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MODIFIED COUMARINS. 4. SYNTHESIS AND BIOLOGICAL PROPERTIES OF CYCLOPENTANE-ANNELATED FUROCOUMARINS

M. M. Garazd,[1] Ya. L. Garazd,[2] S. V. Shilin,[2] T. N. Panteleimonova,[3] and V. P. Khilya[2]

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Psoralen and allopsoralen analogs that contain an annelated cyclopentane were synthesized from 7-hydroxy- and 9-hydroxy-1,2,3,4-tetrahydrocyclopenta[c]chromen-4-ones. 9-Phenyl-1,2,3,4-tetrahydrocyclopenta[c]furo[3,2-g]chromen-4-one exhibited low toxicity, acted as a CNS stimulant, and exhibited cardiotropic activity.

Key words: coumarins, furocoumarins, psoralen, allopsoralen, 1,2,3,4-tetrahydrocyclopenta[c]chromen-4-one.

Furocoumarins are natural compounds of varied structure that are derived from the linear furocoumarin psoralen (7*H*-furo[3,2-*g*]chromen-7-one) or its angular isomer angelicin (2*H*-furo[2,3-*h*]chromen-2-one). Other furocoumarin isomers are distributed much less in nature. Thus, allopsoralen (7*H*-furo[2,3-*f*]chromen-7-one) was isolated from seeds of *Psoralea corylifolia* [1] and aerial parts of *Psoralea plicata* [2]. Natural furocoumarins and their synthetic analogs exhibit various pharmacological properties due to the presence in them of several pharmacophores. In particular, they are photosensitizers and increase the sensitivity of humans and animals to sunlight [3]. Furocoumarins can be used as antitumor agents because they inhibit pathological tissue growth [4]. Derivatives of psoralen and angelicin typically have spasmolytic and cardiotensive properties [5] and antibacterial [6], antihepatitis [7], anti-infection [8], and anti-HIV [9, 10] activity.

The most well known natural compounds containing the 1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one moiety are aflatoxins, which are exceedingly toxic and potent carcinogens produced by *Aspergillus flavus* [11]. Derivatives of 7-hydroxy-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one are also interesting because they possess a wide spectrum of biological activity. In particular, they exhibit insecticidal [12], antiallergic [13], antidepressive [14], antifungal [15], neuroprotective and anticonvulsive [16] properties and act on the CNS [17].

We synthesized furocoumarins containing an annelated cyclopentane moiety by fusing a furan ring to 1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one and performed pharmacological screening of the prepared compounds. Starting 7-hydroxy-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (**1**), 7-hydroxy-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (**2**), and 9-hydroxy-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (**3**) were prepared by Pechmann condensation of ethyl-2-oxocyclopentanecarboxylate with resorcinol, 2-methylresorcinol, and orcine, respectively, in the presence of conc. H_2SO_4 at 0°C.

Several approaches to the construction of furocoumarins are known. In particular, psoralen and its isomers are produced by the method of Spaeth [18] and methods based on Dickman condensation [19], the Perkin reaction [20], and Claisen rearrangement [21]. In our opinion, the most convenient method for preparing polyfunctional furocoumarin derivatives is the method of MacLeod [22], which enables the synthesis in high yields of furocoumarins modified on both the coumarin and furan rings.

The Williamson reaction of furocoumarins **1**-**3** with α-haloketones forms substituted oxoesters **4**-**38**. The reactions

1) Institute of Bioorganic and Petroleum Chemistry, National Academy of Sciences of the Ukraine, 02094, Kiev, ul. Murmanskaya, 1, gmm@i.com.ua; 2) Taras Shevchenko Kiev National University, 01033, the Ukraine, Kiev, ul. Vladimirskaya, 64; 3) Institute of Gerontology, Academy of Medical Sciences of the Ukraine, 03114, Kiev, ul. Vyshgorodskaya, 67. Translated from Khimiya Prirodnykh Soedinenii, No. 3, pp. 192-202, May-June, 2002. Original article submitted May 14, 2002.

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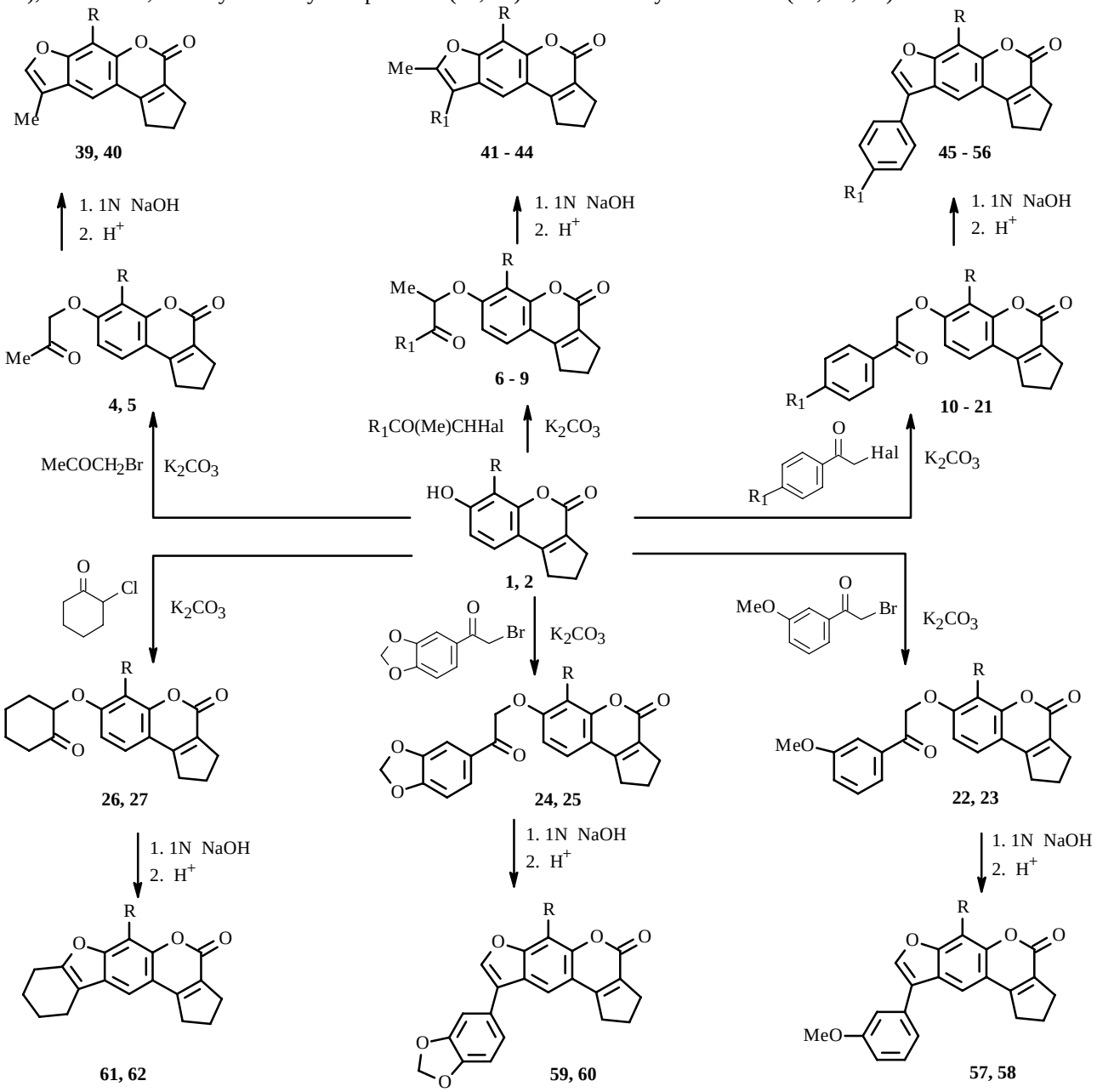
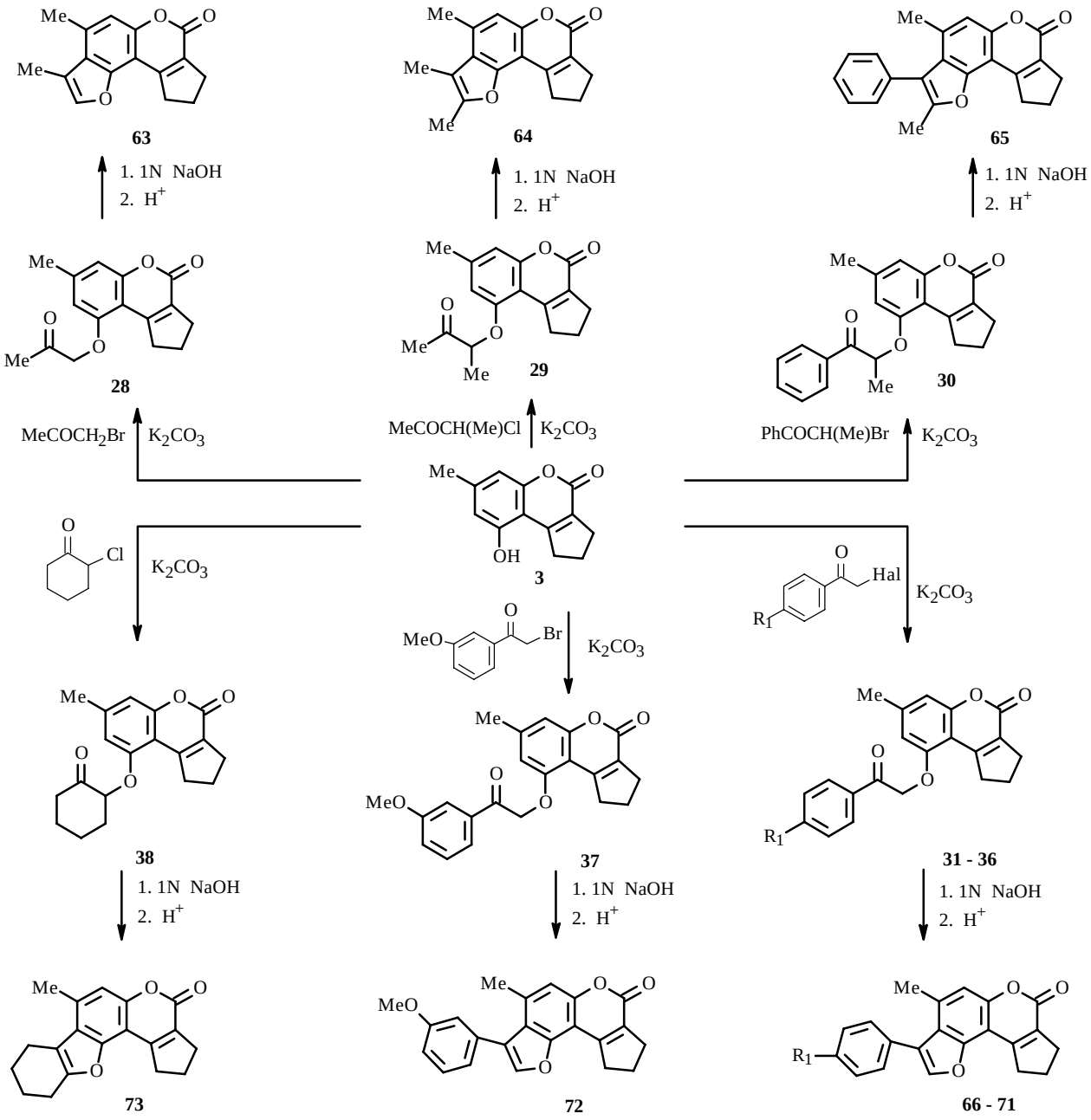
used α-bromoacetone (**4**, **5**, **28**), 3-chloro-2-butanone (**6**, **7**, **29**), α-bromopropiophenone (**8**, **9**, **30**), α-bromoacetophenone (**10**, **11**, **31**), 4-methylphenacylbromide (**12**, **13**, **32**), α-chloro-4-fluoroacetophenone (**14**, **15**, **33**), α-bromo-4-chloroacetophenone (**16**, **17**, **34**), 4-bromophenacylbromide (**18**, **19**, **35**), 4-methoxyphenacylbromide (**20**, **21**, **36**), 3-methoxyphenacylbromide (**22**, **23**, **37**), α-bromo-3,4-methylenedioxyacetophenone (**24**, **25**) and 2-chlorocyclohexanone (**26**, **27**, **38**).



