Crystal structure of 7-benzyloxy-5,6-dihydroxyflavone, $C_{22}H_{16}O_5$

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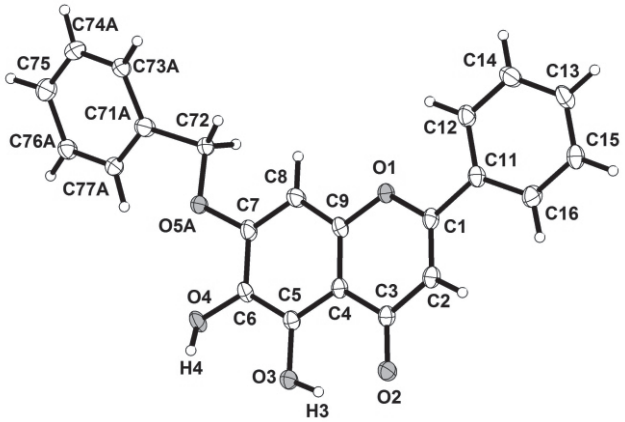

Abstract

$C_{22}H_{16}O_5$, monoclinic, $P2_1/c$ (no. 14), a = 4.8039(3) Å, b = 31.819(2) Å, c = 11.1993(7) Å, β = 107.350(3)°, V = 1634.0 Å^3, Z = 4, $R_{gt}(F)$ = 0.0458, $wR_{ref}(F^2)$ = 0.1173, T = 100 K.

Table 1. Data collection and handling.

Crystal:	yellow cuboid, size 0.09×0.1×0.37 mm
Wavelength:	Mo K_α radiation (0.71073 Å)
μ:	1.04 cm^{-1}
Diffractometer, scan mode:	Bruker X8 APEX II 4K Kappa, φ and ω
$2\theta_{max}$:	56.6°
$N(hkl)_{measured}$, $N(hkl)_{unique}$:	23807, 4061
Criterion for I_{obs}, $N(hkl)_{gt}$:	$I_{obs} > 2\ \sigma(I_{obs})$, 3140
$N(param)_{refined}$:	289
Programs:	SHELX [2], APEX2 [3], SAINT-PLUS, SADABS [4], DIAMOND [5], WinGX [6]

Source of material

Baicalein (0.100 g, 0.370 mmol, 1 eq) and 60% NaH (0.011 g, 0.444 mmol, 1.2 eq) in DMF (8 ml) was stirred at –40 °C for 20 min. The reaction mixture was then treated with benzyl bromide (0.05 ml, 0.444 mmol, 1.2 eq) at the same temperature. After 30 min stirring, the temperature was raised from –40 °C to 0 °C and stirred for a further 6 hrs. The crude product was extracted with EtOAc (3×20 ml), washed with water (20 ml), dried over Na_2SO_4 and concentrated. The crude product was crystallized out with acetone and yielded 7-benzyloxy-5,6-dihydroxyflavone as brown crystals (0.030 g, 37 %). **^{1}H NMR** (600 MHz, $CDCl_3$) δH (ppm): 7.89 (d, 2 H, J 6.9 Hz, H-2' and H-6'); 7.55 (m, 3 H, $OCH_2C_6H^*_5$); 7.49 (d, 2 H, J 7.3 Hz, H-2" and H-6"); 7.45 (t, 2 H, J 7.3 Hz, H-3" and H-5"); 7.40 (t, 1 H, J 7.3 Hz, H-4"); 6.70 (s, 1 H, H-3); 6.68 (s, 1 H, H-8); 5.40 (s, 1 H, OH); 5.28 (s, 2 H, $OCH^*_2C_6H_5$). **^{13}C NMR** (600 MHz, $CDCl_3$) δC (ppm): 182.73; 164.22; 151.91; 150.54; 145.97; 135.39; 132.30; 131.45; 130.05; 129.58; 129.47; 129.31; 129.09; 128.61; 128.51; 128.32; 128.18; 128.15; 128.07; 127.19; 126.89; 126.84; 126.77; 125.87; 125.74; 106.30; 105.15; 104.80; 91.55; 91.21; 78.10; 77.63; 77.57; 71.40. **IR** (KBr) 3855, 3446, 2924, 1654, 1608, 1578, 1507, 1456, 1358, 1297, 1181, 1116, 1098, 1025, 902, 796, 780, 758, 731, 692, 653, 591 cm^{-1}.

