Synthesis of substituted 7,7-dialkyl-5-chromanones and related compounds, new potassium channel activator

Emad M. El-Telbani

Pesticides Department, National Research Centre, Dokki, 12622 Cairo, Egypt

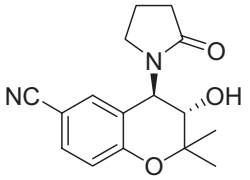
We describe the synthesis of 1-(6-hydroxy-4-methoxy-7,7-dimethyl-6,7-dihydro-5H-furo[3,2-g]chromen-5-yl) pyrrolidin-2-one (**7**) analogue to Cromakalim. Moreover, the synthesised furochromanone used to synthesise a fused heterocyclic compounds containing thiophene and coumarin rings via Gewald and Wittig reactions; respectively.

Keywords: chromanones, benzopyrans, cromakalim, potassium channel openers

Potassium channels play a vital role in the regulation of cellular excitability. They are involved in the maintenance of resting membrane potential, in addition to controlling repolarisation of the action potential.

Opening of K_{ATP} channels results in an efflux of potassium ions from the cell and an accompanying reduction in membrane potential (hyperpolarisation) that restricts calcium entry through l-type calcium channels thereby dampening cellular excitability. There has been widespread interest in exploring K_{ATP} openers as therapeutic agents in the treatment of bladder overactivity, a condition associated, in part, with the hyperexcitability of diseased bladder smooth muscle.[1]

A number of structurally distinct series of K_{ATP} openers have been described.[2] Among these is the benzopyran Cromakalim.[3-5]



Cromakalim **1**

In the search of a novel benzopyrans structurally related to (±)-Cromakalim, and as a part of our interest in bioactive benzopyrans derived from our work on naturally occurring visnagin and khellin[6-10] we have synthesised a novel benzopyran derivative as rigid analogue of Cromakalim.

Treatment of the readily available visnagin and khellin cleavage products **2a** and **2b**, with acetone or 2-butanone in the presence of pyrrolidine using a Dean–Stark apparatus, afforded the benzopyran derivatives **3a–c** in good yields. The IR spectra showed the chromanone keto group at 1677 cm^{-1} and the ^1H NMR spectra showed a characteristic singlet peak at $\delta = 2.71$ ppm for the $COCH_2$ group.

The chromanone derivative **3a** is the precursor of the Cromakalim analogue **7** (Scheme 1). Reduction of **3a** and **3c** using sodium borohydride in ethanol afforded the corresponding furochroman-5-ols **4a** and **4b** Their IR spectra showed the disappearance of the chromanone keto group, and instead a new broad peak appeared at 3600–3300 cm^{-1} characteristic of an OH group.

Dehydration of **4a** and **4b** with *p*-toluene sulfonic acid, produced the chromenes **5a** and **5b** in quantitative yields. The IR spectra of the chromenes **5a** and **5b** showed the absence of the OH peaks present in the parent derivatives **4a** and **4b**. The ^1H NMR of the chromene **5a** and **5b** revealed the presence of two doublets assigned to the olefinic protons at $\delta = 5.65$ and 6.74 ppm (**5b**).

* Correspondent. E-mail: e_misbah@yahoo.co.uk

Epoxidation of the chromene derivative **5a** with m-chloroperoxybenzoic acid (MCPBA) in methylene chloride[11] gave the epoxide derivative **6** in poor yield. The two doublets signals of the parent chromene derivative had disappeared and another two doublets appeared at $\delta = 3.81$ and 3.40 ppm, respectively.

Finally, the desired racemic Cromakalim analogue **7** was obtained in very poor yield (20%) when the expoxide **6** was reacted with 2-pyrrolidinone in the presence of triethylamine.

The reaction of **6** with 2-pyrrolidinone, could give two possible compounds **7** or **7a** or mixture of them. TLC showed that only one compound was obtained.

^1H NMR and ^{13}C showed that only compound **7** was formed, in which ^1H NMR and ^{13}C are so close by obtained in the pyran ring of Cromakalim[12] (see Table 1).

