progress in our laboratory to determine the utility of this X-ray crystallographic approach to the design of potent and specific PAF antagonists and an improved drug–receptor site binding model.

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Psilotropin

By Merle T. Emerson* and M. Reza Asdjodi

Department of Chemistry, University of Alabama in Huntsville, Huntsville, Alabama 35899, *USA*

and Lal A. Ratnapala, V. Subramanian and Karl Seff*

Chemistry Department, University of Hawaii, Honolulu, Hawaii 96822, *USA*

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Abstract. [3a*R*-(3aα,4aβ,8aα,9α,10aα)]-Octahydro-4a,9-dimethyl-3-methylenefuro[2′,3′:5,6]cyclohepta[1,2-*c*]pyran-2,7(3*H*,4*H*)-dione, $C_{15}H_{20}O_4$, $M_r = 264{\cdot}31$, monoclinic, $P2_1$, $a = 10{\cdot}001\ (3)$, $b = 10{\cdot}327\ (2)$, $c = 13{\cdot}388\ (4)$ Å, $\beta = 93{\cdot}12\ (2)^\circ$, $V = 1380{\cdot}6\ (6)$ Å^3, $Z = 4$, $D_x = 1{\cdot}272$, $D_m = 1{\cdot}29\ (2)$ g cm^{-3}, Cu $K\alpha$, $\lambda = 1{\cdot}5418$ Å, $\mu = 7{\cdot}08$ cm^{-1}, $F(000) = 586$, $T = 298$ K, $R = 0{\cdot}0444$ for 1720 unique observed data. The six-membered ring is in the half-chair form, the central seven-membered ring is in the boat form, and the five-membered ring is planar. The angle between the plane of the five-

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* To whom correspondence should be addressed.

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membered ring and that of the five planar atoms of the six-membered ring is small, 10·6 and 14·9° in the two non-equivalent molecules per unit cell.

Introduction. Psilotropin, a sesquiterpene dilactone obtained from *Psilostrophe cooperi* (Grey), was isolated and chemically characterized by de Silva & Geissman (1970). Independently, Herz, Aota, Holub & Samek (1970) reported the isolation of floribundin from both *Hymenoxys richardsonii* and *H. anthemoides*. Floribundin and psilotropin were shortly thereafter shown to be the same compound by Mabry (see Herz, Aota, Holub & Samek, 1970, footnote 22a). The structure and stereochemistry of psilotropin has been related to a large number of similar sesquiterpenes by chemical methods, CD and ORD studies (Stöcklin, Waddell & Geissman, 1970). This work was undertaken to provide a soundly documented structure on which the stereochemistry of a large number of closely related compounds could be based.

Experimental. Clear, colorless crystals were from W. Herz. Density was measured by flotation. Preliminary unit-cell study was made with precession camera. Syntex $P\bar{1}$ automated diffractometer with graphite-monochromated Cu $K\alpha$ radiation was used to collect final data set on parallelepiped crystal approximately 0·9 × 0·4 × 0·3 mm. Cell constants were obtained from 15 diffractometer reflections, range $20{\cdot}3 < 2\theta < 44{\cdot}9°$. 1850 measured reflections ($2\theta_{\max} = 110°$, $0 \le h \le 10$, $0 \le k \le 10$, $-13 \le l \le 13$); 1720 unique with $I > 3\sigma(I)$ were used in the structure refinement. Two reference reflections ($03\bar{1}$, 123) measured after every 97 reflections showed an increase in intensity of 0·5%, appropriate correction was made. Lorentz–polarization correction was applied, absorption corrections were made with transmission coefficients from 0·696 to 0·811.

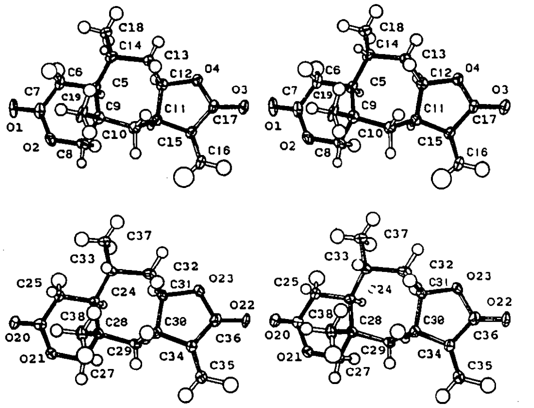

Fig. 1. The two non-equivalent molecules in the crystal structure of psilotropin have been purposely drawn to facilitate comparison; they are not oriented like this in the crystal. Ellipsoids of 15% probability are used.