Experimental details

All hydrogen atoms were positioned geometrically and refined using a riding model, with C–H = 0.95 Å, U_{iso}(H)= 1.2 U_{eq}(C) for the aromatic H, with O–H = 0.84 Å U_{iso}(H)= 1.5 U_{eq}(O) for the hydroxy H and with U_{iso}(H) = 1.5 U_{eq}(C) for methylene H atoms. The hydroxy groups were allowed to rotate with a fixed angle whilst the methylene group C–H distance was allowed to refine to best fit the experimental electron density [HFIX 147 and HFIX 24 in SHELXL97 [2]].

Discussion

Plants are an invaluable resource when used in combination with traditional environmental knowledge, researches have the opportunity to investigate and expand on this important resource. With the cataloging of various traditional medicines, scientific investigations into their combinations and active ingredients can be undertaken by the scientific community. Huang-qin (*Scutellaria baicalensis* Georgi) one such traditional Chinese herb has been listed in the Chinese pharmacopeia [1]. Its active ingredients have shown medicinal promise against tuberculosis, fevers, ulcers, cancers, and inflammation. One of these active components known as Baicalein was used to further functionalize the molecule by the exchange of a hydroxy with a benzyloxy moiety. The title molecule consists of a hydroxy (C5 and C6) and benzyloxy (C7) substituted flavone, the γ-benzopyrone backbone including the hydroxy and carbon (C71) atom of the benzyloxy substituents was seen to be essentially planar with an *r.m.s* deviation of 0.0444 Å (central plane). The maximum deviation above the mean plane was observed for the carbon (C71) atom of the benzyloxy substitutent with a distance of 0.105(2) Å. The phenyl of the benzyloxy moiety was disordered over two positions with a site-occupancy ratio of 0.49(3) with an intersection angle between the mean planes of 51.97(9)°. The angles of intersection of the disordered phenyl planes with the central plane were found to be 23.19(7)° and 28.78(7)°, respectively. A twist angle of 12.85(8)° for the phenyl substitutent of the flavone was observed, this is reinforced by a weak intramolecular hydrogen bond interaction between the ring carbon (C12) and the oxygen (O1) of the γ-benzopyrone with a distance of 2.407 Å. A second weak non-covalent intermolecular interaction forming a chain between the ring carbon (C14) to an adjacent hydroxy oxygen (O4) (symmetry operator [x+1, y, z–1]) with a distance of 3.261(2) Å was seen. The molecules in the title structure are packed in a zig-zag pattern when viewed along the c-axis, with the intermolecular hydrogen bonding chain (C7) between the hydroxy (O4) group and an adjacent carbonyl oxygen (O2) (symmetry operator [x, –y+½, z+½])

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with a distance of 2.745(2) Å forming the turning point in the pattern. Within the parallel layers weak OH···π and CH···π interactions were found. The first, between the hydroxy (O3) and the adjacent pyrone ring (symmetry operator [1+x, ½–y, –½+z]) with a distance of 3.3537(2) Å. The second, was observed between the phenyl carbon (C14) of the flavone and an adjacent phenyl substitutent of the flavone backbone (symmetry operator [1+x, ½–y, –½+z]) with a distance of 3.6461(2) Å.