Since these chromanones **3a–c** are valuable precursors in the synthesis of potentially useful pesticides. The chromanone **3a** was condensed with malononitrile under Knoevenegal conditions to afford the unsaturated malononitrile in 79% yield. This reacted with sulfur and triethylamine[13]

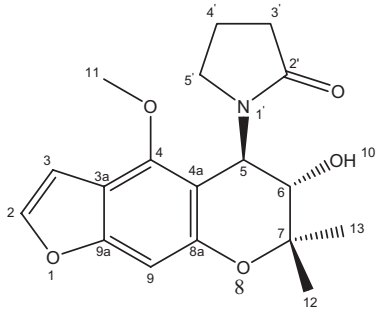
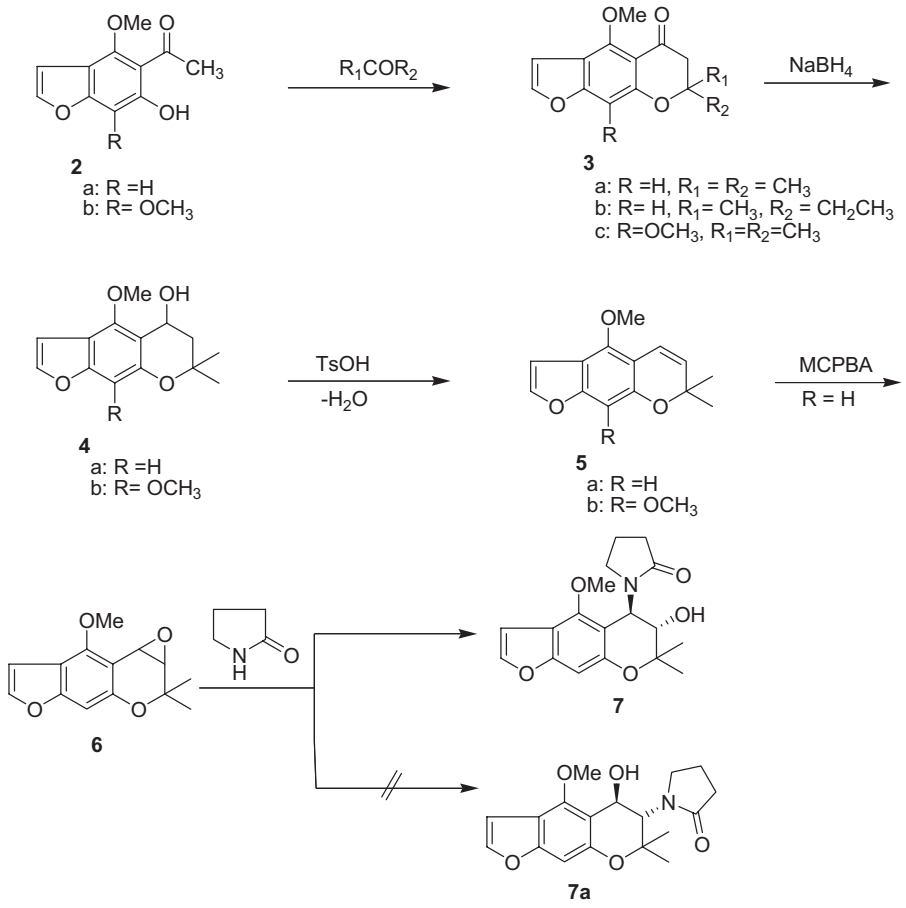


Table 1 ^1H NMR and ^{13}C NMR of compound **7** in $CDCl_3$

	$\delta(^1H)$/ppm	$\delta(^{13}C)$/ppm
2	7.52	148.0
3	6.75	105.88
3a		–109.05
4		–155.47
4a		–105.40
5	5.15	51.87
6	3.73	72.10
7		–79.60
8		–
8a		–151.64
9	6.66	89.10
9a		–156.12
10	~3.20	–
11	3.76	56.00
12	1.48	25.95
13	1.48	18.35
2'		–178.45
3'	2.56	31.65
4'	2.10	18.12
5'	~3.1-3.3	42.15



