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Structure of a Protected C(1)–C(10) Subunit* of Erythronolides A and B

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Abstract. $C_{19}H_{34}O_4$, $M_r = 326{\cdot}48$, orthorhombic, $P2_12_12_1$, $a = 7{\cdot}949\,(2)$, $b = 14{\cdot}880\,(5)$, $c = 17{\cdot}047\,(5)$ Å, $V = 2016\,(1)$ Å^3, $Z = 4$, $D_x = 1{\cdot}08$ g cm^{-3}, $\mu = 0{\cdot}6861$ cm^{-1}, $\lambda(\text{Mo } K\alpha) = 0{\cdot}71069$ Å, $F(000) = 720$, $T = 163$ K, $R = 0{\cdot}0644$ for 1476 reflections $[F_o \geq 4\sigma(F_o)]$. There is an intermolecular H bond involving the hydroxyl group and the carbonyl O (related by $\frac{1}{2}+x, \frac{3}{2}-y, 1-z$) with an O···O distance of 2·838 (5) Å, an H···O distance of 2·06 (5) Å and an O—H···O angle of 172 (6)°. There are no such intramolecular contacts.

Experimental. The title compound (1) corresponds to the C(1)–C(10) portion of the erythromycins and was synthesized by Lewis acid-mediated crotylstannane addition to an aldehyde (Keck & Abbott, 1984). The optical purity was established by an asymmetric aldol condensation (Evans, Bartroli & Shih, 1981) using a (1*S*,2*R*)-(+)-norephedrine hydrochloride-derived reagent. Full synthetic details will be described elsewhere (Martin & Pacofsky, 1989). Crystals of (1) were obtained by slow evaporation from ether. The data crystal was a colorless rod that was cut from a larger crystal, and had dimensions 0·17 × 0·18 × 0·43 mm. The data were collected on a Syntex $P2_1$ diffractometer, using a graphite monochromator, and equipped with a Syntex LT-1 low-temperature delivery system (163 K). Lattice parameters were obtained from the least-squares refinement of 30 reflections with $17{\cdot}0 < 2\theta < 22{\cdot}9°$. The data were collected using the ω scan technique (4403 reflections, of which 2326 were unique, $R_{\text{int}} = 0{\cdot}0342$ from averaging *hkl* and $h,-k,-l$ reflections), with a 2θ range from 4·0–52·5°, with a 1°ω scan at 6–12° min^{-1} ($h = 0 \rightarrow 9$, $k = -18 \rightarrow 18$, $l = -21 \rightarrow 21$). Four reflections ($1\bar{2}2$, 023, $00\bar{4}$, $0\bar{4}0$) were remeasured every 196 reflections to monitor instrument and crystal stability [maximum correction on I was < 1% (Henslee & Davis, 1975)]. The data were also corrected for Lp effects and absorption (based on crystal shape; transmission factor range 0·9821–0·9900). The data reduction procedures are described by Riley & Davis (1976). Reflections having $F_o < 4\sigma(F_o)$ were considered unobserved (850 reflections). The structure was solved by direct methods (Sheldrick, 1985) and refined by full-matrix least squares (Sheldrick, 1976). In all, 332 parameters were refined. The non-H atoms were refined with anisotropic thermal parameters. The ethylenic end of the molecule exhibited very large vibrational motion. As a result, the ethylenic H's were calculated in idealized positions (C—H bond 1·0 Å) and the ethylenic group was refined as a rigid group with the thermal parameters for the H atoms fixed at $1{\cdot}2 \times U_{\text{eq}}$ of the relevant C atom calculated from the previous refinement. All the other H-atom positions were obtained from a ΔF map and refined with isotropic thermal parameters. 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 $(I_{\text{peak}} - I_{\text{background}}) \times$ (scan rate); the 0·02 is a factor to downweight intense reflections and to account for instrument instability and k is the correction due to Lp effects, absorption and decay. $\sigma(I)$ was estimated from counting statistics; $\sigma(I) = [(I_{\text{peak}} + I_{\text{background}})^{1/2} \times \text{(scan rate)}]$. The final R was 0·0644 for 1476 reflections, with $wR = 0{\cdot}0385$ ($R_{\text{all}} = 0{\cdot}112$, $wR_{\text{all}} = 0{\cdot}0428$) and a goodness of fit = 1·601. The maximum $|\Delta/\sigma| < 0{\cdot}1$ in the final refinement cycle and the minimum and maximum peaks in the final ΔF map were −0·24 and 0·26 e Å^{-3}, respectively. Differentiation between enantiomorphs could not be made on the basis of the X-ray results ($wR = 0{\cdot}0385$ for the enantiomorph). The scattering factors for the non-H atoms were taken from Cromer & Mann (1968), with the anomalous-dispersion corrections taken from the work of 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).† Figures were generated using *SHELXTL-PLUS* (Sheldrick, 1987). The positional and thermal parameters for