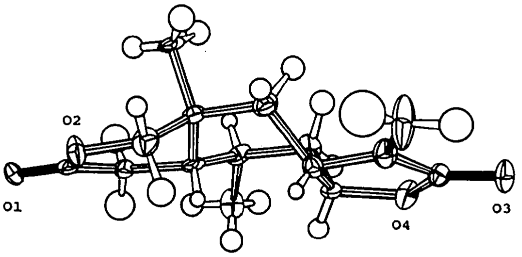

Fig. 2. Side view of molecule 1.

Table 1. *Positional and thermal parameters* (Å^2)

The estimated standard deviation is given in parentheses in the units of the least significant figure given for the corresponding parameter. The equivalent isotropic temperature factors for the C and O atoms were calculated from the corresponding anisotropic thermal and unit-cell parameters by $B_{eq} = (4/3)[\beta_{11}a^2 + \beta_{22}b^2 + \beta_{33}c^2 + \beta_{13}ac(\cos\beta)]$. The y coordinate of O(1) was fixed.

	x	y	z	B_{eq}
O(1)	0·5293 (4)	0·632	0·2741 (3)	6·31 (9)
O(2)	0·7220 (4)	0·6276 (6)	0·20487 (23)	5·84 (8)
O(3)	0·9271 (3)	0·7940 (6)	−0·36466 (24)	5·87 (8)
O(4)	0·7454 (3)	0·7878 (5)	−0·27959 (21)	4·76 (7)
C(5)	0·6158 (4)	0·7525 (6)	0·0236 (3)	3·49 (8)
C(6)	0·5304 (5)	0·7319 (6)	0·1145 (3)	4·49 (10)
C(7)	0·5926 (6)	0·6591 (7)	0·2024 (4)	4·96 (12)
C(8)	0·8034 (5)	0·6578 (7)	0·1205 (4)	5·31 (12)
C(9)	0·7601 (4)	0·7770 (6)	0·0622 (3)	3·91 (9)
C(10)	0·8609 (4)	0·7945 (7)	−0·0211 (3)	4·21 (10)
C(11)	0·8312 (4)	0·7208 (6)	−0·1178 (3)	3·69 (9)
C(12)	0·7039 (4)	0·7612 (6)	−0·1782 (3)	3·71 (8)
C(13)	0·6326 (5)	0·8778 (7)	−0·1413 (3)	4·34 (10)
C(14)	0·5504 (5)	0·8504 (6)	−0·0488 (4)	4·27 (10)
C(15)	0·9379 (5)	0·7382 (7)	−0·1903 (3)	4·46 (10)
C(16)	1·0692 (6)	0·7293 (12)	−0·1741 (4)	9·63 (22)
C(17)	0·8767 (5)	0·7752 (6)	−0·2866 (3)	4·07 (10)
C(18)	0·4090 (5)	0·8100 (8)	−0·0822 (4)	5·81 (12)
C(19)	0·7740 (5)	0·8990 (7)	0·1295 (4)	5·20 (11)
O(20)	0·1719 (4)	0·8952 (6)	0·1124 (3)	6·12 (9)
O(21)	0·1579 (3)	0·7124 (5)	0·19188 (22)	4·64 (7)
O(22)	0·4736 (4)	0·5117 (5)	0·74173 (25)	5·56 (8)
O(23)	0·4192 (3)	0·6938 (5)	0·66057 (23)	5·05 (8)
C(24)	0·2238 (4)	0·8309 (6)	0·3850 (3)	3·31 (8)
C(25)	0·1931 (5)	0·9115 (7)	0·2904 (4)	4·39 (11)
C(26)	0·1749 (5)	0·8417 (7)	0·1926 (4)	4·54 (12)
C(27)	0·1751 (5)	0·6362 (7)	0·2834 (3)	4·11 (10)
C(28)	0·1408 (4)	0·7053 (6)	0·3781 (3)	3·52 (9)
C(29)	0·1758 (5)	0·6089 (6)	0·4639 (3)	3·92 (9)
C(30)	0·3233 (4)	0·6114 (6)	0·5035 (3)	3·57 (9)
C(31)	0·3655 (5)	0·7370 (6)	0·5608 (3)	3·89 (9)
C(32)	0·2557 (5)	0·8331 (7)	0·5769 (4)	4·57 (10)
C(33)	0·2139 (5)	0·9100 (7)	0·4809 (4)	3·95 (9)
C(34)	0·3561 (5)	0·5060 (6)	0·5784 (3)	3·79 (10)
C(35)	0·3332 (6)	0·3804 (7)	0·5695 (4)	5·13 (12)
C(36)	0·4231 (5)	0·5619 (7)	0·6677 (4)	4·34 (11)
C(37)	0·2951 (6)	1·0360 (6)	0·4795 (4)	5·25 (12)
C(38)	−0·0109 (4)	0·7304 (7)	0·3776 (3)	4·51 (10)

