o}C. IR (KBr): 1636cm^{-1} isoflavone (C=O), 1684cm^{-1} aroyl carbonyl. UV (MeOH): 253nm (logε 5.0). ^{1}H-NMR (300MHz, $CDCl_3$): δ 8.28 (d, *J* = 8.0Hz, H-5), 8.27 (s, H-2), 8.19 (d, *J* = 8.4Hz, H-2",6"), 7.97 (s, H-9), 6.90 (d, *J* = 8.0Hz, H-3',5'), 7.30-7.80 (m, 10-H, H-2',6',3",5",2"',6"',3"',5"',4"' and H-6), 3.80 (s, 4'-OCH_3).^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 187.45 (C=O), 174.22 (C-4), 162.60 (C-6a), 157.74 (C-4'), 156.39 (C-2), 156.65 (C-9b), 144.24 (C-4"), 139.92 (C-8), 150.64 (C-1"'), 133.76 (C-4"'), 130.55 (C-2',6'), 144.17 (C-1"), 129.93 (C-3), 128.37 (C-2",6"), 130.96 (C-2"',6"'), 130.55 (C-3",5"), 117.74 (C-4a), 128.37 (C-1'), 133.16 (C-3"',5"'), 104.90 (C-9), 115.48 (C-9a), 125.18 (C-5), 115.48 (C-6), 118.52 (C-3',5'), 55.28 (4'-OCH_3).EIMS: $[M+H]^+$ m/z 473.

v. *8-[4-Phenyl-benzoyl]-4H-furo[2,3-h]-2',4'-dichloroisoflavone* **5e.**

Recrystallized from methanol. . Yield:51%. mp. 204^{o}C. IR (KBr): 1602cm^{-1} isoflavone (C=O), 1636cm^{-1} aroyl carbonyl (C=O). UV(MeOH): 222nm (logε 5.1), 212nm (logε 5.3).^{1}H-NMR (300MHz, $CDCl_3$) : δ 8.42 (d, *J* = 8.0Hz, H-5), 8.22 (d, *J* = 8.4Hz, H-2",6"), 8.06 (s, H-2), 7.93 (s, H-9), 7.80-7.20 (m, 11-H, H-3',5', 6',3",5",2"',3"',4"',5"',6"' and H-6). ^{13}C-NMR (75.5MHz, $CDCl_3$) : δ 182.84 (C=O), 175.41 (C-4), 158.81 (C-6a), 153.62 (C-2), 153.41 (C-9b), 145.27 (C-1"'), 139.65 (C-8), 135.69 (C-1"), 135.69 (C-2'), 132.95 (C-4'),

129.07 (C-6'), 128.94 (C-3''',5'''), 127.28 (C-4'''), 111.26 (C-9), 127.03 (C-5'), 128.48 (C-3'), 128.94 (C-2",6"), 128.31 (C-3",5"), 127.32 (C-4"), 120.44 (C-2''',6'''), 120.40 (C-3), 117.33 (C-4a), 126.37 (C-5), 127.39 (C-1'), 112.73 (C-9a), 111.26 (C-6). EIMS: $[M+H]^+$ m/z 512.

vi. *8-[4-Phenyl-benzoyl]-4H-furo[2,3-h]-3'-chloroisoflavone* **5f.**

Recrystallized from methanol. Yield:53%. mp. 183°C. IR (KBr): 1636 cm^{-1}isoflavone ((C=O), 1684 cm^{-1} aroyl carbonyl (C=O). UV (MeOH): 223nm (logε 4.8), 232nm (logε 4.7). ^{1}H-NMR (300 MHz, $CDCl_3$): δ 8.45 (d, *J* = 8.0Hz, H-5), 8.30 (m, H-2",6"), 8.15(s, H-2), 7.80 (s, H-9), 7.75-7.20 (m,11-H, H- 2',4',5', 6',3",5",2''',4''',3''',5''',6''',6). ^{13}C-NMR (75.5MHz, $CDCl_3$): δ 192.03 (C=O), 175.24 (C-4), 152.36 (C-2), 152.06 (C-9b), 152.33 (C-6a), 146.39 (C-4"), 139.83 (C-8), 139.83 (C-1'''), 139.63 (C-3'), 131.75 (C-1"), 139.26 (C-2'), 130.69 (C-1'), 130.21 (C-5'), 128.93 (C-2",6"), 128.72 (C-4'), 128.72 (C-3''',5'''), 128.26 (C-6'), 127.29 (C-2''',6'''), 127.29 (C-4'''), 127.36 (C-3",5"), 126.38 (C-3), 126.38 (C-5), 111.16 (C-9), 112.70 (C-9a), 116.69 (C-4a), 111.16 (C-6). EIMS: $[M+H]^+$ m/z 477.

