Acta Cryst. (1991). C47, 234–236

The Structure of (±)-21-Oxoisopteropodine

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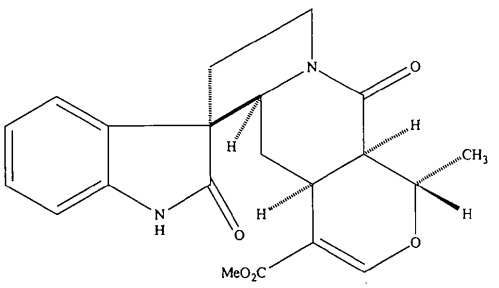
(*Received* 13 *February* 1990; *accepted* 5 *June* 1990)

Abstract. Methyl (1′*S**,3*S**,4a′*S**,5a′*S**,10a′*R**)-3′,4a′,5a′,6′,7′,8′,10′,10a′-octahydro-2-hydroxy-1′-methyl-10′-oxospiro[3*H*-indole-3,6′-[1′*H*]pyrano[3,4-*f*]indolizine-4′-carboxylate, (1), $C_{21}H_{22}N_2O_5$, M_r = 382·42, monoclinic, $P2_1/c$, a = 12·920 (4), b = 10·342 (4), c = 15·192 (8) Å, β = 105·68 (3)°, V = 1954·4 (14) Å^3, Z = 4, D_x = 1·30 g cm^{-3} (298 K), μ = 0·8738 cm^{-1}, Mo $K\alpha$ radiation, λ = 0·7107 Å, $F(000)$ = 808, T = 298 K, R = 0·0800 for 1000 reflections, $F_o \geq 4\sigma(F_o)$. The indole NH group is hydrogen bonded to the amide oxygen, O15′ (related by x, 0·5 − y, −0·5 + z), of the indolizine moiety with relevant parameters: N···O 2·79 (2) Å, H···O 2·02 (15) Å, N—H···O 145 (14)°. A close, non-bonded contact of 2·28 (8) Å is also observed between O15′ and H7′*A* (related by −x, 0·5 + y, 1·5 − z).

Experimental. (1) was synthesized by an oxidative rearrangement of 21-oxotetrahydroalstonine. Treatment of 21-oxotetrahydroalstonine with *tert*-butylhypochlorite and triethylamine was followed by



(1)

stirring at ambient temperature in acidic methanol in the presence of $AgClO_4$. Full details of the synthetic procedure will appear elsewhere (Martin, Benage, Hunter, Geraci & Mortimore, 1990). Crystals were obtained by slow evaporation from a methylene chloride/pentane solution. The data crystal was a very thin, clear, colorless plate of approximate dimensions 0·04 × 0·36 × 0·50 mm. The data were collected at room temperature on a Nicolet *P*3 diffractometer using a graphite monochromator. Lattice parameters were obtained from the least-squares refinement of 23 reflections with 14·3 < 2θ < 19·7°. The data were collected using the ω-scan technique with a 2θ range from 4·0–50·0°, with a 1° ω scan at 3–6° min^{-1} (h = 0→15, k = 0→12, l = −18→18). A total of 3825 reflections were collected of which 3144 were unique (R_{int} = 0·0215). Four reflections, $3\bar{1}1$, $0\bar{2}2$, 210, 020, were remeasured every 96 reflections to monitor instrument and crystal stability. A smoothed curve of the intensities of these check reflections was used to scale the data. The scaling factor ranged from 0·9899–1·027. The data were also corrected for Lp effects but not absorption. The data reduction and decay correction were applied using the Nicolet XRD *SHELXTL-Plus* software package (Sheldrick, 1987). Reflections having $F_o < 4\sigma(F_o)$ were considered unobserved (2144 reflections). The structure was solved by direct methods (Sheldrick, 1987) and refined by full-matrix least squares (Sheldrick, 1976). In all, 323 parameters were refined. The non-H atoms were refined with anisotropic thermal parameters. Methyl H-atom positions were idealized while the remaining H-atom positions were obtained from a ΔF map and refined. Isotropic temperature factors were refined for all H atoms. The function $\sum w(|F_o| - |F_c|)^2$ was minimized, where $w = 1/[\sigma(F_o)]^2$ and $\sigma(F_o) = (0{\cdot}5kI^{-1/2}\{[\sigma(I)]^2 + (0{\cdot}02I)^2\}^{1/2})$. The intensity, I, is given by $(I_{peak} - I_{background}) \times$ (scan rate); where 0·02 is a factor to downweight intense reflections and to account for instrument instability and k is the correction due to Lp effects and decay. $\sigma(I)$ was estimated from counting statistics; $\sigma(I) = [(I_{peak} + I_{background}) \times (\text{scan rate})^{1/2}]$. The final was R = 0·0800 for 1000 reflections, with wR = 0·0629 (R_{all} = 0·244, wR_{all} = 0·0908) and a goodness of fit = 1·557. The maximum $|\Delta/\sigma|$ = 0·1 in the final refinement cycle and the minimum and maximum peaks in the final ΔF map were −0·29 and 0·29 e Å^{-3}, respectively. The very high value for R_{all} is due to the very large number of unobserved reflections even though a fairly conservative cutoff of $4\sigma(F_o)$ was used. The large number of unobserved reflections are due to the thinness of the data crystal and the resulting poor scattering ability. The scattering factors for the