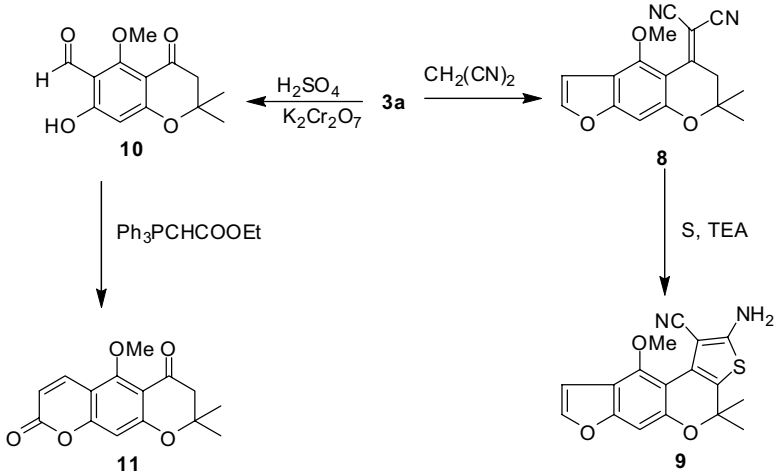
Scheme 1

in absolute ethanol to furnish 2-amino-1-cyano-10-methoxy-4,4-dimethyl-4H furo[3,2-g]thieno[2,2-c]chromene (**9**) (Scheme 2).

The IR spectrum of compound **9** showed absorption bands at υ = 3442, 3337 (NH_2), 2199 cm^{-1} (CN). Moreover, the ^1H NMR spectrum showed beside the furan protons, a new signal (2H) at δ = 4.92 ppm characteristic for NH_2 group.

The chromanone derivative **3a** was oxidised using a mixture of H_2SO_4 and $K_2Cr_2O_7$ to yield 7-hydroxy-5-methoxy-2, 2-dimethyl-4-oxo-3,4-dihydro-2H-chromene-6-carbaldehyde (**10**) in 65% yield. The ^1H NMR spectrum showed the absence of two doublet protons characteristic of the furan ring. New signals appeared at δ = 12.31 and 10.12 ppm (OH and CHO, respectively). The ^{13}C NMR showed presence of two peaks at 192.1 and 196.8 which confirmed presence of two carbonyl groups.

Wittig reaction of the aldehyde **10** with ethyl (triphenylphosphoranylidene) acetate gave the 5-methoxy-8,8-dimethyl-7,8-dihydro-2H,6H-pyrano[3,2-g]chromene-2,6-dione **(11)** in 63% yield. All the spectral and analytical analysis of compound **11** supported the suggested structure, where the IR spectrum showed a new absorption band at υ = 1728 cm^{-1} characteristic for lactonic CO, while the ^1H NMR showed a new two doublets signals at δ = 7.36 and 6.12 ppm characteristic for olifinic protons.



Scheme 2

Experimental

Melting points are uncorrected. IR, NMR, and mass spectra, which were in agreement with the structures cited, were recorded on Mattson 5000 FTIR spectrometer, Jeol 270 MHz and Bruker Ac 250 MHz with internal standard tetramethylsilane (TMS), a Finigan SSQ 7000 mass spectrometer at 70 ev. Elemental analyses were carried out in the microanalytical unit, Faculty of Science Mansoura and Cairo University. Precoated silica gel 60 F_{254} plates with a layer thickness 0.25 mm from Merck were used for thin layer chromatography. Yields are not optimised.

Dihydrofurochromanones **3a,b***: General procedure:* A mixture of visnaginone **2a** or khellinone **2b** (10 mmol), the appropriate ketone (acetone or 2-butanone), (12 mmol), and pyrrolidine (1 ml) in absolute toluene (100 ml) was refluxed using Dean-Stark apparatus until the calculated amount of water had collected. The solvent was evaporated and the residue purified by crystallisation from ethanol to yield:

4-Methoxy-7,7-dimethyl-6,7-dihydrofuro[3,2-g]chromen-5-one **(3a)**: Colourless needles, m.p. 82–83°C; (2 g, yield = 81%). IR (KBr): ν = (CO)/cm^{-1}1677; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.44 (d, 1H, *J* = 2.3 Hz, H-2), 6.92 (d, 1H, *J* = 2.3 Hz, H-3), 6.73 (s, 1H, H-9), 4.16 (s, 3H, OCH_3), 2.71 (s, 2H, CH_2), 1.45 (s, 6H, 2X CH_3); ^{13}C NMR ($CDCl_3$): δ 26.4, 48.0, 78.0, 62.4, 94.0, 144.5, 105, 108, 113, 158, 159, 160, 189. Found: C, 68.10; H, 5.80%. $C_{14}H_{14}O_4$ (246.26) requires C, 68.28; H, 5.73%.