Table 2. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	Occ.	x	y	z	U_{iso}
H(2)	4*e*		0.6485	0.2675	0.5150	0.024
H(8)	4*e*		0.7965	0.4043	0.8409	0.029
H(12)	4*e*		1.1408	0.3891	0.5798	0.028
H(13)	4*e*		1.3686	0.4091	0.4313	0.039
H(14)	4*e*		1.2805	0.3717	0.2435	0.031
H(15)	4*e*		0.9590	0.3151	0.2037	0.028
H(16)	4*e*		0.7368	0.2941	0.3523	0.031
H(71A)	4*e*	0.489(3)	0.5704	0.4548	0.9550	0.023
H(71B)	4*e*	0.489(3)	0.9022	0.4387	1.0059	0.023
H(71C)	4*e*	0.511(3)	1.0006	0.4188	1.0918	0.023
H(71D)	4*e*	0.511(3)	0.8234	0.4489	0.9788	0.023
H(75)	4*e*		0.7494	0.5332	1.4176	0.038
H(3)	4*e*		0.2167	0.2549	0.8028	0.034
H(4)	4*e*		0.2967	0.3059	1.0640	0.033
H(73A)	4*e*	0.489(3)	1.1525	0.4954	1.1737	0.025
H(74A)	4*e*	0.489(3)	1.0792	0.5461	1.3142	0.030
H(76A)	4*e*	0.489(3)	0.3528	0.4854	1.3288	0.025
H(77A)	4*e*	0.489(3)	0.4214	0.4351	1.1854	0.023
H(73B)	4*e*	0.511(3)	0.7443	0.5220	1.0574	0.026
H(74B)	4*e*	0.511(3)	0.8237	0.5634	1.2396	0.028
H(76B)	4*e*	0.511(3)	0.7505	0.4594	1.4346	0.028
H(77B)	4*e*	0.511(3)	0.6706	0.4185	1.2531	0.025

Table 3. Atomic coordinates and displacement parameters (in Å^2).