0108-2701/91/010234-03$03.00

Table 1. *Fractional coordinates and equivalent isotropic thermal parameters* ($Å^2$) *for the non-hydrogen atoms of* (1)

$$U_{eq} = (1/3)\sum_i \sum_j U_{ij} a_i^* a_j^* \mathbf{a}_i . \mathbf{a}_j .$$

	x	y	z	U
N1	0·0946 (10)	0·1202 (11)	0·4727 (9)	0·061 (5)
C2	0·0426 (11)	0·2337 (13)	0·4772 (9)	0·052 (7)
C3	0·0644 (9)	0·2681 (11)	0·5792 (7)	0·041 (5)
C3a	0·1343 (9)	0·1593 (11)	0·6239 (9)	0·044 (6)
C4	0·1813 (10)	0·1331 (13)	0·7162 (10)	0·053 (6)
C5	0·2434 (11)	0·024 (2)	0·7396 (11)	0·069 (8)
C6	0·2602 (12)	−0·057 (2)	0·6760 (14)	0·075 (9)
C7	0·2096 (12)	−0·0343 (15)	0·5823 (12)	0·071 (8)
C7a	0·1502 (10)	0·0755 (13)	0·5588 (10)	0·050 (6)
O8	−0·0087 (7)	0·2966 (8)	0·4133 (5)	0·072 (4)
C1′	0·3638 (14)	0·4868 (15)	0·8006 (9)	0·080 (7)
O2′	0·4579 (7)	0·5610 (10)	0·7938 (8)	0·096 (5)
C3′	0·458 (2)	0·597 (2)	0·7087 (13)	0·097 (10)
C4′	0·3763 (12)	0·5945 (12)	0·6354 (11)	0·066 (7)
C4a′	0·2642 (9)	0·5554 (12)	0·6426 (8)	0·046 (6)
C5′	0·2291 (10)	0·4241 (13)	0·5981 (9)	0·048 (6)
C7′	−0·0386 (11)	0·2857 (14)	0·6102 (11)	0·059 (7)
C5a′	0·1136 (9)	0·4039 (12)	0·5996 (8)	0·042 (6)
C8′	−0·0044 (12)	0·3710 (15)	0·6934 (11)	0·062 (7)
N9′	0·0969 (8)	0·4313 (9)	0·6888 (7)	0·043 (4)
C10′	0·1584 (11)	0·5001 (11)	0·7565 (9)	0·053 (6)
C10a′	0·2622 (11)	0·5543 (12)	0·7418 (9)	0·052 (6)
C11′	0·3877 (12)	0·6335 (14)	0·5465 (11)	0·070 (9)
O12′	0·3163 (8)	0·6452 (11)	0·4795 (7)	0·106 (6)
O13′	0·4913 (8)	0·6574 (8)	0·5490 (6)	0·092 (5)
C14′	0·5083 (13)	0·685 (2)	0·4589 (10)	0·118 (10)
O15′	0·1343 (6)	0·5191 (7)	0·8280 (5)	0·067 (4)
C16′	0·3679 (15)	0·470 (2)	0·8996 (9)	0·115 (10)

non-H atoms were taken from Cromer & Mann (1968), with the anomalous-dispersion corrections taken from Cromer & Liberman (1970). The scattering factors for the H atoms were obtained from Stewart, Davidson & Simpson (1965). Values used to calculate the linear absorption coefficient are from *International Tables for X-ray Crystallography* (1974, Vol. IV, p. 55). Figures were generated using *SHELXTL-Plus* (Sheldrick, 1987). The positional and thermal parameters for non-H atoms are listed in Table 1,* while the bond lengths and angles for the non-H atoms are listed in Table 2. The atom-labelling scaheme is shown in Fig. 1. Other computer programs used in this work are listed in Gadol & Davis (1982).

Related literature. The structure of (1) was determined during the course of developing a generalized approach to the syntheses of alkaloids of the indole family (Martin, Benage & Hunter, 1988). The ultimate goal of these efforts is the total syntheses of selected alkaloids of the *Strychnos* group.

