

Yagamare Fall [a], Lourdes Santana [b],* and Eugenio Uriarte [b]

[a] Department of Organic Chemistry, University of Vigo, Spain

[b] Department of Organic Chemistry, Faculty of Pharmacy, University of Santiago de Compostela, Spain

The first synthesis of the 6-hydroxy-4-methoxycoumarin (**5**) was carried out in 25 % overall yield from 6-methoxy-4-hydroxycoumarin (**1**) by hydrolysis of the methoxy group and subsequent selective methylation of the hydroxyl group at position 4. The ^1H and ^{13}C NMR data of compounds **1-6** are reported.

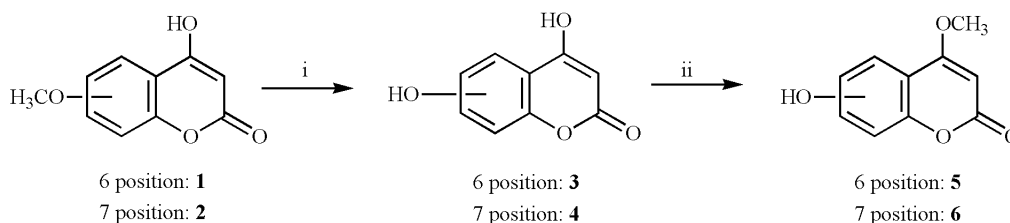
J. Heterocyclic Chem., **38**, 1231 (2001).

Though long known, coumarins have in recent years attracted growing interest, some having been found to possess properties of considerable pharmacological or industrial significance [1-5]. In the course of our previous work in this field [5-7] we realized that several very simple coumarins of apparent interest have not yet been synthesized, and that others have been characterized only incompletely. In particular, this is true of coumarins with hydroxy or methoxy groups in positions 4, 6 and/or 7 (the usual substitution positions in both natural and synthetic coumarins), which have great synthetic potential. For example, in spite of abundant references in the literature to 4,7-disubstituted coumarins of this type

(compounds **2**, **4** and **6**) [8-12], only the 4-hydroxy-7-methoxy derivative **4** has been totally characterized [12], while the 4-methoxy-6-hydroxy compound **5** appears not to have been synthesized and its precursors in Scheme 1 (**1** and **3**) have been only very incompletely characterized [8,9]. Here we describe the first synthesis of compound **5**, and present ^1H and ^{13}C NMR data for this compound and for the other disubstituted coumarins shown in Scheme 1.

Compound **3** was obtained from **1** [9] in 45% yield by hydrolysis of the methoxy group with HI in acetic acid [10], and selective methylation of the 4-OH group by a mixture of hydrochloric acid and methanol [11] then

Scheme 1



Reagents: (i) HI / $(\text{AcO})_2\text{O}/\text{AcOH}$; (ii) conc. HCl/MeOH.

Table 1

^1H NMR Spectra of Coumarins **1-6** in $\text{DMSO}-d_6$: Chemical Shifts and Coupling Constants

Compound	H3	H5	H6	H7	H8	OH-4	OH-6	OH-7	CH3
1	5.59, s	7.22 d, $J = 2.40$		7.19 dd, $J = 8.33, 2.40$	7.30 d, $J = 8.33$	12.56, s			3.79, s
2	5.43	7.71 d, $J = 7.87$	6.93 dd, $J = 7.87, 2.43$		6.90 d, $J = 2.43$	12.45, s			3.83
3	5.53, s	7.10 d, $J = 2.87$		7.04 dd, $J = 8.87, 2.80$	7.20 d, $J = 8.87$	12.35, s	9.72, s		
4	5.37, s	7.62 d, $J = 8.65$	6.75 dd, $J = 8.65, 2.24$		6.65 d, $J = 2.24$	12.23, s		10.51, s	
5	5.85, s	7.09 d, $J = 2.86$		7.09 dd, $J = 8.73, 2.86$	7.24 d, $J = 8.73$		9.80, s		3.80, s
6	5.65, s	7.61 d, $J = 8.78$	6.76 dd, $J = 8.78, 2.23$		6.68 d, $J = 2.23$			10.60, s	3.95, s

Table 2
¹³C NMR Spectra of Coumarins 1-6 in DMSO-*d*₆

Compound	C2	C3	C4	C4a	C5	C6	C7	C8	C8a	CH ₃
1	162.42	91.54	165.78	120.71	105.29	155.61	116.58	117.92	148.19	55.97
2	162.82	87.46	167.05	108.03	124.75	114.53	163.14	100.79	155.79	56.18
3	162.50	91.60	165.83	123.12	110.40	154.72	121.03	119.89	145.73	
4	162.40	87.75	166.00	107.50	124.45	112.48	161.50	101.93	156.03	
5	162.29	90.62	165.99	115.94	107.08	153.99	117.87	121.31	146.311	57.30
6	162.53	87.20	166.79	107.40	124.47	113.18	162.02	102.37	154.96	57.33

afforded compound **5** in 55% yield. Compound **6** was prepared analogously from **2** via **4** [9], with an overall yield of 48%. ¹H and ¹³C NMR data for compounds **1-6** are listed in Tables 1 and 2, respectively.