Attempts to solve the structure with an early version of *MULTAN* failed to give a recognizable structure. *MULTAN*80 (Main, Hull, Lessinger, Germain, Declercq & Woolfson, 1980) also failed to produce the expected structure but gave enough information to permit its determination. *MULTAN*80 results: 36 connected peaks containing three recognizable fragments of 29 atoms. Four of the seven remaining peaks joined the three fragments. 29-atom fragment was used to calculate phases to generate F_o function (Hubbard, Quicksall

Table 2. *Bond distances* (Å) *and angles* (°) *with e.s.d.'s in parentheses*

Molecule 1		Molecule 2	
O(1)—C(7)	1·211 (5)	O(20)—C(26)	1·206 (7)
O(2)—C(7)	1·334 (7)	O(21)—C(26)	1·349 (9)
O(2)—C(8)	1·461 (6)	O(21)—C(27)	1·459 (6)
O(3)—C(17)	1·200 (6)	O(22)—C(36)	1·205 (6)
O(4)—C(12)	1·467 (5)	O(23)—C(31)	1·481 (6)
O(4)—C(17)	1·328 (6)	O(23)—C(36)	1·368 (9)
C(5)—C(6)	1·539 (6)	C(24)—C(25)	1·533 (7)
C(5)—C(9)	1·528 (6)	C(24)—C(28)	1·542 (8)
C(5)—C(14)	1·523 (7)	C(24)—C(33)	1·530 (7)
C(6)—C(7)	1·503 (7)	C(25)—C(26)	1·498 (8)
C(8)—C(9)	1·510 (8)	C(27)—C(28)	1·511 (6)
C(9)—C(10)	1·554 (6)	C(28)—C(29)	1·547 (7)
C(9)—C(19)	1·553 (8)	C(28)—C(38)	1·540 (6)
C(10)—C(11)	1·517 (6)	C(29)—C(30)	1·541 (6)
C(11)—C(12)	1·530 (6)	C(30)—C(31)	1·555 (8)
C(11)—C(15)	1·492 (6)	C(30)—C(34)	1·505 (7)
C(12)—C(13)	1·499 (8)	C(31)—C(32)	1·506 (8)
C(13)—C(14)	1·550 (7)	C(32)—C(33)	1·550 (7)
C(14)—C(18)	1·519 (7)	C(33)—C(37)	1·536 (9)
C(15)—C(16)	1·323 (7)	C(34)—C(35)	1·324 (10)
C(15)—C(17)	1·450 (6)	C(34)—C(36)	1·459 (7)
C(7)—O(2)—C(8)	120·6 (4)	C(26)—O(21)—C(27)	121·4 (4)
C(12)—O(4)—C(17)	112·2 (3)	C(31)—O(23)—C(36)	111·8 (4)
C(6)—C(5)—C(9)	108·1 (3)	C(25)—C(24)—C(28)	109·0 (4)
C(6)—C(5)—C(14)	110·9 (4)	C(25)—C(24)—C(33)	112·5 (5)
C(9)—C(5)—C(14)	118·0 (4)	C(28)—C(24)—C(33)	116·2 (4)
C(5)—C(6)—C(7)	117·7 (4)	C(24)—C(25)—C(26)	118·0 (5)
O(1)—C(7)—O(2)	118·2 (4)	O(20)—C(26)—O(21)	116·8 (5)
O(1)—C(7)—C(6)	121·6 (5)	O(20)—C(26)—C(25)	123·6 (6)
O(2)—C(7)—C(6)	120·1 (4)	O(21)—C(26)—C(25)	119·5 (5)
O(2)—C(8)—C(9)	114·7 (4)	O(21)—C(27)—C(28)	115·3 (5)
C(5)—C(9)—C(8)	106·2 (4)	C(24)—C(28)—C(27)	107·6 (4)
C(5)—C(9)—C(10)	114·5 (3)	C(24)—C(28)—C(29)	113·5 (4)
C(5)—C(9)—C(19)	112·5 (4)	C(24)—C(28)—C(38)	112·7 (5)
C(8)—C(9)—C(10)	106·7 (4)	C(27)—C(28)—C(29)	105·4 (4)
C(8)—C(9)—C(19)	110·4 (4)	C(27)—C(28)—C(38)	110·2 (4)
C(10)—C(9)—C(19)	106·3 (4)	C(29)—C(28)—C(38)	107·2 (4)
C(9)—C(10)—C(11)	116·7 (4)	C(28)—C(29)—C(30)	114·7 (4)
C(10)—C(11)—C(12)	115·6 (4)	C(29)—C(30)—C(31)	114·4 (4)
C(10)—C(11)—C(15)	112·4 (4)	C(29)—C(30)—C(34)	112·7 (4)
C(12)—C(11)—C(15)	103·1 (4)	C(31)—C(30)—C(34)	103·4 (4)
O(4)—C(12)—C(11)	105·7 (3)	O(23)—C(31)—C(30)	105·6 (4)
O(4)—C(12)—C(13)	108·5 (4)	O(23)—C(31)—C(32)	107·5 (4)
C(11)—C(12)—C(13)	116·3 (4)	C(30)—C(31)—C(32)	116·2 (4)
C(12)—C(13)—C(14)	113·5 (5)	C(31)—C(32)—C(33)	112·7 (4)
C(5)—C(14)—C(13)	113·7 (4)	C(24)—C(33)—C(32)	113·3 (5)
C(5)—C(14)—C(18)	111·4 (5)	C(24)—C(33)—C(37)	112·6 (4)
C(13)—C(14)—C(18)	109·9 (4)	C(32)—C(33)—C(37)	109·0 (4)
C(11)—C(15)—C(16)	128·6 (4)	C(30)—C(34)—C(35)	128·4 (5)
C(11)—C(15)—C(17)	109·2 (4)	C(30)—C(34)—C(36)	109·5 (5)
C(16)—C(15)—C(17)	122·1 (4)	C(35)—C(34)—C(36)	122·2 (5)
O(3)—C(17)—O(4)	120·6 (4)	O(22)—C(36)—O(23)	119·8 (5)
O(3)—C(17)—C(15)	129·8 (5)	O(22)—C(36)—C(34)	131·1 (7)
O(4)—C(17)—C(15)	109·5 (4)	O(23)—C(36)—C(34)	109·1 (4)