4-Methoxy-7-ethyl-7-methyl-6,7-dihydrofuro[3,2-g]chromen-5-one **(3b)**: Colourless needles, m.p. 89–90°C; (2 g, 77% yield). IR (KBr): ν = (CO)/cm^{-1}1675; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.44 (d, 1H, *J* = 2.3 Hz, H-2), 6.92 (d, 1H, *J* = 2.3 Hz, H-3), 6.73 (s, 1H, H-9), 4.16 (s, 3H, OCH_3), 2.71 (s, 2H, $COCH_2$), 1.8 (m, 2H, CH_2CH_3), 1.38 (s, 3H, CH_3), 1.00 (t, 3H, *J* = 7.4 Hz, CH_2CH_3). Found: C, 69.20; H, 6.10%. $C_{15}H_{16}O_4$ (260.28) requires C, 69.22; H, 6.20%.

4,9-Dimethoxy-7,7-dimethyl-6,7-dihydrofuro[3,2-g]chromen-5-one **(3c)**: Colourless needles, m.p. 88–89°C; (2 g, 75% yield). IR (KBr): ν = (CO)/cm^{-1}1677; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.5 (d, 1H, *J* = 2.3 Hz, H-2), 6.9 (d, 1H, *J* = 2.3 Hz, H-3), 4.1 (s, 3H, OCH_3), 4.0 (s, 3H, OCH_3), 2.71 (s, 2H, $COCH_2$), 1.5 (s, 6H, 2X CH_3). Found: C, 65.10; H, 5.70%. $C_{15}H_{16}O_5$ (276.29) requires C, 65.21; H, 5.84%.

Reduction of compounds **3a,c** *using $NaBH_4$. General procedure:* Sodium borohydride (15 mmol) was added portion-wise during 30 min to a solution of compound **3a** or **3c** (10 mmol) in absolute ethanol (50 ml) with stirring at room temperature for 2 h. The reaction mixture was poured onto crushed ice. The organic product was extracted using ethyl acetate (3x 50 ml), dried (anhydrous $MgSO_4$), evaporated and crystallised from ethanol to yield colourless crystals of:

4-Methoxy-7,7-dimethyl-6,7-dihydro-5H-furo[3,2-g]chromen-5-ol **(4a)**: Colourless crystals, m.p. 72–73°C; (2 g, 81% yield). IR (KBr): ν = (br., OH)/cm^{-1} 3600–3200; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.45 (d, 1H, *J* = 2.3 Hz, H-2), 6.89 (d, 1H, *J* = 2.3 Hz, H-2), 6.71 (s, 1H, H-9), 5.11 (dd, 1H, *J* = 5.5, 5.7 Hz, H-5), 4.23 (s, 3H, OCH_3), 3.4 (brs., 1H, OH), 2.11 (m, 2H, H-6), 1.44 (s, 6H, 2X CH_3). Found: C, 67.60; H, 6.30%. $C_{14}H_{16}O_4$ (248.27) requires C, 67.73; H, 6.50%.

4,9-Dimethoxy-7,7-dimethyl-6,7-dihydro-5H-furo[3,2-g]chromen-5-ol **(4b)**: Colourless crystals, m.p. 74–75°C; (2.2 g 79% yield). IR (KBr): ν = (br. OH)/cm^{-1} 3600–3200; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.44 (d, 1H, *J* = 2.3 Hz, H-2), 6.70 (d, 1H, *J* = 2.3 Hz, H-3), 5.10 (dd, 1H, *J* = 5.5, 5.6 Hz, H-5), 4.10 (s, 3H, OCH_3), 4.0 (s, 3H, OCH_3), 3.4 (brs., 1H, OH), 2.05 (m, 2H, H-6), 1.45 (s, 6H, 2X CH_3). Found: C, 64.60; H, 6.40%. $C_{15}H_{18}O_5$ (278.30) requires C, 64.74; H, 6.52%.