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* [4*R*-(4α,5*β*)]-5-[(1*S**,2*R**,3*S**)-2-Hydroxy-1,3-dimethyl-4-pentenyl]-2,2,4-trimethyl-4-[(2*R**)-2-methyl-3-oxopentyl]-1,3-dioxolane.

† Tables of anisotropic thermal parameters, H-atom positional parameters, bond distances and angles involving the H atoms, structure-factor amplitudes and a unit-cell packing diagram have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 51612 (23 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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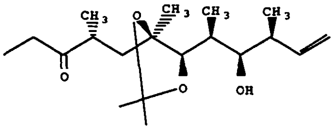
non-H atoms are listed in Table 1, while the bond lengths and angles for the non-H atoms are listed in Table 2. The atom-labelling scheme is shown in Fig. 1. Other computer programs used in this work are listed in reference 11 of Gadol & Davis (1982).



(1)

Table 1. *Fractional coordinates and equivalent isotropic thermal parameters* (Å^2) *for non*-H *atoms of* $C_{19}H_{34}O_4$

	x	*y*	*z*	*U*
C1	0·2831 (9)	0·2733 (4)	0·4176 (4)	0·155 (5)
C2	0·3171 (9)	0·3576 (4)	0·4343 (4)	0·082 (3)
C3	0·2673 (7)	0·4363 (4)	0·3844 (3)	0·042 (2)
C4	0·1500 (7)	0·5003 (3)	0·4286 (3)	0·034 (2)
C5	−0·0047 (7)	0·4556 (3)	0·4652 (3)	0·035 (2)
C6	−0·0985 (6)	0·5209 (3)	0·5178 (3)	0·032 (2)
C7	−0·0123 (6)	0·5604 (3)	0·5913 (3)	0·031 (2)
C8	0·0697 (7)	0·6515 (3)	0·5769 (3)	0·033 (2)
C9	0·0836 (7)	0·7093 (3)	0·6498 (3)	0·041 (2)
C10	−0·0849 (7)	0·7509 (3)	0·6708 (3)	0·039 (2)
C11	−0·1392 (9)	0·7465 (4)	0·7563 (3)	0·050 (2)
C12	−0·3064 (10)	0·7900 (5)	0·7739 (4)	0·062 (3)
O13	−0·1695 (5)	0·7894 (2)	0·6217 (2)	0·0490 (14)
C14	0·2072 (9)	0·7875 (5)	0·6371 (5)	0·064 (3)
O15	−0·1542 (4)	0·5744 (2)	0·6430 (2)	0·0380 (12)
C16	0·1039 (8)	0·4935 (4)	0·6304 (3)	0·043 (2)
O17	−0·2412 (4)	0·4741 (2)	0·5508 (2)	0·0442 (13)
C18	−0·1229 (8)	0·4177 (5)	0·4026 (4)	0·052 (3)
O19	0·0905 (5)	0·5694 (3)	0·3778 (2)	0·0464 (13)
C20	0·4231 (8)	0·4852 (5)	0·3555 (4)	0·050 (2)
C21	−0·4291 (9)	0·5955 (6)	0·5885 (5)	0·069 (3)
C22	−0·2978 (7)	0·5270 (4)	0·6146 (3)	0·048 (2)
C23	−0·3619 (12)	0·4638 (6)	0·6779 (4)	0·076 (3)

For anisotropic atoms, the *U* value is U_{eq}, calculated as $U_{eq} = \frac{1}{3}\sum_i\sum_j U_{ij}a_i^*a_j^*A_{ij}$ where A_{ij} is the dot product of the *i*th and *j*th direct-space unit-cell vectors.