4, 22, 24, 26, 39, 57, 59, 61: R = H; **5, 23, 25, 27, 40, 58, 60, 62:** R = Me; **6, 41:** R = H, R_1 = Me; **7, 42:** R = R_1 = Me; **8, 43:** R = H, R_1 = Ph; **9, 44:** R = Me, R_1 = Ph; **10, 45:** R = R_1 = H; **11, 46:** R = Me, R_1 = H; **12, 47:** R = H, R_1 = Me; **13, 48:** R = R_1 = Me; **14, 49:** R = H, R_1 = F; **15, 50:** R = Me, R_1 = F; **16, 51:** R = H, R_1 = Cl; **17, 52:** R = Me, R_1 = Cl; **18, 53:** R = H, R_1 = Br; **19, 54:** R = Me, R_1 = Br; **20, 55:** R = H, R_1 = OMe; **21, 56:** R = Me, R_1 = OMe

The PMR spectra of the prepared ketones contain signals characteristic of the coumarin ring and alkoxyl. The IR spectra have two bands in the range 1690-1730 cm^{-1}, typical for C=O stretching of the coumarin ring and the alkoxyl carbonyl [23]. The UV spectra of **4-38** contain three strong maxima at 203-206, 250-260, and 310-330 nm, characteristic of this type of compounds [23].



29, 64: R_1 = Me; **30, 65:** R_1 = Ph; **31, 66:** R_1 = H; **32, 67:** R_1 = Me; **33, 68:** R_1 = F; **34, 69:** R_1 = Cl; **35, 70:** R_1 = Br; **36, 71:** R_1 = OMe

Ketones **4-38** cyclize readily into the corresponding 1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-ones **39-62** (psoralen-type furocoumarins) and 7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-ones **63-73** (allopsoralen-type furocoumarins) upon heating with 1 N NaOH. Construction of the furan ring at the 7,8-positions of 1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (**39-62**) or the 8,9-positions of this same system (**63-73**) was confirmed by PMR spectroscopy. The PMR spectra of **39-62** have simple splitting for the aromatic protons owing to a lack of coupling to H-8 of the ring of 1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one. As a result, aromatic proton H-10 of furocoumarin appears as a singlet. An analogous picture develops for furocoumarins **63-73**. Proton H-5 of the furocoumarin resonates as a singlet owing to a lack of coupling to H-8 of the starting coumarin. Furthermore, a 1-H singlet is observed at 7.8-8.5 ppm for furocoumarins **39**, **40**, and **45-62**, which are unsubstituted at the 8-position, and for **63** and **66-72**, which are unsubstituted at the 2-position.

This is also characteristic of formation of the furocoumarin ring. The UV spectra have strong absorption bands in the range 250-270 nm that are stronger than in the starting ketones. This also provides evidence that the furan ring was added to the coumarin [23].

The pharmacological screening of 9-phenyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (**45**) using Wistar rats has shown that **45** has low toxicity. The LD_{50} is greater than 3300 mg/kg. Compound **45** at a dose of 400 mg/kg caused rats to move stereotypically in one direction in elongated circles around the cage without other visual symptons, i.e., it has features of a CNS stimulant. Furthermore, **45** at a dose of 100 mg/kg showed cardiotropic activity. The bioelectric activity of the rat myocardium typically had a decreased frequency of cardiac contractions.

Thus, the pharmacological screening revealed that further investigations of furocoumarin derivatives is promising for finding new biologically active compounds.

EXPERIMENTAL

The course of the reactions and purity of the products were monitored by TLC on Merck 60 F254 plates using $CHCl_3$—CH_3OH (9:1) and (95:5). IR and UV spectra were measured on Nicolet FTIR Nexus 475 and Specord M40 spectrometers, respectively. PMR spectra were taken on a Varian VXR-300 spectrometer relative to TMS (internal standard). Elemental analyses of all compounds agreed with those calculated.

7-Hydroxy-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (1). A cooled (0°C) solution of resorcinol (22 g, 0.2 mole) and ethyl-2-oxocyclopentanecarboxylate (29 mL, 0.2 mole) in absolute ethanol (50 mL) was vigorously stirred and cooled, treated dropwise with conc. H_2SO_4 (20 mL), stirred until congealed, left overnight at room temperature, and poured into 500 mL of icewater. The resulting solid was filtered off and crystallized from isopropanol (75%). Yield 68%, $C_{12}H_{10}O_3$, mp 246-247°C (lit. 224°C [15], 243.5°C [24], 250-252°C [25]). IR spectrum (KBr, cm^{-1}): 3209, 2967, 2928, 1677, 1621, 1561, 1517, 1460, 1392, 1350, 1307, 1266, 1147, 1132, 1075, 851, 827, 754, 718. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.72), 218 (4.26), 321 (4.24). PMR spectrum (300 MHz, DMSO-d, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.71 (2H, m, CH_2-1), 2.99 (2H, m, CH_2-3), 6.69 (1H, d, J = 2.1, H-6), 6.73 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.32 (1H, d, J = 8.4, H-9), 10.20 (1H, br.s, OH-7).

7-Hydroxy-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (2). Prepared analogously to **1** from 2-methylresorcinol (24.8 g). Yield 74%, $C_{13}H_{12}O_3$, mp 290-292°C (dec.) (lit. 257°C [26], 259°C [27]). IR spectrum (KBr, cm^{-1}): 3365, 2962, 2924, 1683, 1605, 1579, 1509, 1378, 1364, 1299, 1084, 808, 758. UV spectrum (EtOH, λ_{max}, nm, log ε): 205 (4.74), 221 (4.29), 328 (4.28). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.08 (2H, m, CH_2-2), 2.17 (3H, s, CH_3-6), 2.71 (2H, m, CH_2-1), 3.00 (2H, m, CH_2-3), 6.86 (1H, d, J = 8.4, H-8), 7.24 (1H, d, J = 8.4, H-9), 10.30 (1H, br.s, OH-7).

9-Hydroxy-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (3). Prepared analogously to **1** from orcine monohydrate (28.4 g). Crystallized from isopropanol (60%). Yield 67%, $C_{13}H_{12}O_3$, mp 253-255°C (dec.) (lit. 253-254°C [28], 255°C [15]). IR spectrum (KBr, cm^{-1}): 3340, 2955, 2862, 1686, 1611, 1567, 1516, 1441, 1391, 1337, 1283, 1146, 1113, 1076, 1030, 984, 829, 740. UV spectrum (EtOH, λ_{max}, nm, log ε): 206 (4.71), 213 (4.59), 256 (4.05), 311 (4.27). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.01 (2H, m, CH_2-2), 2.28 (3H, s, CH_3-7), 2.63 (2H, m, CH_2-1), 3.25 (2H, m, CH_2-3), 6.54 (1H, s, H-8), 6.63 (1H, s, H-6), 10.38 (1H, br.s, OH-7).

General Synthetic Method for Ketones 4-25 and 28-37. A hot solution of coumarin **1**, **2**, or **3** (10 mmole) in absolute acetone (50 mL) was treated with freshly calcined potash (2.76 g, 20 mmole), stirred vigorously, heated (50-56°C), and treated with the appropriate α-haloketone (11 mmole). The reaction mixture was held for 1-3 h with heating and vigorous stirring (completion of the reaction was determined by TLC) and treated with H_2SO_4 (300 mL, 1 N). The resulting solid was filtered off and crystallized from isopropanol (75%).

7-(2-Oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (4). Yield 85%, $C_{15}H_{14}O_4$, mp 145°C (lit. 139°C [25]). IR spectrum (KBr, cm^{-1}): 3447, 3069, 2911, 1721, 1612, 1509, 1422, 1396, 1281, 1246, 1163, 1132, 1073, 1028, 953, 880, 832, 753. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.79), 220 (4.38), 223 (4.32), 321 (4.34). PMR spectrum (300 MHz, deuteroacetone, δ, ppm, J/Hz): 2.12 (2H, m, CH_2-2), 2.24 (3H, s, CH_3-3′), 2.77 (2H, m, CH_2-1), 3.08 (2H, m, CH_2-3), 4.89 (2H, s, CH_2-1′), 6.89 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 6.95 (1H, d, J = 2.1, H-6), 7.46 (1H, d, J = 8.4, H-9).