4-Methoxy and (4,9-dimethoxy)-7,7-dimethyl-7H-furo[3,2-g] chromene **(5a)** *and* **(5b)***: general procedure*
To a solution of chromen-5-ol derivative **4a** or **4b** (10 mmol) in dry benzene (50 ml), *p*-toluene sulfonic acid (0.1 g) was added and refluxed for 3 h with a Dean–Stark apparatus. The reaction mixture was cooled to room temperature, washed with $NaHCO_3$ solution. The organic layer was separated, dried (anhydrous $MgSO_4$), evaporated, and the residue was crystallised from cyclohexane to yield **5a**: as colourless crystals, m.p. 87–88°C; (1.6 g, 70% yield). IR (KBr): ν = (C =C)/cm^{-1}1625; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.41 (d, 1H, *J* = 2.3 Hz, H-2); 6.81–6.71 (m, 2H, H-3, CH=CH), 5.57 (d, 1H, *J* = 12.5 Hz, CH=CH), 4.0 (s, 3H, OCH_3), 1.43 (s, 6H, 2X CH_3). Found: C, 73.10; H, 5.90%. $C_{14}H_{14}O_3$ (230.26) requires C, 73.03; H, 6.13%.

5b: Crystals needles, m.p. 67–68°C; (1.8 g,71% yield). IR (KBr): ν = (C =C)/cm^{-1}1630; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.47 (d, 1H, *J* = 2.3 Hz, H-2),6.81 (d, 1H, *J* = 2.3 Hz, H-3), 6.74 (d, 1H, *J* = 12.5 Hz, CH=CH), 5.65 (d, 1H, *J* = 12.5 Hz, CH=CH); 4.03 (s, 3H, OCH_3), 3.99 (s, 3H, OCH_3), 1.48 (s, 6H, 2X CH_3); MS *m/z* = 260.1 [M$^+$]. Found: C, 69.10; H, 6.10%. $C_{15}H_{16}O_4$ (260.29) requires C, 69.22; H, 6.19%.

5,6-Epoxy-4-methoxy-7,7-dimethyl-5,6-dihydro-7H-furo[3,2-g] chromene **(6)**: 3-chloroperoxybenzoic acid (12 mmol) dissolved in CH_2Cl_2 (20 ml) was added drop-wise to a solution of **5a** (2.30 g, 10 mmol) in CH_2Cl_2 (100 ml) at 5°C. After the mixture was stirred over night at room temperature, a precipitate was filtered off. The remaining solution was evaporated and the residue purified by column chromatography (silica gel, CH_2Cl_2/petroleum ether, 3 : 1, R_f = 0.3), affording **6** as colourless needles, m.p. 50–52°C; (0.9 g, 36% yield). ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.5 (d, 1H, *J* = 2.3 Hz, H-2), 6.81 (d, 1H, *J* = 2.3 Hz, H-3), 6.7 (s, 1H, H-9), 3.81 (d, 1H, *J* = 4.0 Hz, H-5), 3.75 (s, 3H, OCH_3), 3.40 (d, 1H, *J* = 4.0 Hz, H-6), 1.48 (s, 6H, 2X CH_3); MS *m/z*: 246 [M$^+$]. Found: C, 68.40; H, 5.60%. $C_{14}H_{14}O_4$ (246.26) requires C, 68.28; H, 5.73%.

1-(6-Hydroxy-4-methoxy-7,7-dimethyl-6,7-dihydro-5H-furo[3,2-g] chromen-5-yl)pyrrolidin-2-one **(7)**: The epoxide **6** (1 g, 0.004 mmol), 2-pyrrolidinone (0.35 g, 0.004 mmol) and Et_3N (0.5 ml) were heated at reflux in ethanol (10 ml) for 2 days. The reaction mixture was evaporated, and the residue was redissolved in CH_2Cl_2 and washed twice with H_2O. After drying, the organic phase was evaporated and chromatographed (silica gel, petroleum ether/Et_2O 1: 3, R_f = 0.4) to yield **7** as colourless needles, m.p. 146–148°C; (0.7 g, 20% yield). IR (KBr): ν_{max}cm^{-1}1692(60), 3600–3300 (OH); ^{1}H NMR (270 MHz, DMSO): δ 7.52 (d, 1H, *J* = 2.3 Hz, H-2), 6.75 (d, 1H, *J* = 2.3 Hz, H-3), 6.66 (s, 1H, H-9), 5.15(d, 1H, CH), 3.76(s, 3H, OCH_3), 3.73 (d, 1H, CH), 3.10–3.35 (m, 3H, CH_2 and OH), 2.56 (m, 2H, CH_2), 2.10 (m, 2H, CH_2), 1.48 (s, 6H, 2X CH_3); ^{13}C NMR ($CDCl_3$): δ 18.12, 18.35, 25.95, 31.65, 42.15, 51.87, 56.00, 72.10, 79.60, 89.10, 105.40, 105.88, 109.05, 148.0, 151.64, 155.47, 156.12, 178. Found: C, 65.20; H, 6.40; N, 4.10%. $C_{18}H_{21}NO_5$ (331.36) requires C, 65.24; H, 6.39; N, 4.23%.