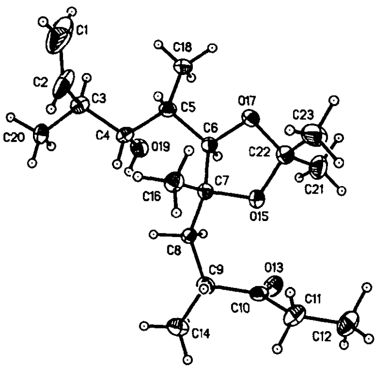


Fig. 1. View of $C_{19}H_{34}O_4$ showing the atom-labelling scheme. Thermal ellipsoids are scaled to the 30% probability level.

Table 2. *Bond lengths* (Å) *and angles* (°) *for non*-H *atoms of* $C_{19}H_{34}O_4$

1	2	3	1–2	1–2–3
C2	C1		1·315 (9)	
C3	C2	C1	1·500 (8)	124·6 (6)
C4	C3	C20	1·531 (7)	111·0 (5)
C4	C3	C2		111·6 (5)
C20	C3	C2	1·519 (8)	110·1 (5)
C5	C4	O19	1·531 (7)	107·1 (4)
C5	C4	C3		114·8 (4)
O19	C4	C3	1·426 (6)	110·6 (4)
C6	C5	C18	1·517 (7)	110·3 (5)
C6	C5	C4		110·9 (4)
C18	C5	C4	1·530 (8)	111·7 (4)
C7	C6	O17	1·544 (7)	102·5 (4)
C7	C6	C5		120·3 (4)
O17	C6	C5	1·445 (6)	107·9 (4)
C8	C7	O15	1·524 (7)	107·6 (4)
C8	C7	C16		113·3 (4)
C8	C7	C6		113·5 (4)
O15	C7	C16	1·447 (6)	107·6 (4)
O15	C7	C6		101·7 (4)
C16	C7	C6	1·513 (8)	112·2 (4)
C9	C8	C7	1·515 (7)	113·8 (4)
C10	C9	C14	1·518 (7)	106·8 (4)
C10	C9	C8		111·2 (4)
C14	C9	C8	1·538 (9)	111·1 (5)
C11	C10	O13	1·520 (8)	121·5 (5)
C11	C10	C9		117·3 (5)
O13	C10	C9	1·217 (6)	121·1 (5)
C12	C11	C10	1·508 (10)	115·0 (5)
C22	O15	C7	1·426 (6)	110·3 (3)
C22	O17	C6	1·416 (6)	106·3 (4)
C22	C21		1·526 (10)	
C23	C22	O15	1·519 (10)	109·5 (5)
C23	C22	O17		107·9 (5)
C23	C22	C21		113·0 (6)
O15	C22	O17		106·3 (4)
O15	C22	C21		108·4 (5)
O17	C22	C21		111·4 (5)

Related literature. The total synthesis of erythronolide A and B has been reported (Sviridov, Ermolenko, Yashunsky, Borodkin & Kochetkov, 1987).

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References

Cromer, D. T. & Liberman, D. (1970). *J. Chem. Phys.* **53**, 1891–1898.

Cromer, D. T. & Mann, J. B. (1968). *Acta Cryst.* A**24**, 321–324.

Evans, D. A., Bartroli, J. & Shih, T. L. (1981). *J. Am. Chem. Soc.* **103**, 2127–2129.

Gadol, S. M. & Davis, R. E. (1982). *Organometallics*, **1**, 1607–1613.

Henslee, W. H. & Davis, R. E. (1975). *Acta Cryst.* **B31**, 1551–1558.

International Tables for X-ray Crystallography (1974). Vol. IV, p. 55. Birmingham: Kynoch Press. (Present distributor Kluwer Academic Publishers, Dordrecht.)

Keck, G. E. & Abbott, D. E. (1984). *Tetrahedron Lett.* **25**, 1883–1886.

MARTIN, S. F. & PACOFSKY, G. J. (1989). In preparation.
RILEY, P. E. & DAVIS, R. E. (1976). *Acta Cryst.* B**32**, 381–386.
SHELDRICK, G. M. (1976). *SHELX*76. Program for crystal structure determination. Univ. of Cambridge, England.
SHELDRICK, G. M. (1985). *SHELXS*-86. In *Crystallographic Computing* 3, edited by G. M. SHELDRICK, C. KRUGER & R. GODDARD. Oxford Univ. Press.
SHELDRICK, G. M. (1987). *SHELXTL-PLUS*. Nicolet XRD, Madison, Wisconsin, USA.
STEWART, R. F., DAVIDSON, E. R. & SIMPSON, W. T. (1965). *J. Chem. Phys.* **42**, 3175–3187.
SVIRIDOV, A. F., ERMOLENKO, M. S., YASHUNSKY, D. V., BORODKIN, V. S. & KOCHETKOV, N. K. (1987). *Tetrahedron Lett.* **28**, 3835–3838, 3839–3842.