6-Methyl-7-(2-oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (5). Yield 92%, $C_{16}H_{16}O_4$, mp 163-165°C. IR spectrum (KBr, cm^{-1}): 3437, 2954, 2897, 1734, 1704, 1615, 1574, 1504, 1460, 1432, 1420, 1377, 1286, 1186, 1120,

1057, 1036, 805, 756. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.69), 219 (4.29), 322 (4.25). PMR spectrum (300 MHz, deuteroacetone, δ, ppm, J/Hz): 2.16 (2H, m, CH_2-2), 2.26 (3H, s, CH_3-3′), 2.33 (3H, s, CH_3-6), 2.80 (2H, m, CH_2-1), 3.06 (2H, m, CH_2-3), 4.86 (2H, s, CH_2-1′), 6.88 (1H, d, J = 8.4, H-8), 7.35 (1H, d, J = 8.4, H-9).

7-(1-Methyl-2-oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (6). Yield 78%, $C_{16}H_{16}O_4$, mp 102-103°C. IR spectrum (KBr, cm^{-1}): 3415, 2956, 2920, 1721, 1628, 1613, 1510, 1428, 1398, 1360, 1277, 1244, 1162, 1138, 1125, 1091, 1062, 1023, 994, 834, 752. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (5.06), 223 (4.75), 248 (4.63), 294 (4.53), 308 (4.60). PMR spectrum (300 MHz, deuteroacetone, δ, ppm, J/Hz): 1.53 (3H, d, J = 6.9, CH_3-4′), 2.10 (2H, m, CH_2-2), 2.22 (3H, s, CH_3-1′), 2.79 (2H, m, CH_2-1), 3.08 (2H, m, CH_2-3), 5.00 (1H, q, H-3′), 6.85 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 6.96 (1H, d, J = 2.1, H-6), 7.49 (1H, d, J = 8.4, H-9).

6-Methyl-7-(1-methyl-2-oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (7). Yield 84%, $C_{17}H_{18}O_4$, mp 149-151°C. IR spectrum (KBr, cm^{-1}): 3434, 2966, 2919, 2854, 1729, 1703, 1603, 1570, 1499, 1430, 1375, 1281, 1262, 1123, 1109, 1083, 1041, 811, 757. UV spectrum (EtOH, λ_{max}, nm, log ε): 206 (4.73), 220 (4.35), 321 (4.34). PMR spectrum (300 MHz, deuteroacetone, δ, ppm, J/Hz): 1.55 (3H, d, J = 6.9, CH_3-4′), 2.13 (2H, m, CH_2-2), 2.20 (3H, s, CH_3-1′), 2.34 (3H, s, CH_3-6), 2.79 (2H, m, CH_2-1), 3.08 (2H, m, CH_2-3), 4.99 (1H, q, H-3′), 6.84 (1H, d, J = 8.4, H-8), 7.38 (1H, d, J = 8.4, H-9).

7-(1-Methyl-2-oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (8). Yield 85%, $C_{21}H_{18}O_4$, mp 159.5-160.5°C. IR spectrum (KBr, cm^{-1}): 3435, 3061, 2978, 2934, 1708, 1696, 1625, 1611, 1515, 1448, 1404, 1298, 1280, 1251, 1233, 1164, 1134, 1116, 1066, 1028, 968, 698. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 203 (4.83), 223 (4.35), 245 (4.27), 294 (4.07), 321 (4.36). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 1.60 (3H, d, J = 6.9, CH_3-3′), 2.10 (2H, m, CH_2-2), 2.71 (2H, m, CH_2-1), 3.01 (2H, m, CH_2-3), 6.22 (1H, q, H-2′), 6.92 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 6.96 (1H, d, J = 2.1, H-6), 7.47 (1H, d, J = 8.4, H-9), 7.60 (2H, m, H-3″, H-5″), 7.73 (1H, m, H-4″), 8.10 (2H, m, H-2″, H-6″).

6-Methyl-7-(1-methyl-2-oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (9). Yield 87%, $C_{22}H_{20}O_4$, mp 152-154°C. IR spectrum (KBr, cm^{-1}): 3432, 2918, 2852, 1703, 1606, 1576, 1501, 1452, 1428, 1376, 1279, 1255, 1227, 1133, 1099, 1036, 964, 810, 758, 704. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.89), 223 (4.40), 245 (4.41), 319 (4.36). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 1.63 (3H, d, J = 6.9, CH_3-3′), 2.07 (2H, m, CH_2-2), 2.26 (3H, s, CH_3-6), 2.72 (2H, m, CH_2-1), 2.98 (2H, m, CH_2-3), 6.19 (1H, q, H-2′), 6.88 (1H, d, J = 8.4, H-8), 7.30 (1H, d, J = 8.4, H-9), 7.57 (2H, m, H-3″, H-5″), 7.70 (1H, m, H-4″), 8.06 (2H, m, H-2″, H-6″).

7-(2-Oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (10). Yield 90%, $C_{20}H_{16}O_4$, mp 194°C. IR spectrum (KBr, cm^{-1}): 3433, 2906, 1701, 1626, 1563, 1515, 1449, 1427, 1393, 1295, 1228, 1154, 1084, 1057, 986, 836, 751, 686. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 203 (3.83), 224 (3.31), 244 (3.26), 322 (3.24). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.74 (2H, m, CH_2-1), 3.05 (2H, m, CH_2-3), 5.69 (2H, s, CH_2-2′), 7.00 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.10 (1H, d, J = 2.1, H-6), 7.50 (1H, d, J = 8.4, H-9), 7.57 (2H, m, H-3″, H-5″), 7.70 (1H, m, H-4″), 8.01 (2H, m, H-2″, H-6″).

6-Methyl-7-(2-oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (11). Yield 91%, $C_{21}H_{18}O_4$, mp 202-203°C. IR spectrum (KBr, cm^{-1}): 3417, 2920, 1715, 1602, 1578, 1503, 1449, 1432, 1377, 1283, 1223, 1127, 1061, 1037, 971, 762, 688. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.78), 220 (4.27), 243 (4.24), 320 (4.24). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.30 (3H, s, CH_3-6), 2.74 (2H, m, CH_2-1), 3.03 (2H, m, CH_2-3), 5.72 (2H, s, CH_2-2′), 7.01 (1H, d, J = 8.4, H-8), 7.34 (1H, d, J = 8.4, H-9), 7.57 (2H, m, H-3″, H-5″), 7.70 (1H, m, H-4″), 8.01 (2H, m, H-2″, H-6″).

7-[2-(4-Methylphenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (12). Yield 91%, $C_{21}H_{18}O_4$, mp 178.5-179.5°C. IR spectrum (KBr, cm^{-1}): 3442, 2918, 1712, 1699, 1625, 1562, 1514, 1444, 1427, 1396, 1295, 1234, 1156, 1058, 996, 835, 809, 750. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (5.03), 222 (4.56), 252 (4.53), 292 (4.31), 319 (4.49). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.41 (3H, s, CH_3-4″), 2.73 (2H, m, CH_2-1), 3.05 (2H, m, CH_2-3), 5.67 (2H, s, CH_2-2′), 7.01 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.08 (1H, d, J = 2.1, H-6), 7.39 (2H, d, J = 8.4, H-3″, H-5″), 7.50 (1H, d, J = 8.4, H-9), 7.92 (2H, J = 8.4, H-2″, H-6″).

7-[2-(4-Methylphenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (13). Yield 94%, $C_{22}H_{20}O_4$, mp 211.5-212.5°C. IR spectrum (KBr, cm^{-1}): 3421, 2968, 2921, 1715, 1701, 1609, 1574, 1503, 1458, 1431, 1284, 1231, 1129, 1061, 1037, 972, 801, 758. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 207 (4.83), 254 (4.36), 319 (4.32). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.30 (3H, s, CH_3-6), 2.41 (3H, s, CH_3-4″), 2.77 (2H, m, CH_2-1), 3.03 (2H, m, CH_2-3), 5.67 (2H, s, CH_2-2′), 6.99 (1H, d, J = 8.4, H-8), 7.34 (1H, d, J = 8.4, H-9), 7.38 (2H, d, J = 8.4, H-3″, H-5″), 7.91 (2H, d, J = 8.4, H-2″, H-6″).

7-[2-(4-Fluorophenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (14). Yield 92%, $C_{20}H_{15}FO_4$, mp 214-215°C. IR spectrum (KBr, cm^{-1}): 3431, 2916, 1719, 1702, 1625, 1600, 1510, 1413, 1396, 1296, 1233, 1155, 1086, 1059, 993, 858, 834, 812, 750, 583. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.95), 223 (4.45), 247 (4.36), 292 (4.16), 319 (4.39). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.74 (2H, m, CH_2-1), 3.07 (2H, m, CH_2-3), 5.72 (2H, s, CH_2-2′), 7.03 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.12 (1H, d, J = 2.1, H-6), 7.43 (2H, m, H-3″, H-5″), 7.53 (1H, d, J = 8.4, H-9), 8.13 (2H, m, H-2″, H-6″).

7-[2-(4-Fluorophenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (15). Yield 93%, $C_{21}H_{17}FO_4$, mp 186-187°C. IR spectrum (KBr, cm^{-1}): 3437, 3049, 2931, 1729, 1703, 1633, 1602, 1508, 1431, 1379, 1289, 1233, 1135, 838, 800, 757, 583. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.93), 222 (4.42), 246 (4.39), 323 (4.40). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.30 (3H, s, CH_3-6), 2.74 (2H, m, CH_2-1), 3.03 (2H, m, CH_2-3), 5.73 (2H, s, CH_2-2′), 7.01 (1H, d, J = 8.4, H-8), 7.34 (1H, d, J = 8.4, H-9), 7.42 (2H, m, H-3″, H-5″), 8.11 (2H, m, H-2″, H-6″).