2-(4-Methoxy-7,7-dimethyl-6,7-dihydrofuro[3,2-g]chromen-5-ylidene)malononitrile **(8):** A mixture of dihydro furochromananone **3a** (2.46 g 10 mmol), malononitrile (0.7 g, 11 mmol), ammonium acetate (2 g) and acetic acid (3 ml) in chloroform (100 ml) was refluxed using Dean-Stark apparatus for 10 h. The solvent was evaporated and water (100 ml) was added. The precipitate formed was filtered off, washed with water and crystallised from ethanol to yield ylidene malononitrile **8**: as yellow needles, m.p. 133–134°C; (2.3 g, 78% yield). IR (KBr): ν (C≡N)/cm^{-1} 2222(CN), 1622 (col). ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.45 (d, 1H, *J* = 2.3 Hz, H-2), 6.94 (d, 1H, *J* = 2.3 Hz, H-3), 6.64 (s, 1H, H-9), 4.25 (s, 3H, OCH_3), 2.82 (s, 2H, CH_2), 1.64 (s, 6H, 2X CH_3). Found: C, 69.10; H, 4.60; N, 9.40. $C_{17}H_{14}N_2O_3$ (294.31) requires C, 69.38; H, 4.79; N, 9. 52%.

2-Amino-1-cyano-10-methoxy-4,4-dimethyl-4H Furo[3,2-g]thieno [2,2-c]chromene **(9)**: A solution of ylidene malononitrile derivative **8** (2.94 g, 10 mmol), elemental sulfur (0.4 g, 12 mmol) triethylamine (2 ml), in absolute ethanol (50 ml) was boiled under reflux for 8 h. The reaction mixture was filtered, the solvent was evaporated and the residue purified by chromatography (Silica gel, EtOAc–petroleum ether, 2 : 8, R_f = 0.25). Affording **9** (2.6 g, 79% yield) as colourless crystals of m.p. 194–195°C. IR (KBr): ν = (NH_2)/cm^{-1} 3442, 3337, ν = (C≡N)/cm^{-1} 2199; ^{1}H NMR (270 MHz, $CDCl_3$): δ 7.45 (d, 1H, *J* = 2.3 Hz, H-2), 6.92 (d, 1H, *J* = 2.3 Hz, H-3), 6.81 (s, 1H, H-9), 4.92 (brs, 2H, NH_2), 4.30 (s, 3H, OCH_3), 1.5 (s, 6H, 2X CH_3). Found: C, 62.40; H, 4.30; N, 8.40%. $C_{17}H_{14}N_2O_3S$ (326.31) requires C, 62.57; H, 4.32; N, 8.58%.