Atom	Site	Occ.	x	y	z	U_{11}	U_{22}	U_{33}	U_{12}	U_{13}	U_{23}
C(1)	4*e*		0.7795(3)	0.32518(5)	0.5762(1)	0.0179(6)	0.0248(8)	0.0149(7)	0.0028(6)	0.0074(5)	–0.0035(6)
C(2)	4*e*		0.6442(3)	0.28797(5)	0.5763(1)	0.0233(7)	0.0212(7)	0.0179(7)	0.0029(6)	0.0087(6)	–0.0045(6)
C(3)	4*e*		0.4944(3)	0.27842(5)	0.6662(1)	0.0200(6)	0.0185(7)	0.0159(7)	0.0037(5)	0.0054(5)	–0.0005(5)
C(4)	4*e*		0.5112(3)	0.31055(4)	0.7597(1)	0.0180(6)	0.0180(7)	0.0147(7)	0.0037(5)	0.0053(5)	–0.0001(5)
C(5)	4*e*		0.3797(3)	0.30562(4)	0.8565(1)	0.0196(6)	0.0161(7)	0.0156(7)	0.0030(5)	0.0058(5)	0.0014(5)
C(6)	4*e*		0.4136(3)	0.33583(5)	0.9489(1)	0.0234(7)	0.0191(7)	0.0144(7)	0.0027(6)	0.0089(6)	0.0022(5)
C(7)	4*e*		0.5684(4)	0.37292(5)	0.9414(1)	0.0341(8)	0.0193(7)	0.0163(7)	–0.0012(6)	0.0123(6)	–0.0034(6)
C(8)	4*e*		0.6942(4)	0.37916(5)	0.8457(2)	0.0367(9)	0.0191(7)	0.0221(8)	–0.0060(6)	0.0163(7)	–0.0041(6)
C(9)	4*e*		0.6657(3)	0.34756(5)	0.7577(1)	0.0213(7)	0.0213(7)	0.0153(7)	0.0021(6)	0.0091(6)	0.0006(6)
C(11)	4*e*		0.9207(3)	0.33892(5)	0.4827(1)	0.0176(6)	0.0236(8)	0.0171(7)	0.0038(5)	0.0082(5)	–0.0011(6)
C(12)	4*e*		1.1060(3)	0.37361(5)	0.5043(2)	0.0327(8)	0.0210(8)	0.0184(7)	0.0002(6)	0.0113(6)	–0.0021(6)
C(13)	4*e*		1.2400(4)	0.38565(5)	0.4155(2)	0.050(1)	0.0243(9)	0.0291(9)	–0.0102(8)	0.0215(8)	–0.0019(7)
C(14)	4*e*		1.1871(4)	0.36361(5)	0.3037(2)	0.0375(9)	0.0245(8)	0.0219(8)	0.0034(7)	0.0176(7)	0.0036(6)
C(15)	4*e*		0.9984(3)	0.32990(5)	0.2807(2)	0.0266(7)	0.0285(8)	0.0182(7)	0.0045(6)	0.0108(6)	–0.0033(6)
C(16)	4*e*		0.8659(3)	0.31742(6)	0.3690(2)	0.0256(8)	0.0331(9)	0.0236(8)	–0.0043(6)	0.0131(6)	–0.0087(7)
C(71A)	4*e*	0.489(3)	0.7141(9)	0.4404(2)	1.0250(4)	0.023(2)	0.019(1)	0.016(2)	–0.003(1)	0.008(1)	–0.002(1)
O(5A)	4*e*	0.489(3)	0.615(2)	0.3999(4)	1.042(1)	0.026(3)	0.018(1)	0.017(2)	–0.005(2)	0.011(2)	–0.005(1)
C(71B)	4*e*	0.511(3)	0.8148(9)	0.4340(1)	1.0551(4)	0.023(2)	0.019(1)	0.016(2)	–0.003(1)	0.008(1)	–0.002(1)
O(5B)	4*e*	0.511(3)	0.546(2)	0.4029(3)	1.0257(9)	0.026(3)	0.018(1)	0.017(2)	–0.005(2)	0.011(2)	–0.005(1)
C(72)	4*e*		0.7521(4)	0.46425(5)	1.1492(2)	0.0387(9)	0.0212(8)	0.0264(8)	–0.0081(7)	0.0203(7)	–0.0076(6)
C(75)	4*e*		0.7467(4)	0.51699(5)	1.3460(2)	0.049(1)	0.0263(9)	0.0264(9)	–0.0087(8)	0.0196(8)	–0.0116(7)
O(1)	4*e*		0.7952(2)	0.35505(3)	0.6653(1)	0.0250(5)	0.0232(5)	0.0168(5)	–0.0033(4)	0.0122(4)	–0.0060(4)
O(2)	4*e*		0.3571(2)	0.24461(3)	0.6659(1)	0.0323(6)	0.0182(5)	0.0205(5)	–0.0028(4)	0.0124(5)	–0.0029(4)
O(3)	4*e*		0.2210(2)	0.27093(3)	0.8628(1)	0.0310(6)	0.0202(5)	0.0190(5)	–0.0046(4)	0.0122(5)	–0.0039(4)
O(4)	4*e*		0.2972(2)	0.33142(3)	1.0450(1)	0.0344(6)	0.0189(5)	0.0177(5)	0.0005(4)	0.0160(5)	0.0006(4)
C(73A)	4*e*	0.489(3)	0.9835(7)	0.4947(1)	1.2011(3)	0.023(2)	0.022(2)	0.020(2)	–0.002(1)	0.010(1)	–0.001(1)
C(74A)	4*e*	0.489(3)	0.9518(8)	0.5227(1)	1.2916(3)	0.029(2)	0.021(2)	0.026(2)	–0.007(1)	0.008(2)	–0.005(1)
C(76A)	4*e*	0.489(3)	0.5179(7)	0.4865(1)	1.2987(3)	0.023(2)	0.022(2)	0.021(2)	–0.000(1)	0.011(1)	–0.001(1)
C(77A)	4*e*	0.489(3)	0.5483(8)	0.4586(1)	1.2071(3)	0.022(2)	0.018(2)	0.019(2)	–0.001(1)	0.007(1)	–0.001(1)
C(73B)	4*e*	0.511(3)	0.7573(6)	0.5095(1)	1.1359(3)	0.022(1)	0.024(2)	0.020(2)	–0.001(1)	0.008(1)	0.001(1)
C(74B)	4*e*	0.511(3)	0.7820(7)	0.5343(1)	1.2415(3)	0.025(2)	0.016(1)	0.029(2)	–0.001(1)	0.009(1)	–0.005(1)
C(76B)	4*e*	0.511(3)	0.7390(7)	0.4722(1)	1.3566(3)	0.028(2)	0.025(2)	0.018(2)	–0.002(1)	0.009(1)	–0.001(1)
C(77B)	4*e*	0.511(3)	0.7146(7)	0.44760(9)	1.2515(3)	0.022(2)	0.016(1)	0.025(2)	–0.001(1)	0.009(1)	–0.004(1)

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