7-[2-(4-Chlorophenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (16). Yield 94%, $C_{20}H_{15}ClO_4$, mp 202.5-203.5°C. IR spectrum (KBr, cm^{-1}): 3434, 2913, 1702, 1623, 1589, 1403, 1294, 1232, 1158, 1092, 1060, 991, 835, 823. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.94), 223 (4.44), 252 (4.46), 291 (4.20), 320 (4.39). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.74 (2H, m, CH_2-1), 3.07 (2H, m, CH_2-3), 5.67 (2H, s, CH_2-2′), 7.00 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.08 (1H, d, J = 2.1, H-6), 7.52 (1H, d, J = 8.4, H-9), 7.64 (2H, d, J = 7.2, H-3″, H-5″), 8.05 (2H, d, J = 7.2, H-2″, H-6″).

7-[2-(4-Chlorophenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (17). Yield 89%, $C_{21}H_{17}ClO_4$, mp 223-224°C. IR spectrum (KBr, cm^{-1}): 3424, 2921, 1717, 1612, 1430, 1376, 1285, 1224, 1130, 1091, 1036, 978, 971, 827, 800, 757. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.25), 255 (3.76), 321 (3.70). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.13 (2H, m, CH_2-2), 2.31 (3H, s, CH_3-6), 2.76 (2H, m, CH_2-1), 3.04 (2H, m, CH_2-3), 5.67 (2H, s, CH_2-2′), 7.03 (1H, d, J = 8.4, H-8), 7.39 (1H, d, J = 8.4, H-9), 7.64 (2H, d, J = 7.2, H-3″, H-5″), 8.05 (2H, d, J = 7.2, H-2″, H-6″).

7-[2-(4-Bromophenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (18). Yield 91%, $C_{20}H_{15}BrO_4$, mp 204-205°C. IR spectrum (KBr, cm^{-1}): 3424, 2919, 1720, 1702, 1625, 1586, 1402, 1296, 1233, 1159, 1072, 991, 817. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (5.12), 215 (4.77), 257 (4.66), 291 (4.40), 319 (4.59). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.17 (2H, m, CH_2-2), 2.76 (2H, m, CH_2-1), 3.08 (2H, m, CH_2-3), 5.60 (2H, s, CH_2-2′), 6.97 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.05 (1H, d, J = 2.1, H-6), 7.44 (1H, d, J = 8.4, H-9), 7.74 (2H, d, J = 8.4, H-3″, H-5″), 7.94 (2H, d, J = 8.4, H-2″, H-6″).

7-[2-(4-Bromophenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (19). Yield 95%, $C_{21}H_{17}BrO_4$, mp 229-230°C. IR spectrum (KBr, cm^{-1}): 3433, 2926, 1698, 1625, 1604, 1588, 1501, 1446, 1376, 1296, 1226, 1122, 1072, 1048, 979, 970, 815, 758. UV spectrum (dioxane, λ_{max}, nm, log ε): 213 (4.67), 256 (4.40), 296 (4.22), 319 (4.30). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.29 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.04 (2H, m, CH_2-3), 5.70 (2H, s, CH_2-2′), 7.02 (1H, d, J = 8.4, H-8), 7.34 (1H, d, J = 8.4, H-9), 7.80 (2H, d, J = 8.4, H-3″, H-5″), 7.93 (2H, d, J = 8.4, H-2″, H-6″).

7-[2-(4-Methoxyphenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (20). Yield 88%, $C_{21}H_{18}O_5$, mp 198-199°C. IR spectrum (KBr, cm^{-1}): 3434, 3069, 2963, 1711, 1684, 1624, 1612, 1602, 1514, 1428, 1404, 1373, 1284, 1267, 1233, 1164, 1078, 1057, 1025, 978, 831, 814. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.94), 219 (4.67), 285 (4.56), 320 (4.49). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.73 (2H, m, CH_2-1), 3.04 (2H, m, CH_2-3), 3.87 (3H, s, OCH_3-4″), 5.64 (2H, s, CH_2-2′), 6.99 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 7.06 (1H, d, J = 2.1, H-6), 7.09 (2H, d, J = 8.4, H-3″, H-5″), 7.49 (1H, d, J = 8.4, H-9), 8.00 (2H, J = 8.4, H-2″, H-6″).

7-[2-(4-Methoxyphenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (21). Yield 92%, $C_{22}H_{20}O_5$, mp 208°C. IR spectrum (KBr, cm^{-1}): 3420, 2918, 2849, 1717, 1697, 1602, 1574, 1504, 1459, 1425, 1378, 1315, 1285, 1265, 1240, 1189, 1129, 1023, 973, 832, 800, 757, 606. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.84), 220 (4.56), 282 (4.45), 319 (4.36). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.30 (3H, s, CH_3-6), 2.74 (2H, m, CH_2-1), 3.04 (2H, m, CH_2-3), 3.86 (3H, s, OCH_3-4″), 5.67 (2H, s, CH_2-2′), 6.98 (1H, d, J = 8.4, H-8), 7.10 (2H, d, J = 8.4, H-3″, H-5″), 7.35 (1H, d, J = 8.4, H-9), 7.99 (2H, J = 8.4, H-2″, H-6″).

7-[2-(3-Methoxyphenyl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (22). Yield 91%, $C_{21}H_{18}O_5$, mp 173-174°C. IR spectrum (KBr, cm^{-1}): 3433, 3066, 2910, 1723, 1701, 1611, 1510, 1487, 1469, 1453, 1428, 1402, 1336,

1268, 1253, 1221, 1199, 1169, 1068, 1028, 1011, 880, 828, 804, 787, 755, 686. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.76), 220 (4.63), 250 (4.07), 292 (4.05), 319 (4.29). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.13 (2H, m, CH_2-2), 2.75 (2H, m, CH_2-1), 3.05 (2H, m, CH_2-3), 3.85 (3H, s, OCH_3-3″), 5.63 (2H, s, CH_2-2′), 6.97 (1H, dd, $J_{8,6}$ = 2.4, $J_{8,9}$ = 8.4, H-8), 7.06 (1H, d, J = 2.1, H-6), 7.23 (1H, dd, J = 2.7, J = 8.4, H-4″), 7.44 (1H, d, J = 8.4, H-5″), 7.47 (1H, d, J = 8.4, H-9), 7.51 (1H, d, J = 2.7, H-2″), 7.65 (1H, J = 8.4, H-6″).

7-[2-(3-Methoxyphenyl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (23). Yield 93%, $C_{22}H_{20}O_5$, mp 195-196°C. IR spectrum (KBr, cm^{-1}): 3424, 2925, 2860, 1718, 1707, 1632, 1599, 1490, 1471, 1435, 1377, 1338, 1320, 1288, 1260, 1207, 1182, 1134, 1069, 1043, 1013, 975, 871, 824, 793, 757, 687, 618. UV spectrum (dioxane, λ_{max}, nm, log ε): 204 (4.71), 219 (4.68), 248 (4.01), 292 (4.00), 321 (4.32). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.30 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.03 (2H, m, CH_2-3), 3.84 (3H, s, OCH_3-3″), 5.70 (2H, s, CH_2-2′), 7.00 (1H, d, J = 8.4, H-8), 7.25 (1H, dd, J = 2.7, J = 8.4, H-4″), 7.35 (1H, d, J = 8.4, H-9), 7.47 (1H, d, J = 8.4, H-5″), 7.51 (1H, d, J = 2.7, H-2″), 7.60 (1H, J = 8.4, H-6″).

7-[2-(1,3-Benzodioxol-5-yl)-2-oxoethoxy]-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (24). Yield 88%, $C_{21}H_{16}O_6$, mp 187-188°C. IR spectrum (KBr, cm^{-1}): 3434, 2920, 1711, 1688, 1624, 1562, 1503, 1457, 1428, 1399, 1296, 1266, 1156, 1140, 1114, 1075, 1047, 998, 936, 835, 805, 750. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.88), 224 (4.61), 231 (4.55), 279 (4.25), 294 (4.30), 319 (4.53). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.74 (2H, m, CH_2-1), 3.06 (2H, m, CH_2-3), 5.61 (2H, s, CH_2-2′), 6.16 (2H, s, CH_2-2″), 6.99 (1H, dd, $J_{8,6}$ = 2.4, $J_{8,9}$ = 8.4, H-8), 7.07 (1H, d, J = 2.1, H-6), 7.10 (1H, d, J = 8.4, H-7″), 7.50 (1H, d, J = 8.4, H-9), 7.53 (1H, d, J = 2.1, H-4″), 7.69 (1H, dd, $J_{6",4"}$ = 2.1, $J_{6",7"}$ = 8.4, H-6″).

7-[2-(1,3-Benzodioxol-5-yl)-2-oxoethoxy]-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (25). Yield 92%, $C_{22}H_{18}O_6$, mp 234-235°C. IR spectrum (KBr, cm^{-1}): 3423, 2918, 1721, 1694, 1604, 1502, 1449, 1438, 1378, 1277, 1253, 1136, 1108, 1034, 997, 975, 924, 817, 801, 757. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.75), 226 (4.45), 231 (4.40), 286 (4.12), 319 (4.42). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.29 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.10 (2H, m, CH_2-3), 5.67 (2H, s, CH_2-2′), 6.13 (2H, s, CH_2-2″), 6.95 (1H, J = 8.4, H-8), 7.05 (1H, d, J = 8.4, H-7″), 7.34 (1H, d, J = 8.4, H-9), 7.48 (1H, d, J = 2.1, H-4″), 7.65 (1H, dd, $J_{6",4"}$ = 2.1, $J_{6",7"}$ = 8.4, H-6″).

7-Methyl-9-(2-oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (28). Yield 78%, $C_{16}H_{16}O_4$, mp 143-145°C. IR spectrum (KBr, cm^{-1}): 3436, 2951, 2918, 1714, 1705, 1615, 1497, 1441, 1421, 1384, 1253, 1157, 1139, 1075, 828, 739. UV spectrum (EtOH, λ_{max}, nm, log ε): 207 (4.50), 247 (3.75), 314 (4.11). PMR spectrum (300 MHz, deuteroacetone, δ, ppm): 2.17 (2H, m, CH_2-2), 2.25 (3H, s, CH_3-1′), 2.37 (3H, s, CH_3-7), 2.77 (2H, m, CH_2-1), 3.41 (2H, m, CH_2-3), 4.91 (2H, s, CH_2-3′), 6.66 (1H, s, H-8), 6.76 (1H, d, H-6).