* Lists of structure factors, anisotropic thermal parameters, torsion angles, and H-atom parameters on a unit-cell packing diagram have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 53215 (29 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

Table 2. *Bond lengths* (Å) *and angles* (°) *for the non-*H *atoms of* (1)

C2	N1	1·36 (2)	C3′	O2′	1·35 (2)
C7a	N1	1·39 (2)	C4′	C3′	1·31 (2)
C3	C2	1·54 (2)	C4a′	C4′	1·54 (2)
O8	C2	1·207 (15)	C11′	C4′	1·45 (2)
C3a	C3	1·49 (12)	C5′	C4a′	1·53 (2)
C7′	C3	1·54 (2)	C10a′	C4a′	1·51 (2)
C5a′	C3	1·54 (2)	C5a′	C5′	1·51 (2)
C4	C3a	1·40 (2)	C8′	C7′	1·51 (2)
C7a	C3a	1·37 (2)	N9′	C5a′	1·46 (2)
C5	C4	1·38 (2)	N9′	C8′	1·47 (2)
C6	C5	1·34 (3)	C10′	N9′	1·324 (15)
C7	C6	1·42 (3)	C10a′	C10′	1·52 (2)
C7a	C7	1·36 (2)	O15′	C10′	1·22 (2)
O2′	C1′	1·47 (2)	O12′	C11′	1·18 (2)
C10a′	C1′	1·54 (2)	O13′	C11′	1·35 (2)
C16′	C1′	1·50 (2)	C14′	O13′	1·47 (2)

C2	N1	C7a	112·0 (12)	C4a′	C4′	C11′	118·2 (12)
C3	C2	O8	126·6 (12)	C4a′	C4′	C3′	120 (2)
C3	C2	N1	106·9 (10)	C11′	C4′	C3′	122 (2)
O8	C2	N1	126·4 (13)	C5′	C4a′	C10a′	110·5 (11)
C3a	C3	C7′	114·8 (11)	C5′	C4a′	C4′	112·0 (11)
C3a	C3	C5a′	115·6 (9)	C10a′	C4a′	C4′	110·1 (10)
C3a	C3	C2	102·0 (10)	C5a′	C5′	C4a′	107·0 (11)
C7′	C3	C5a′	100·1 (10)	C8′	C7′	C3	104·1 (11)
C7′	C3	C2	113·4 (10)	N9′	C5a′	C3	101·9 (10)
C5a′	C3	C2	111·5 (10)	N9′	C5a′	C5′	112·4 (9)
C4	C3a	C7a	119·6 (11)	C3	C5a′	C5′	118·6 (10)
C4	C3a	C3	130·6 (12)	N9′	C8′	C7′	105·8 (13)
C7a	C3a	C3	109·9 (10)	C10′	N9′	C5a′	128·2 (11)
C5	C4	C3a	118·9 (13)	C10′	N9′	C8′	123·2 (12)
C6	C5	C4	121·5 (14)	C5a′	N9′	C8′	108·6 (10)
C7	C6	C5	120·2 (15)	C10a′	C10′	O15′	121·1 (10)
C7a	C7	C6	118 (2)	C10a′	C10′	N9′	116·8 (13)
N1	C7a	C3a	109·2 (11)	O15′	C10′	N9′	122·1 (13)
N1	C7a	C7	129·4 (14)	C1′	C10a′	C4a′	109·8 (12)
C3a	C7a	C7	121·4 (14)	C1′	C10a′	C10′	113·2 (11)
O2′	C1′	C10a′	108·3 (11)	C4a′	C10a′	C10′	113·7 (10)
C10a′	C1′	C16′	115·3 (15)	O12′	C11′	O13′	123 (2)
C16′	C1′	O2′	109·0 (12)	O12′	C11′	C4′	125 (2)
C3′	O2′	C1′	115·3 (12)	O13′	C11′	C4′	111·9 (12)
C4′	C3′	O2′	127 (2)	C14′	O13′	C11′	113·9 (11)

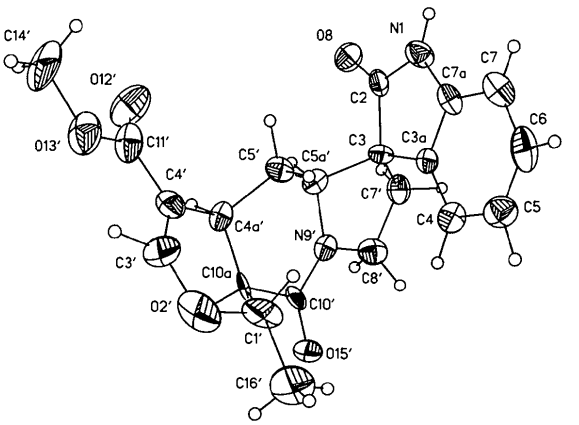


Fig. 1. View of (1) showing the atom-labelling scheme. The non-H atoms are scaled to the 30% probability level while the H atoms are drawn to an arbitrary size.

Funding for this project was provided by the Robert A. Welch Foundation and the National Institutes of Health (GM 25439).

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