7-Hydroxy-5-methoxy-2,2-dimethyl-4-oxo-3,4-dihydro-2H-chromene-6-carbaldehyde **(10)**: To a hot solution of dihydrofurochromanone **3a** (2.46 g, 10 mmol) in 10% sulfuric acid (100 ml), $K_2Cr_2O_7$ (30 ml, 10%) was added dropwisly with stirring within 3 h. The reaction mixture was kept over night at room temperature. The solid which was formed, filtered, washed with water, dried, and crystallised from ethanol to yield 7-hydroxy-5-methoxy-2,2-dimethyl-4-oxo-3,4-dihydro-2H-chromene-6-carbaldehyde (**10**) (1.6 g, 65% yield) as colourless needles, m.p. 51–52°C. IR (KBr): ν = (OH)/cm^{-1}3518-3480, ν = (C=O)/cm^{-1}1675, ν = (C=O aldehydic)/cm^{-1}1698; ^{1}H NMR (270 MHz, $CDCl_3$): δ 12.31 (s, 1H, OH), 10.12 (s, 1H, CHO), 6.17 (s, 1H, H-8), 3.99 (s, 3H, OCH_3), 2.68 (s, 2H, $COCH_2$), 1.46 (s, 6H, 2X CH_3); ^{13}C NMR ($CDCl_3$): δ 26.7, 49.5, 61.8, 78.0, 102.5, 113.4, 120.2, 130.7, 164.0, 166.8, 192.1, 196.8.

Found: C, 62.30; H, 5.50. $C_{13}H_{14}O_5$ (250.25) requires C, 62.39; H, 5.64%.

5-Methoxy-8,8-dimethyl-7,8-dihydro-2H,6H-pyrano[3,2-g] chromene-2,6-dione **(11)**: A solution of **10** (2.5 g, 10 mmol) and ethyl (triphenylphosphoranylidene) acetate (12 mmol) in dry xylene (20 ml) was refluxed for 12 h. Then the mixture was concentrated, and residue was purified by chromatography (Silica gel, toluene/ethyl acetate 8 : 1, R_f = 0.3) to yield **11** (1.8 g, 63% yield) as colourless needles, m.p. 152–153°C. IR (KBr): ν = (CO, lactone CO)/cm^{-1}1678, 1728; ^{1}H NMR (270 MHz, DMSO): δ 7.36 (d, 1H, *J* = 9.4 Hz, H-4), 6.71 (s, 1H, H-10), 6.12 (d, 1H, *J* = 9.4 Hz, H-3), 3.73 (s, 3H, OCH_3), 2.79 (s, 2H, CH_2), 1.48 (s, 6H, 2X CH_3); ^{13}C NMR (DMSO d_6): δ 26.7, 49.5, 62.2, 78.0, 107.0, 113.4, 113.7, 117.0, 127.2, 143.5, 155.1, 156.0, 160.8, 196.8. Found: C, 65.60; H, 5.00. $C_{15}H_{14}O_5$ (274.27) C, 65.69; H, 5.15%.

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References

1 K.E. Andersson, *Urology,* 1997, **50**, 74.
2 M.J. Coghlan, W.A. Carroll and M. Gopalakrishnan, *J. Med. Chem*., 2001, **44**, 1628.
3 D.E. Nurse, J.M. Restorick and A.R. Mundy, *Br. J. Urol.*, 1991, **68**, 27.
4 J.M. Restorick and D.E. Nurse, *Neurourol. Urodyn.*, 1988, **7**, 207.
5 I. Bagcivan, T. Kaya, M.K. Yildirim and M. Turan, *Pancreatology,* 2006, **6**, 286.
6 S.I. El-Desoky, M.A. Hammad, N. Grant, E.M. El-Telbani and A.H. Abdel Rahman, *Tetrahedron,* 1997, **53**(46), 15799.
7 S.I. El-Desokey, E.M. El-Telbani, M.A. Hammad, F.A. Badria and A.H. Abdel Rahman, *Z. Naturforsch***.**, 1998, **53b**, 909.
8 E.M. El-Telbani, S.I. El-Desokey, M.A. Hammad, A.H. Abdel Rahman and R.R. Schmidt, *Eur. J. Org. Chem*, 1998, 2317.
9 A.H. Abdel-Rahman, E.M. Keshk and E.M. El-Telbani, *Z. Naturforsch.*, 2002, **57b**, 557.
10 E.M. Keshk, E.M. El-Telbani and A.H. Abdel Rahman, *Z. Naturforsch.*, 2003, **58b**, 1237.
11 R. Bergmann and R. Gericke, *J. Med. Chem.*, 1990, **33** (2), 492.
12 E. Gerhard, K. Hermann, L. Luckhana and P. Wolschann, *Monatshefte,* 2001, **132**(3), 373.
13 K. Gewald, E. Schenkeand and H. Brottcher, *Chem. Ber.*, 1966, **93**, 94.