7-Methyl-9-(1-methyl-2-oxopropoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (29). Yield 75%, $C_{17}H_{18}O_4$, mp 146-148°C. IR spectrum (KBr, cm^{-1}): 3416, 2974, 2928, 2860, 1721, 1615, 1560, 1498, 1456, 1429, 1380, 1292, 1257, 1163, 1128, 1097, 1065, 1047, 1029, 988, 830. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.84), 246 (4.35), 305 (4.45). PMR spectrum (300 MHz, deuteroacetone, δ, ppm, J/Hz): 1.58 (3H, d, J = 6.9, CH_3-4′), 2.10 (2H, m, CH_2-2), 2.21 (3H, s, CH_3-1′), 2.36 (3H, s, CH_3-7), 2.75 (2H, m, CH_2-1), 3.45 (2H, m, CH_2-3), 5.03 (1H, q, H-3′), 6.54 (1H, s, H-8), 6.78 (1H, s, H-6).

7-Methyl-9-(1-methyl-2-oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (30). Yield 82%, $C_{22}H_{20}O_4$, mp 195-196°C. IR spectrum (KBr, cm^{-1}): 3434, 2918, 1717, 1688, 1612, 1496, 1439, 1380, 1257, 1237, 1223, 1139, 1114, 1061, 962, 837, 705. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.99), 247 (4.56), 310 (4.45). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 1.61 (3H, d, J = 6.9, CH_3-3′), 2.03 (2H, m, CH_2-2), 2.28 (3H, s, CH_3-7), 2.68 (2H, m, CH_2-1), 3.32 (2H, m, CH_2-3), 6.22 (1H, q, H-2′), 6.68 (1H, s, H-8), 6.81 (1H, s, H-6), 7.59 (2H, m, H-3″, H-5″), 7.71 (1H, m, H-4″), 8.08 (2H, m, H-2″, H-6″).

7-Methyl-9-(2-oxo-2-phenylethoxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (31). Yield 89%, $C_{21}H_{18}O_4$, mp 213-215°C. IR spectrum (KBr, cm^{-1}): 3434, 2904, 1719, 1696, 1614, 1499, 1448, 1424, 1232, 1160, 1139, 1076, 998. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.84), 244 (4.40), 308 (4.30). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.07 (2H, m, CH_2-2), 2.36 (3H, s, CH_3-7), 2.70 (2H, m, CH_2-1), 3.40 (2H, m, CH_2-3), 5.59 (2H, s, CH_2-2′), 6.76 (1H, s, H-8), 6.80 (1H, d, H-6), 7.55 (2H, m, H-3″, H-5″), 7.67 (1H, m, H-4″), 8.03 (2H, d, J = 8.4, H-2″, H-6″).

9-[2-(4-Methylphenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (32). Yield 90%, $C_{22}H_{20}O_4$, mp 209-211°C. IR spectrum (KBr, cm^{-1}): 3434, 2920, 1701, 1612, 1497, 1421, 1236, 1139, 1074, 1054, 1027, 997, 813. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.40), 253 (4.00), 328 (3.88). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.04 (2H, m, CH_2-2), 2.35 (3H, s, CH_3-7), 2.40 (3H, s, CH_3-4″), 2.69 (2H, m, CH_2-1), 3.38 (2H, m, CH_2-3), 5.60 (2H,

s, CH_2-2′), 6.75 (1H, s, H-8), 6.82 (1H, s, H-6), 7.39 (2H, d, J = 8.4, H-3″, H-5″), 7.92 (2H, d, J = 8.4, H-2″, H-6″).

9-[2-(4-Fluorophenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (33). Yield 89%, $C_{21}H_{17}FO_4$, mp 212-214°C. IR spectrum (KBr, cm^{-1}): 3433, 2915, 2856, 1702, 1611, 1560, 1498, 1459, 1445, 1424, 1385, 1342, 1263, 1232, 1155, 1139, 1075, 1054, 1025, 993, 830, 592, 568. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.79), 245 (4.38), 308 (4.26). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.08 (2H, m, CH_2-2), 2.68 (2H, m, CH_2-1), 3.39 (2H, m, CH_2-3), 5.65 (2H, s, CH_2-2′), 6.84 (1H, s, H-8), 6.88 (1H, s, H-6), 7.41 (2H, m, H-3″, H-5″), 8.13 (2H, m, H-2″, H-6″).

9-[2-(4-Chlorophenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (34). Yield 94%, $C_{21}H_{17}ClO_4$, mp 221-222°C. IR spectrum (KBr, cm^{-1}): 3433, 2912, 1703, 1613, 1590, 1499, 1429, 1401, 1232, 1156, 1139, 1091, 1076, 992, 820. UV spectrum (dioxane, λ_{max}, nm, log ε): 214 (4.66), 252 (4.42), 311 (4.24). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.06 (2H, m, CH_2-2), 2.35 (3H, s, CH_3-7), 2.70 (2H, m, CH_2-1), 3.36 (2H, m, CH_2-3), 5.61 (2H, s, CH_2-2′), 6.81 (1H, s, H-8), 6.84 (1H, s, H-6), 7.62 (2H, d, J = 7.2, H-3″, H-5″), 8.05 (2H, d, J = 7.2, H-2″, H-6″).

9-[2-(4-Bromophenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (35). Yield 88%, $C_{21}H_{17}BrO_4$, mp 236-237°C. IR spectrum (KBr, cm^{-1}): 3434, 2922, 1702, 1612, 1586, 1500, 1459, 1430, 1401, 1261, 1229, 1157, 1139, 1076, 1056, 992, 818. UV spectrum (dioxane, λ_{max}, nm, log ε): 215 (4.67), 254 (4.43), 306 (4.31). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.08 (2H, m, CH_2-2), 2.35 (3H, s, CH_3-7), 2.69 (2H, m, CH_2-1), 3.38 (2H, m, CH_2-3), 5.64 (2H, s, CH_2-2′), 6.84 (1H, s, H-8), 6.87 (1H, s, H-6), 7.81 (2H, d, J = 8.4, H-3″, H-5″), 7.96 (2H, d, J = 8.4, H-2″, H-6″).

9-[2-(4-Methoxyphenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (36). Yield 94%, $C_{22}H_{20}O_5$, mp 193-194°C. IR spectrum (KBr, cm^{-1}): 3433, 2950, 2849, 1709, 1695, 1611, 1599, 1560, 1513, 1502, 1460, 1421, 1383, 1320, 1306, 1268, 1237, 1170, 1153, 1137, 1076, 1058, 1025, 990, 829. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.79), 215 (4.68), 258 (4.26), 286 (4.49), 310 (4.36). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.04 (2H, m, CH_2-2), 2.34 (3H, s, CH_3-7), 2.68 (2H, m, CH_2-1), 3.38 (2H, m, CH_2-3), 3.87 (3H, s, CH_3O-4″), 5.58 (2H, s, CH_2-2′), 6.81 (1H, s, H-8), 6.85 (1H, s, H-6), 7.11 (2H, d, J = 8.4, H-3″, H-5″), 8.01 (2H, d, J = 8.4, H-2″, H-6″).

9-[2-(3-Methoxyphenyl)-2-oxoethoxy]-7-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (37). Yield 91%, $C_{22}H_{20}O_5$, mp 169-170°C. IR spectrum (KBr, cm^{-1}): 3434, 2920, 1719, 1708, 1613, 1585, 1560, 1497, 1459, 1432, 1384, 1263, 1138, 1075, 1052, 1026, 992, 789, 686. UV spectrum (EtOH, λ_{max}, nm, log ε): 207 (4.03), 217 (4.00), 251 (3.53), 313 (3.64). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.04 (2H, m, CH_2-2), 2.35 (3H, s, CH_3-7), 2.68 (2H, m, CH_2-1), 3.38 (2H, m, CH_2-3), 3.85 (3H, s, OCH_3-3″), 5.63 (2H, s, CH_2-2′), 6.82 (1H, s, H-8), 6.87 (1H, s, H-6), 7.25 (1H, dd, J = 2.7, J = 8.4, H-4″), 7.48 (1H, d, J = 8.4, H-5″), 7.53 (1H, d, J = 2.7, H-2″), 7.63 (1H, J = 8.4, H-6″).

7-(2-Oxocyclohexyloxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (26). A solution of coumarin (**1**, 3.03 g, 15 mmole) in dry DMF (50 mL) was treated with freshly calcined potash (6.2 g, 45 mmole) and 2-chlorocyclohexanone (3.43 mL, 30 mmole). The reaction mixture was stirred vigorously and heated (75-80°C) for 24 h and treated with H_2SO_4 (300 mL, 1 N). The solid was filtered off and crystallized from isopropanol. Yield 59%, $C_{18}H_{18}O_4$, mp 180°C. IR spectrum (KBr, cm^{-1}): 3417, 2946, 2868, 1714, 1709, 1624, 1558, 1435, 1393, 1320, 1292, 1255, 1151, 1133, 1074, 1057, 1024, 860, 819. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.70), 220 (4.30), 224 (4.28), 293 (4.05), 321 (4.31). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.09 (2H, m, CH_2-2), 1.60-2.66 (8H, m, CH_2-3′, CH_2-4′, CH_2-5′, CH_2-6′), 2.71 (2H, m, CH_2-1), 3.04 (2H, m, CH_2-3), 5.20 (1H, m, H-1′), 6.88 (1H, dd, $J_{8,6}$ = 2.1, $J_{8,9}$ = 8.4, H-8), 6.95 (1H, d, J = 2.1, H-6), 7.46 (1H, d, J = 8.4, H-9).

6-Methyl-7-(2-oxocyclohexyloxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (27). Prepared analogously to **26**. Yield 63%, $C_{19}H_{20}O_4$, mp 224-226°C. IR spectrum (KBr, cm^{-1}): 3432, 2950, 2859, 1724, 1701, 1605, 1573, 1502, 1445, 1374, 1313, 1284, 1263, 1120, 1104, 1073, 1044, 811, 758, 533. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.65), 220 (4.23), 323 (4.23). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.09 (2H, m, CH_2-2), 2.25 (3H, s, CH_3-6), 1.60-2.66 (8H, m, CH_2-3′, CH_2-4′, CH_2-5′, CH_2-6′), 2.74 (2H, m, CH_2-1), 3.02 (2H, m, CH_2-3), 5.14 (1H, m, H-1′), 6.86 (1H, d, J = 8.4, H-8), 7.29 (1H, d, J = 8.4, H-9).