& Jacobson, 1971). Three more atoms fitting the expected structure were selected from largest unassigned Fourier peaks. Four cycles reduced the R value from 0·42 for the 29-atom structure to 0·22 for 38 atoms. Least-squares refinement with isotropic temperature factors (Gantzel, Sparks & Trueblood, 1976) reduced the R value to 0·11 for 30 carbons and eight oxygens.

A Fourier difference function with phases calculated using the 38 non-hydrogen positions revealed all hydrogens. Full-matrix least-squares refinement with anisotropic thermal parameters for all non-hydrogen atoms and isotropic ones for all hydrogen atoms converged with $R = 0{\cdot}0444$, $wR = 0{\cdot}0495$ and $S = 3{\cdot}14$, max. $\Delta/\sigma = 0{\cdot}38$; minimization of the function $\sum w(F_o - |F_c|)^2$, $w = \sigma^{-2}(F)$, $p = 0{\cdot}02$ in $\sigma(I) = [\omega^2(\mathrm{CT} + B_1 + B_2) + (pI)^2]^{1/2}$ (Peterson & Levy, 1957) where ω is the scan rate, CT is the total integrated count, B_1 and B_2 are the background counts, and the intensity $I = \omega(\mathrm{CT} - B_1 - B_2)$. No significant features in the final ΔF synthesis with max. $\Delta\rho = 0{\cdot}22$ e Å^{-3}. Atomic scattering factors (O, $\mathrm{C_{val}}$ and $\mathrm{H_{bonded}}$) and anomalous-dispersion corrections were from *International Tables for X-ray Crystallography* (1974). The absolute configuration herein reported is that which Herz, Aota, Holub & Samek (1970) determined by chemical methods; the R values calculated for the two enantiomers did not differ sufficiently for this work to determine the absolute configuration.

Discussion. Fig. 1 shows an *ORTEP* stereodrawing (Johnson, 1965) of the two independent molecules of the title compound. The differences in their structures and thermal ellipsoids are small. The conformations of the rings are more easily seen in Fig. 2. The six-membered ring is in a half-chair form [the C(9) atom is 0·68 Å out of the least-squares plane of the other five atoms in the ring], the seven-membered ring is in the boat form, and the five-membered ring is planar.

The atomic and thermal parameters with e.s.d.'s are presented in Table 1. The bond distances and angles not involving hydrogen are given in Table 2.* The mean bond distances are normal: ester C=O, 1·206 (4); ester C—O, 1·345 (15); C—O, 1·487 (14); C=C, 1·324 (9); C—C, 1·532 (16) Å.

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* Tables of bond lengths and angles involving hydrogen atoms, least-squares-planes data, anisotropic thermal parameters, hydrogen-atom parameters, and structure factors have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 52470 (17 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.