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Structure of 2-Methyl-3-phenyl-5*H*-1,4-benzodiazepine

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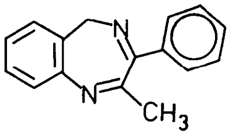
Abstract. $C_{16}H_{14}N_2$, $M_r = 234\cdot30$, monoclinic, $P2_1/c$, $a = 10\cdot046$ (2), $b = 15\cdot842$ (3), $c = 8\cdot066$ (2) Å, $\beta = 91\cdot81$ (2)°, $V = 1283\cdot05$ Å^3, $Z = 4$, $D_m = 1\cdot21$, $D_x = 1\cdot21$ g cm^{-3}, λ(Cu $K\alpha$) = 1·5418 Å, $\mu = 4\cdot86$ cm^{-1}, $F(000) = 496$, $T = 293$ K, $R = 0\cdot060$ for 2041 unique observed reflections. The heterocyclic ring adopts a bent conformation with the N=C—C=N torsion angle 50·3 (3)°. This means that one of the methylene H atoms is in a pseudo-equatorial position, almost planar to the fused benzene ring, whereas the other is pseudo-axial and almost perpendicular to the ring, thus explaining the difference of *ca* δ 0·9 between their NMR chemical shifts. No structures have previously been reported for the 5*H*-benzodiazepine ring system.

Experimental. Compound (I) isolated as major isomer from reaction between *o*-aminobenzylamine and 3-phenyl-2,3-propanedione. Crystals obtained by slow evaporation of a solution in methanol. Density measured by flotation in mixture of hexane and tetrachloromethane. A *ca* 0·30 mm cuboidal crystal mounted on glass fibre for X-ray analysis. Intensities measured by SERC service with an Enraf–Nonius CAD-4 diffractometer and ω–2θ scans. Unit cell determined from least-squares analysis of angle data for 25 reflections with $35 < \theta < 42°$. Data collected to $(\sin\theta)/\lambda$ of 0·60 Å^{-1}, $-12 < h < 12$, $0 < k < 18$, $0 < l < 9$; empirical absorption correction applied, transmission factors 0·999–0·859. Three standard reflections ($\bar{1},\overline{13},1$, 821, $4\bar{7}5$) varied ±2%; linear drift correction applied. 2707 unique reflections measured, 666 reflections with $F < 5\sigma(F)$ considered unobserved. Solved by direct methods with *MULTAN*80 (Main, Fiske, Hull, Lessinger, Germain, Declercq & Woolfson, 1980). Full-matrix least squares on F values with *SHELX*76 (Sheldrick, 1976). Non-H atoms refined anisotropically, H atoms calculated geometrically and allowed to 'ride' on associated heavy atoms with four common isotropic temperature factors for methylene, phenyl, fused benzene and methyl hydrogens, respectively, for a total of 171 variables. $R = 0\cdot060$, $wR = 0\cdot081$ where weight = $1\cdot000/[\sigma^2(F) + 0\cdot0129F^2]$. Extinction correction of form $F^* = F(1-0\cdot001XF^2/\sin\theta)$ where $X = 0\cdot045$ applied. Final $(\Delta/\sigma)_{\max} < 0\cdot59$ (methyl rotor), $< 0\cdot05$ elsewhere, $\Delta\rho_{\max} = 0\cdot18$ and $\Delta\rho_{\min} = -0\cdot13$ e Å^{-3} on final difference map. Atomic scattering factors from *International Tables for X-ray Crystallography* (1974).† Atom parameters are listed in Table 1 and bond lengths and angles in Table 2. The molecule and numbering scheme are shown in Fig. 1.



(I)

Related literature. Structures of 50 compounds containing the basic ring connectivity of the benzo-1,4-diazepine system are listed in the Cambridge Crystallographic Database (version of June 1988) but none of these have the double-bond pattern of the system reported here (*i.e.* they are not 5*H*-benzodiazepines). The structure described here is therefore unique in that respect.

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† Lists of structure factors, H-atom coordinates and isotropic temperature factors, and anisotropic temperature factors for non-H atoms have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 51697 (16 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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