7-Methyl-9-(2-oxocyclohexyloxy)-1,2,3,4-tetrahydrocyclopenta[*c*]chromen-4-one (38). Prepared analogously to **26**. Yield 52%, $C_{19}H_{20}O_4$, mp 170-171°C. IR spectrum (KBr, cm^{-1}): 3424, 2943, 2863, 1716, 1613, 1494, 1445, 1383, 1290, 1254, 1169, 1127, 1109, 1072, 841, 821. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 207 (4.61), 246 (3.91), 254 (3.86), 310 (4.21). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.32 (3H, s, CH_3-7), 1.60-2.60 (8H, m, CH_2-3′, CH_2-4′, CH_2-5′, CH_2-6′), 2.68 (2H, m, CH_2-1), 3.30 (2H, m, CH_2-3), 5.19 (1H, m, H-1′), 6.62 (1H, s, H-8), 6.78 (1H, s, H-6).

General Synthetic Method for Furocoumarins 39-73. A solution or suspension of ketone **4-38** (6 mmole) in isopropanol (50 mL) was treated with NaOH (50 mL, 1 N). The reaction mixture was heated for 3-4 h until the starting ketone dissolved completely (course of the reaction monitored by TLC) and treated with H_2SO_4 (300 mL, 1 N). The solid was filtered off and crystallized from isopropanol.

9-Methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (39). Yield 86%, $C_{15}H_{12}O_3$, mp 232-233°C (lit. 237°C [25]). IR spectrum (KBr, cm^{-1}): 3422, 3119, 2919, 1716, 1637, 1599, 1578, 1459, 1446, 1402, 1385, 1345, 1258, 1128, 1067, 1052, 944, 865, 816, 752. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 210 (4.58), 250 (4.48), 296 (4.16), 328 (4.06). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.14 (2H, m, CH_2-2), 2.25 (3H, s, CH_3-9), 2.75 (2H, m, CH_2-1), 3.13 (2H, m, CH_2-3), 7.64 (1H, s, H-6), 7.76 (1H, s, H-10), 7.86 (1H, s, H-8),

6,9-Dimethyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (40). Yield 89%, $C_{16}H_{14}O_3$, mp 204-205°C. IR spectrum (KBr, cm^{-1}): 3414, 2962, 2923, 2861, 1719, 1638, 1621, 1597, 1459, 1444, 1395, 1354, 1264, 1102, 1059, 1038, 984, 855, 814, 758. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 212 (4.62), 251 (4.54), 300 (4.24), 328 (4.05). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-2), 2.25 (3H, s, CH_3-9), 2.45 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.10 (2H, m, CH_2-3), 7.52 (1H, s, H-10), 7.86 (1H, s, H-8).

8,9-Dimethyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (41). Yield 78%, $C_{16}H_{14}O_3$, mp 211.5-212.5°C. IR spectrum (KBr, cm^{-1}): 3409, 3055, 2963, 2921, 2587, 1718, 1643, 1581, 1460, 1441, 1403, 1384, 1347, 1298, 1267, 1175, 1142, 1074, 1060, 952, 878, 861, 752. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 211 (4.57), 253 (4.56), 295 (4.16), 302 (4.15), 335 (4.04). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-2), 2.16 (3H, s, CH_3-9), 2.38 (3H, s, CH_3-8), 2.77 (2H, m, CH_2-1), 3.14 (2H, m, CH_2-3), 7.44 (1H, s, H-6), 7.52 (1H, s, H-10).

6,8,9-Trimethyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (42). Yield 84%, $C_{17}H_{16}O_3$, mp 215-216°C. IR spectrum (KBr, cm^{-1}): 3418, 2952, 2922, 2861, 1716, 1642, 1599, 1461, 1438, 1407, 1386, 1354, 1267, 1176, 1148, 1098, 1038, 984, 955, 852, 820, 757. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 212 (4.40), 254 (4.39), 299 (4.01), 305 (4.00), 337 (3.81). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.09 (2H, m, CH_2-2), 2.12 (3H, s, CH_3-9), 2.38 (3H, s, CH_3-8), 2.40 (3H, s, CH_3-6), 2.73 (2H, m, CH_2-1), 3.07 (2H, m, CH_2-3), 7.29 (1H, s, H-10).

8-Methyl-9-phenyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (43). Yield 86%, $C_{21}H_{16}O_3$, mp 205-206°C. IR spectrum (KBr, cm^{-1}): 3427, 3051, 2952, 2917, 2852, 1718, 1635, 1581, 1572, 1497, 1456, 1438, 1403, 1345, 1197, 1137, 1064, 1019, 956, 942, 894, 865, 835, 774, 751, 707. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 201 (4.36), 207 (4.32), 225 (4.12), 254 (4.27), 296 (3.94), 299 (3.93), 335 (3.72). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.11 (2H, m, CH_2-2), 2.54 (3H, s, CH_3-8), 2.77 (2H, m, CH_2-1), 3.12 (2H, m, CH_2-3), 7.44 (1H, m, H-4′), 7.56 (4H, m, H-2′, H-3′, H-5′, H-6′), 7.59 (1H, s, H-6), 7.64 (1H, s, H-10).

6,8-Dimethyl-9-phenyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (44). Yield 86%, $C_{22}H_{18}O_3$, mp 242-244°C. IR spectrum (KBr, cm^{-1}): 3420, 2960, 2922, 1729, 1634, 1598, 1438, 1401, 1341, 1175, 1103, 1033, 982, 952, 773, 756, 705. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 212 (4.69), 255 (4.67), 299 (4.35), 305 (4.33), 338 (4.04). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.09 (2H, m, CH_2-2), 2.50 (3H, s, CH_3-6), 2.54 (3H, s, CH_3-8), 2.76 (2H, m, CH_2-1), 3.06 (2H, m, CH_2-1), 7.39 (1H, s, H-10), 7.43 (1H, m, H-4′), 7.54 (4H, m, H-2′, H-3′, H-5′, H-6′).

9-Phenyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (45). Yield 85%, $C_{20}H_{14}O_3$, mp 203-204°C. IR spectrum (KBr, cm^{-1}): 3406, 2948, 1714, 1632, 1610, 1578, 1457, 1440, 1420, 1400, 1349, 1150, 1103, 1089, 1067, 941, 840, 818, 749, 694. UV spectrum (EtOH, λ_{max}, nm, log ε): 203 (4.57), 213 (4.55), 227 (4.40), 250 (4.42), 305 (4.21), 337 (4.00). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-2), 2.77 (2H, m, CH_2-1), 3.18 (2H, m, CH_2-3), 7.43 (1H, m, H-4′), 7.54 (2H, m, H-3′, H-5′), 7.75 (1H, s, H-6), 7.79 (2H, m, H-2′, H-6′), 7.92 (1H, s, H-10), 8.44 (1H, s, H-8).

6-Methyl-9-phenyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (46). Yield 92%, $C_{21}H_{16}O_3$, mp 237-238°C. IR spectrum (KBr, cm^{-1}): 3403, 2967, 1710, 1632, 1594, 1565, 1394, 1355, 1259, 1114, 1088, 1054, 1035, 982, 915, 812, 770, 757, 699. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 215 (4.39), 251 (4.29), 306 (4.10). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.11 (2H, m, CH_2-2), 2.50 (3H, s, CH_3-6), 2.77 (2H, m, CH_2-1), 3.14 (2H, m, CH_2-3), 7.42 (1H, m, H-4′), 7.53 (2H, m, H-3′, H-5′), 7.74 (1H, s, H-10), 7.76 (2H, m, H-2′, H-6′), 8.42 (1H, s, H-8).

9-(4-Methylphenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (47). Yield 82%, $C_{21}H_{16}O_3$, mp 189-190°C. IR spectrum (KBr, cm^{-1}): 3429, 2919, 1723, 1705, 1633, 1585, 1576, 1509, 1450, 1402, 1349, 1152, 1097, 1069, 941, 819. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.72), 227 (4.48), 246 (4.51), 250 (4.52), 297 (4.31), 304 (4.32), 328 (4.08). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.38 (3H, s, CH_3-4″), 2.78 (2H, m, CH_2-1), 3,19 (2H, m, CH_2-3), 7.36 (2H, d, J = 8.4, H-3″, H-5″), 7.65 (2H, d, J = 8.4, H-2″, H-6″), 7.76 (1H, d, H-6), 7.92 (1H, s, H-10), 8.41

(1H, s, H-8).

9-(4-Methylphenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (48). Yield 86%, $C_{22}H_{18}O_3$, mp 229-231°C. IR spectrum (KBr, cm^{-1}): 3423, 2967, 2916, 1724, 1636, 1598, 1457, 1394, 1354, 1113, 1083, 1033, 983, 917, 805. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.68), 251 (4.56), 304 (4.34), 333 (3.97). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.38 (3H, s, CH_3-4″), 2.50 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.11 (2H, m, CH_2-3), 7.33 (2H, d, J = 8.4, H-3″, H-5″), 7.61 (2H, d, J = 8.4, H-2″, H-6″), 7.67 (1H, s, H-10), 8.34 (1H, s, H-8).

9-(4-Fluorophenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (49). Yield 81%, $C_{20}H_{13}FO_3$, mp 252-253°C. IR spectrum (KBr, cm^{-1}): 3434, 2931, 1714, 1634, 1579, 1504, 1457, 1421, 1402, 1350, 1329, 1220, 1152, 1104, 1085, 1068, 942, 840, 818, 803. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 203 (4.59), 212 (4.52), 249 (4.44), 301 (4.20). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-2), 2.76 (2H, m, CH_2-1), 3.17 (2H, m, CH_2-3), 7.36 (2H, m, H-3″, H-5″), 7.74 (1H, s, H-6), 7.81 (2H, m, H-2″, H-6″), 7.89 (1H, s, H-10), 8.43 (1H, s, H-8).

9-(4-Fluorophenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (50). Yield 84%, $C_{21}H_{15}FO_3$, mp 246-247°C. IR spectrum (KBr, cm^{-1}): 3432, 2930, 1712, 1633, 1599, 1576, 1505, 1393, 1219, 1117, 1088, 1052, 839, 804. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 200 (4.67), 210 (4.59), 248 (4.49), 304 (4.28). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-2), 2.45 (3H, s, CH_3-6), 2.73 (2H, m, CH_2-1), 3.09 (2H, m, CH_2-3), 7.33 (2H, m, H-3″, H-5″), 7.63 (1H, s, H-10), 7.76 (2H, m, H-2′, H-6″), 8.38 (1H, s, H-8).