EXPERIMENTAL

Melting points were determined in a Reichert Kofler thermopan, and are uncorrected. IR spectra were recorded in a Perkin-Elmer 1640FT spectrometer (ν in cm⁻¹). ¹H and ¹³C NMR spectra were recorded in a Bruker AMX spectrometer at 300 and 75.47 MHz, respectively, using TMS as internal standard (chemical shifts in δ values, *J* in Hz). Mass spectrometry was carried out in a Hewlett Packard 5988A spectrometer. Elemental analyses were performed on a Perkin-Elmer 240B microanalyser. Flash chromatography (FC) was performed on silica gel (Merck 60, 230-400 mesh).

4,6-Dihydroxycoumarin (**3**).

Compound **1** (1 g, 5.2 mmol) was added to a mixture of hydriodic acid (25 ml), acetic anhydride (10 ml) and acetic acid (10 ml), and the mixture was heated at 80 °C for 1 hour. After cooling to room temperature, 100 ml of water was added. The resulting precipitate was isolated by filtration and purified by flash chromatography (FC) using 4:1 CH₂Cl₂/MeOH as eluent. Yield 0.4 g. (45%), mp 286-288 °C (MeOH); RF: 0.22 (4:1 CH₂Cl₂/MeOH); ir: ν 3100-2800, 1663, 1567, 1462, 1325, 1153, 1097, 1002 cm⁻¹; MS *m/z* (%): 178 (M⁺, 96), 150 (M⁺ - CO, 30), 136 (M⁺ - CO₂, 100), 108 (47), 78 (64).

Anal. Calcd. for C₉H₆O₄: C, 62.5; H, 4.20. Found: C, 62.38; H, 4.43.

6-Hydroxy-4-methoxycoumarin (**5**).

A mixture of **3** (1 g, 5.6 mmol), MeOH (40 ml) and concentrated HCl (5 ml) was refluxed for 1.5 hours. The solvent was removed *in vacuo* and the residue was purified by FC using 9:1

CH₂Cl₂/MeOH, yielding the desired compound **5** (0.6 g 55%), and 0.16 g (15%) of the starting coumarin **3**; mp 283-285 °C (EtOH); RF: 0.43 (9:1 CH₂Cl₂/MeOH); ir: ν 3186, 1664, 1571, 1468, 1398, 1243, 1092 cm⁻¹; MS *m/z* (%): 192 (M⁺, 100), 164 (M⁺ - CO, 41), 149 (M⁺ - CO₂, 46), 134 (27), 121 (14), 78 (25).

Anal. Calcd. for C₁₀H₈O₄: C, 60.68; H, 3.39. Found: C, 60.51; H, 3.55.

Acknowledgment.

We thank the Xunta de Galicia (PGIDTOOPXI20317PR) for financial support.

REFERENCES AND NOTES

- [1] R. D. H. Murray, *The Natural Coumarins: Occurrence, Chemistry and Biochemistry*. Wiley-Interscience, NY 1982.
- [2] S. Wang, G. Milne, W. A. Yan and I. J. Posey, *J. Med. Chem.*, **39**, 2047 (1996).
- [3] B. Rendenbach-Müller, R. Schleker, M. Traut and H. Weifenbach, *Bioorg. Med. Chem. Lett.*, **42**, 2662 (1999).
- [4] L. Xie, Y. Takeuchi, L. M Cosentino, and K-H. Lee, *J. Med. Chem.*, **42**, 2662 (1999).
- [5] L. Santana, C. Teran, E. Uriarte, Y. Fall, L. Unellius and B-R. Tolf, *Bioorg. Med. Chem. Lett.*, **8**, 3567 (1998).
- [6] Y. Fall, C. Teran, M. Teijeira, L. Santana, and E. Uriarte, *Synthesis*, **5**, 643 (2000).
- [7] E. Estrada, J. C. González, L. Santana and E. Uriarte, *Struc. Chem.*, **11**, 249 (2000).
- [8] J. F. Garden, N. F. Hayes and R. H. Thomson, *J. Chem. Soc.*, 3315 (1956).
- [9] D. R. Buckle, B. C. C. Cantello, H. Smith and B. A. Spicer, *J. Med. Chem.*, **18**, 391 (1975).
- [10] T. Mizuno, I. Nishiguchi, T. Hirashima, A. Ogawa, N. Kambe and N. Sonoda, *Synthesis*, **3**, 257 (1988).
- [11] V. K. Ahluwalia and D. Kumar, *Indian J. Chem.*, **15B**, 945 (1977).
- [12] V. F. Traven, V. V. Negrebetsky, L. I. Vorobjeva and A. C. Carberry, *Can. J. Chem.*, **75**, 377 (1977).