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REFERENCES

[1] Nazur, W.; Alerereutz, H.; pure and Applied Chem, 70, 1759, (1998).
[2] Akiyama, T.; Ishida, J.; Snakagawa, Ogawara, H.; Watanabe, S.; Itoh, N.; Shibuya, M.; Fukami, Y. Biological Chemistry, 25, 5592, (1987).
[3] Wegrzyn, G.; Jakobkiewiez-Benecka, J.; Gabig-Ciminskam Piotrowska, E.; Narajczyk, M.; Kloska, A.; Malinowska, M.; Dziedzic, D.; Golebiewska, I.; Moskat, M.; Wegrazyn, A.; Biochem Soc Trans, 38, 695, (2010).
[4] Zhongtao, W.; Gaoyan, L.; Biao, Y.; Zhen Zhong, W.; Yiwu, Z.; Xiao Wei, Chin J Chem, 28, 1725, (2010).
[5] Tsuneo, O.; Notoya, K.; Gotoh, M.; Taketomi, S.; Fujisawa, Y.; Makino, H.; Sohda, T. J Med Chem, 42, 751,(1999).
[6] Civitelli, R. Caclcified tissue international, 61, 512, (1997).
[7] Jayaprakash Rao, Y.; David Krupadanam, G. L.; Bull Chem Soc Japan, 67, 1972, (1994).
[8] Rao, CH. P.; David Krupadanam, G. L.; Srimannarayana, G. Indian J Chem, 30B, 666, (1991).
[9] Prasunamba, P. L.; Srimannarayana, G. Indian J Chem, 28B, 71, (1989).
[10] a). Prashanth, A.; David Krupadanam, G. L.; Srimannarayana, G. Bull. Chem. Soc. Japan 65, 1191, (1992). b). Daniel, V.; Jayaprakash Rao, Y.; Santosh Kumar, K.; Krupadanam, G. L. D. Het Comm, 5, 337, (2008).
[11] Joshi, S. C.; Trivedi, K. N. Indian J Chem, 27B, 806, (1988).
[12] Sathe, Venkatraman, K. Current Science, 10, 373, (1949).
[13] Briggs, L. H.; Cabalo, T. Tetrahedron, 19, 2301, (1949).
[14] Iyer, R. N.; Shah, K. H.; Venkatraman, K. Current Science, 11, 404, (1949).
[15] Ogata, Y.; Kawasaki, A.; Sugiura, F. Tetrahedron, 24, 5001, (1968).
[16] Robinson, R.; Venkataraman, K. J Chem Soc, 2344, (1926).
[17] "Dictionary of organic compounds" (Chapman and Hall, 5th edition), Auwers, K.V.; Lechnew, M.; and Budesmann, H. New York, (1933). a) p749 (B-01885), b) p768 (B-02055), c) p1617 (D-01411), d) p822 (B-02653).
[18] a) Bisagni, M.; Buu-Noi, N. P.; Royer, R. J Chem Soc (1955), 3693. b) Singh,H.;

Kapil, R. S. J Org Chem, 24, 206, (1959).
[19] Rangaswami, S.; Seshadri, T. R. Proc Indian Acad Sci, 9A, 1, (1939).
[20] Spath, Gruber, Ber (1938), 71, 106. b) Schonberg, Sina , J Amer Chem Soc, 72, 1611, (1950).

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