9-(4-Chlorophenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (51). Yield 90%, $C_{20}H_{13}ClO_3$, mp 199-200°C. IR spectrum (KBr, cm^{-1}): 3434, 2923, 1736, 1634, 1583, 1490, 1476, 1401, 1349, 1154, 1090, 1060, 1012, 940, 819, 798. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 203 (4.70), 251 (4.52), 302 (4.30), 329 (4.08). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.15 (2H, m, CH_2-2), 2.79 (2H, m, CH_2-1), 3.20 (2H, m, CH_2-3), 7.57 (2H, d, J = 7.2, H-3′, H-5′), 7.76 (1H, s, H-6), 7.80 (2H, d, J = 7.2, H-2′, H-6′), 7.94 (1H, s, H-10), 8.46 (1H, s, H-8).

9-(4-Chlorophenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (52). Yield 93%, $C_{21}H_{15}ClO_3$, mp 242-244°C. IR spectrum (KBr, cm^{-1}): 3423, 2970, 2916, 1725, 1637, 1597, 1580, 1492, 1392, 1353, 1114, 1093, 1082, 1030, 1015, 982, 915, 839, 804. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.70), 213 (4.62), 249 (4.61), 302 (4.38), 335 (4.00). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.50 (3H, s, CH_3-6), 2.76 (2H, m, CH_2-1), 3.14 (2H, m, CH_2-3), 7.56 (2H, d, J = 7.2, H-3′, H-5′), 7.72 (1H, s, H-10), 7.77 (2H, d, J = 7.2, H-2′, H-6′), 8.48 (1H, s, H-8).

9-(4-Bromophenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (53). Yield 88%, $C_{20}H_{13}BrO_3$, mp 192-193°C. IR spectrum (KBr, cm^{-1}): 3434, 2921, 1727, 1635, 1603, 1582, 1475, 1448, 1398, 1348, 1151, 1106, 1081, 1061, 1008, 941, 821, 810. UV spectrum (EtOH, λ_{max}, nm, log ε): 203 (4.81), 213 (4.70), 249 (4.64), 302 (4.42), 335 (4.16). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.18 (2H, m, CH_2-2), 2.82 (2H, m, CH_2-1), 3.22 (2H, m, CH_2-3), 7.65 (2H, d, J = 8.4, H-3′, H-5′), 7.69 (1H, s, H-6), 7.72 (2H, d, J = 8.4, H-2′, H-6′), 7.92 (1H, s, H-10), 8.41 (1H, s, H-8).

9-(4-Bromophenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (54). Yield 91%, $C_{21}H_{15}BrO_3$, mp 229-230°C. IR spectrum (KBr, cm^{-1}): 3421, 2961, 1723, 1637, 1596, 1577, 1488, 1392, 1353, 1115, 1083, 1030, 1011, 983, 915, 837, 804. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.69), 212 (4.60), 249 (4.59), 301 (4.35). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.13 (2H, m, CH_2-2), 2.48 (3H, s, CH_3-6), 2.78 (2H, m, CH_2-1), 3.16 (2H, m, CH_2-3), 7.71 (5H, m, H-10, H-2′, H-3′, H-5′, H-6′), 8.48 (1H, s, H-8).

9-(4-Methoxyphenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (55). Yield 89%, $C_{21}H_{16}O_4$, mp 189-190°C. IR spectrum (KBr, cm^{-1}): 3449. 2972, 2838, 1713, 1633, 1585, 1507, 1465, 1402, 1350, 1272, 1245, 1179, 1151, 1113, 1091, 1067, 1035, 941, 874, 836, 819, 795, 753. UV spectrum (EtOH, λ_{max}, nm, log ε): 206 (4.70), 232 (4.53), 252 (4.56), 310 (4.34). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.13 (2H, m, CH_2-2), 2.79 (2H, m, CH_2-1), 3.20 (2H, m, CH_2-3), 7.11 (2H, d, J = 8.4, H-3′, H-5′), 7.71 (2H, d, J = 8.4, H-2′, H-6′), 7.77 (1H, s, H-6), 7.92 (1H, s, H-10), 8.37 (1H, s, H-8).

9-(4-Methoxyphenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (56). Yield 83%, $C_{22}H_{18}O_4$, mp 195-196°C. IR spectrum (KBr, cm^{-1}): 3421, 2967, 1722, 1585, 1509, 1449, 1393, 1332, 1301, 1250, 1179, 1112, 1082, 1027, 983, 916, 836, 806. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.80), 252 (4.72), 305 (4.49). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.10 (2H, m, CH_2-2), 2.48 (3H, s, CH_3-6), 2.75 (2H, m, CH_2-1), 3.12 (2H, m, CH_2-3), 7.09 (2H, d, J = 8.4, H-3′, H-5′), 7.67 (2H, d, J = 8.4, H-2′, H-6′), 7.70 (1H, s, H-10), 8.36 (1H, s, H-8).

9-(3-Methoxyphenyl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (57). Yield 92%, $C_{21}H_{16}O_4$, mp 226-227° C. IR spectrum (KBr, cm^{-1}): 3433, 3097, 3084, 2966, 2918, 1709, 1635, 1603, 1577, 1498, 1465, 1451, 1425, 1406,

1353, 1265, 1248, 1221, 1159, 1101, 1069, 1013, 870, 843, 822, 792. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 212 (4.76), 251 (4.49), 301 (4.32), 328 (4.06). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.16 (2H, m, CH_2-2), 2.79 (2H, m, CH_2-1), 3.17 (2H, m, CH_2-3), 3.86 (3H, s, OCH_3-3′), 6.95 (1H, dd, J = 2.7, J = 8.4, H-4′), 7.22 (1H, d, J = 2.7, H-2′), 7.28 (1H, d, J = 8.4, H-5′), 7.41 (1H, J = 8.4, H-6′), 7.59 (1H, s, H-6), 7.84 (1H, s, H-10), 8.29 (1H, s, H-8).

9-(3-Methoxyphenyl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (58). Yield 87%, $C_{22}H_{18}O_4$, mp 225.5-226.5° C. IR spectrum (KBr, cm^{-1}): 3435, 2929, 1707, 1603, 1491, 1475, 1456, 1419, 1392, 1218, 1115, 1056, 1027, 857, 838, 793. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 214 (5.00), 250 (4.66), 301 (4.49), 333 (4.21). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.16 (2H, m, CH_2-2), 2.54 (3H, s, CH_3-6), 2.80 (2H, m, CH_2-1), 3.15 (2H, m, CH_2-3), 3.86 (3H, s, OCH_3-3′), 6.95 (1H, dd, J = 2.7, J = 8.4, H-4′), 7.22 (1H, d, J = 2.7, H-2′), 7.28 (1H, d, J = 8.4, H-5′), 7.40 (1H, J = 8.4, H-6′), 7.69 (1H, s, H-10), 8.31 (1H, s, H-8).

9-(1,3-Benzodioxol-5-yl)-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (59). Yield 86%, $C_{21}H_{14}O_5$, mp 189.5-190.5° C. IR spectrum (KBr, cm^{-1}): 3432, 3103, 2901, 1713, 1634, 1577, 1502, 1489, 1477, 1435, 1402, 1344, 1236, 1165, 1137, 1097, 1068, 1037, 929, 867, 819. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 211 (4.77), 253 (4.55), 308 (4.42). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.13 (2H, m, CH_2-2), 2.77 (2H, m, CH_2-1), 3.18 (2H, m, CH_2-3), 6.09 (2H, s, CH_2-2′), 7.04 (1H, d, J = 8.4, H-7′), 7.23 (1H, dd, J = 2.1, J = 8.4, H-6′), 7.29 (1H, d, J = 2.1, H-4′), 7.69 (1H, s, H-6), 7.86 (1H, s, H-10), 8.32 (1H, s, H-8).

9-(1,3-Benzodioxol-5-yl)-6-methyl-1,2,3,4-tetrahydrocyclopenta[*c*]furo[3,2-*g*]chromen-4-one (60). Yield 91%, $C_{22}H_{16}O_5$, mp 220-221° C. IR spectrum (KBr, cm^{-1}): 3427, 2901, 1711, 1633, 1597, 1574, 1504, 1490, 1474, 1437, 1393, 1347, 1270, 1238, 1120, 1103, 1084, 1038, 985, 931, 865, 810, 789. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 214 (4.78), 250 (4.56), 302 (4.40), 328 (4.05). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.11 (2H, m, CH_2-2), 2.48 (3H, s, CH_3-6), 2.76 (2H, m, CH_2-1), 3.14 (2H, m, CH_2-3), 6.09 (2H, s, CH_2-2′), 7.04 (1H, d, J = 8.4, H-7′), 7.23 (1H, dd, J = 2.1, J = 8.4, H-6′), 7.28 (1H, d, J = 2.1, H-4′), 7.67 (1H, s, H-10), 8.33 (1H, s, H-8).

1,2,3,4,8,9,10,11-Octahydrobenzo[4,5]furo[3,2-*g*]cyclopenta[*c*]chromen-4-one (61). Yield 79%, $C_{18}H_{16}O_3$, mp 223-224° C. IR spectrum (KBr, cm^{-1}): 3403, 3059, 2936, 2859, 1711, 1647, 1634, 1579, 1461, 1439, 1406, 1344, 1130, 1113, 1068, 1024, 942, 867, 751. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 212 (4.37), 254 (4.43), 295 (4.00), 301 (3.99), 338 (3.87). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 1.85 (4H, m, CH_2-9, CH_2-10), 2.13 (2H, m, CH_2-2), 2.61 (2H, m, CH_2-11), 2.74 (4H, m, CH_2-1, CH_2-8), 3.12 (2H, m, CH_2-3), 7.53 (1H, s, H-6), 7.56 (1H, s, H-10).

6-Methyl-1,2,3,4,8,9,10,11-octahydrobenzo[4,5]furo[3,2-*g*]cyclopenta[*c*]chromen-4-one (62). Yield 82%, $C_{19}H_{18}O_3$, mp 238-239° C. IR spectrum (KBr, cm^{-1}): 3433, 2943, 2854, 1708, 1642, 1596, 1440, 1412, 1340, 1181, 1137, 1100, 1088, 1042, 984. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 202 (4.57), 210 (4.55), 255 (4.55), 299 (4.15), 338 (3.91). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 1.84 (2H, m, CH_2-10), 1.94 (2H, m, CH_2-9), 2.15 (2H, m, CH_2-2), 2.45 (3H, s, CH_3-6), 2.60 (2H, m, CH_2-11), 2.74 (4H, m, CH_2-1, CH_2-8), 3.07 (2H, m, CH_2-3), 7.28 (1H, s, H-10).

3,4-Dimethyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (63). Yield 81 %, $C_{16}H_{14}O_3$, mp 241-243° C. IR spectrum (KBr, cm^{-1}): 3436, 3114, 2964, 2933, 1704, 1632, 1585, 1569, 1447, 1392, 1172, 1114, 1095, 1075, 1051, 981, 961, 849, 819. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.41), 226 (4.43), 253 (4.46), 301 (4.21), 307 (4.22), 331 (3.97). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.15 (2H, m, CH_2-9), 2.36 (3H, s, CH_3-4), 2.65 (3H, s, CH_3-3), 2.74 (2H, m, CH_2-10), 3.31 (2H, m, CH_2-8), 7.03 (1H, s, H-5), 7.75 (1H, s, H-2).

2,3,4-Trimethyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (64). Yield 73%, $C_{17}H_{16}O_3$, mp 209-210° C. IR spectrum (KBr, cm^{-1}): 3432, 2958, 2916, 1706, 1631, 1611, 1567, 1441, 1424, 1391, 1166, 1105, 1069, 1057, 989, 878. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 202 (4.64), 227 (4.46), 257 (4.43), 302 (4.27), 308 (4.26), 338 (3.88). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.12 (2H, m, CH_2-9), 2.26 (3H, s, CH_3-3), 2.36 (3H, s, CH_3-4), 2.59 (3H, s, CH_3-2), 2.70 (2H, m, CH_2-10), 3.22 (2H, m, CH_2-8), 7.03 (1H, s, H-5).

2,4-Dimethyl-3-phenyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (65). Yield 85%, $C_{22}H_{18}O_3$, mp 181-182° C. IR spectrum (KBr, cm^{-1}): 3433, 2965, 2921, 1713, 1633, 1610, 1561, 1491, 1451, 1396, 1206, 1153, 1106, 1073, 990, 945, 881, 759, 714. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.63), 225 (4.50), 254 (4.55), 301 (4.30), 307 (4.29), 337 (3.93). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.09 (3H, s, CH_3-2), 2.15 (2H, m, CH_2-9), 2.32 (3H, s, CH_3-4), 2.74 (2H, m, CH_2-10), 3.32 (2H, m, CH_2-8), 7.00 (1H, s, H-5), 7.38-7.55 (5H, m, H-2′, H-3′, H-4′, H-5′, H-6′).

4-Methyl-3-phenyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*g*]chromen-7-one (66). Yield 86%, $C_{21}H_{16}O_3$, mp 215-217° C. IR spectrum (KBr, cm^{-1}): 3435, 2972, 2923, 1708, 1633, 1607, 1573, 1450, 1396, 1382, 1181, 1115, 1083, 1057, 1007, 939, 847, 764, 708. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 204 (4.64), 230 (4.54), 249 (4.47), 298 (4.27), 307 (4.28),

329 (4.02). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.17 (2H, m, CH_2-9), 2.28 (3H, s, CH_3-4), 2.76 (2H, m, CH_2-10), 3.35 (2H, m, CH_2-8), 7.09 (1H, s, H-5), 7.45 (5H, m, H-2′, H-3′, H-4′, H-5′, H-6′), 8.08 (1H, s, H-2).

3-(4-Methylphenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (67). Yield 89%, $C_{22}H_{18}O_3$, mp 233-234° C. IR spectrum (KBr, cm^{-1}): 3421, 2920, 2854, 1717, 1633, 1612, 1581, 1568, 1450, 1385, 1179, 1116, 1083, 1052, 981, 937, 860, 827, 798, 747. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 206 (4.59), 223 (4.55), 248 (4.46), 300 (4.24), 307 (4.25). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.16 (2H, m, CH_2-9), 2.23 (3H, s, CH_3-4), 2.38 (3H, s, CH_3-4′), 2.75 (2H, m, CH_2-10), 3.34 (2H, m, CH_2-8), 7.05 (1H, s, H-5), 7.28 (2H, d, J = 8.4, H-3″, H-5″), 7.34 (2H, d, J = 8.4, H-2″, H-6″), 8.00 (1H, s, H-2).

3-(4-Fluorophenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (68). Yield 85%, $C_{21}H_{15}FO_3$, mp 224-225° C. IR spectrum (KBr, cm^{-1}): 3404, 2919, 1708, 1631, 1579, 1500, 1451, 1227, 1113, 1086, 1056, 939, 842, 793. UV spectrum (EtOH, λ_{max}, nm, log ε): 201 (4.59), 226 (4.55), 254 (4.42), 308 (4.25), 335 (4.00). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.15 (2H, m, CH_2-9), 2.23 (3H, s, CH_3-4), 2.74 (2H, m, CH_2-10), 3.29 (2H, m, CH_2-8), 7.10 (1H, s, H-5), 7.32 (2H, d, J = 8.4, H-3′, H-5′), 7.54 (2H, d, J = 8.4, H-2′, H-6′), 8.14 (1H, s, H-2).

3-(4-Chlorophenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (69). Yield 91%, $C_{21}H_{15}ClO_3$, mp 265-266°C. IR spectrum (KBr, cm^{-1}): 3412, 2952, 2853, 1715, 1632, 1572, 1484, 1450, 1398, 1382, 1181, 1118, 1089, 1050, 1016, 937, 857, 846, 831. UV spectrum (dioxane, λ_{max}, nm, log ε): 215 (4.51), 224 (4.58), 252 (4.54), 298 (4.28), 306 (4.28), 331 (4.04). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 2.18 (2H, m, CH_2-9), 2.25 (3H, s, CH_3-4), 2.78 (2H, m, CH_2-10), 3.37 (2H, m, CH_2-8), 7.10 (1H, s, H-5), 7.51 (4H, s, H-2′, H-3′, H-5′, H-6′), 8.09 (1H, s, H-2).

3-(4-Bromophenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (70). Yield 89%, $C_{21}H_{15}BrO_3$, mp 285-286°C. IR spectrum (KBr, cm^{-1}): 3404, 2952, 2923, 1710, 1631, 1569, 1481, 1450, 1397, 1382, 1117, 1087, 1050, 1011, 980, 937, 857, 843, 831. UV spectrum (dioxane, λ_{max}, nm, log ε): 215 (4.56), 235 (4.62), 252 (4.60), 298 (4.32), 306 (4.31), 329 (4.05). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.22 (2H, m, CH_2-9), 2.28 (3H, s, CH_3-4), 2.80 (2H, m, CH_2-10), 3.41 (2H, m, CH_2-8), 7.11 (1H, s, H-5), 7.42 (2H, d, J = 8.1, H-3′, H-5′), 7.63 (2H, d, J = 8.1, H-2′, H-6′), 8.02 (1H, s, H-2).

3-(4-Methoxyphenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (71). Yield 91%, $C_{22}H_{18}O_4$, mp 212-214°C. IR spectrum (KBr, cm^{-1}): 3434, 2953, 1711, 1632, 1580, 1502, 1448, 1289, 1246, 1176, 1116, 1083, 1051, 1035, 937, 839, 796, 748. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 225 (4.58), 239 (4.62), 298 (4.27), 308 (4.28), 336 (4.00). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.16 (2H, m, CH_2-9), 2.24 (3H, s, CH_3-4), 2.74 (2H, m, CH_2-10), 3.33 (2H, m, CH_2-8), 3.82 (3H, s, CH_3O-4′), 7.04 (2H, d, J = 8.4, H-3′, H-5′), 7.10 (1H, s, H-5), 7.38 (2H, d, J = 8.4, H-2′, H-6′), 8.03 (1H, s, H-2).

3-(3-Methoxyphenyl)-4-methyl-7,8,9,10-tetrahydrocyclopenta[*c*]furo[2,3-*f*]chromen-7-one (72). Yield 94%, $C_{22}H_{18}O_4$, mp 222-224°C. IR spectrum (KBr, cm^{-1}): 3436, 2920, 1710, 1633, 1610, 1589, 1570, 1481, 1452, 1437, 1328, 1288, 1259, 1221, 1116, 1082, 1056, 953, 855, 826, 791, 708. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 227 (4.61), 250 (4.47), 300 (4.28), 307 (4.28), 329 (4.02). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm, J/Hz): 2.19 (2H, m, CH_2-9), 2.28 (3H, s, CH_3-4), 2.77 (2H, m, CH_2-10), 3.36 (2H, m, CH_2-8), 3.85 (3H, s, CH_3O-3′), 7.00 (3H, m, H-2′, H-4′, H-5′), 7.10 (1H, s, H-5), 7.36 (1H, J = 8.4, H-6′), 7.97 (1H, s, H-2).

7-Methyl-1,2,3,4,8,9,10,11-octahydrobenzo[4,5]furo[2,3-*f*]cyclopenta[*c*]chromen-4-one (73). Yield 76%, $C_{19}H_{18}O_3$, mp 234-235°C. IR spectrum (KBr, cm^{-1}): 3434, 2952, 2842, 1706, 1637, 1610, 1570, 1428, 1399, 1363, 1286, 1178, 1153, 1122, 1101, 1069, 1027, 985, 886. UV spectrum (CH_3CN, λ_{max}, nm, log ε): 205 (4.44), 226 (4.34), 230 (4.35), 259 (4.53), 302 (4.22), 342 (3.82). PMR spectrum (300 MHz, DMSO-d_6, δ, ppm): 1.84 (4H, m, CH_2-9, CH_2-10), 2.15 (2H, m, CH_2-2), 2.59 (3H, s, CH_3-7), 2.74 (4H, m, CH_2-1, CH_2-8), 2.83 (2H, m, CH_2-11), 3.31 (2H, m, CH_2-3), 7.01 (1H, s, H-6).

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