Brisse, F. & Sygusch, J. (1974). *Acta Cryst.* B**30**, 480–486.
Butcher, H. J. & Hamor, T. A. (1985). *Acta Cryst.* C**41**, 265–266.
Chananont, P., Hamor, T. A. & Martin, I. L. (1979). *Cryst. Struct. Commun.* **8**, 393–400.
Cortés, E. & Martínez, R. (1983). *J. Heterocycl. Chem.* **20**, 161–167.
Cortés, E., Romero, M. C. & Ceballos, I. (1986). *J. Heterocycl. Chem.* In the press.
Guthikonda, R. M., Cama, L. D. & Christensen, B. G. (1974). *J. Am. Chem. Soc.* **96**, 7584–7585.
Hamor, T. A. & Martin, I. L. (1983). *Prog. Med. Chem.* **20**, 157–223.
International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press. (Present distributor D. Reidel, Dordrecht.)
Itil, T. M., Saletu, B. & Marasa, J. (1974). *Pharmakopsychiatr./Neuro-Psychopharmakol.* **7**, 265–280.
Sheldrick, G. M. (1981). *SHELXTL*, revision 3. *An Integrated System for Solving, Refining and Displaying Crystal Structures from Diffraction Data*. Univ. of Göttingen.
Soriano-García, M., Toscano, R. A., Cortés, E. & Martínez, R. (1984). *Acta Cryst.* C**40**, 1460–1462.
Sutton, L. E. (1965). *Tables of Interatomic Distances and Configuration in Molecules and Ions*. Spec. Publ. No. 18. London: The Chemical Society.

Acta Cryst. (1987). C**43**, 272–274

Structure and Stereochemistry of 2-Hydroxy-12(*S*)-hydroxyneoclerodane-3,13(14)-diene-15,16;19,20-diolide (Semiatrin), a Diterpene*

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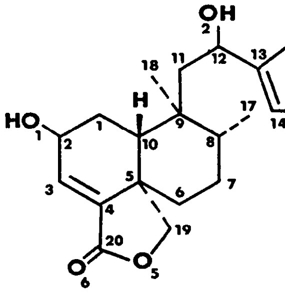
Abstract. $C_{20}H_{26}O_6$, $M_r = 362{\cdot}4$, orthorhombic, $P2_12_12_1$, $a = 8{\cdot}564$ (3), $b = 10{\cdot}550$ (4), $c = 20{\cdot}456$ (5) Å, $V = 1848$ (1) Å^3, $Z = 4$, $D_x = 1{\cdot}30$ Mg m^{-3}, Mo $K\alpha$, $\lambda = 0{\cdot}7107$ Å, $\mu = 0{\cdot}089$ mm^{-1}, $F(000) = 776$, $T = 293$ K, final $R = 0{\cdot}061$ for 1284 reflections. The structure determination of (1) establishes the configuration at C(12) to be 12*S*. The cyclohexene and cyclohexane rings are *trans*-fused and adopt half-chair and chair conformations, respectively. The γ-lactone has an α-envelope conformation whilst the 13(16*H*)-furanone ring is planar to within $\pm 0{\cdot}02$ (1) Å. Bond lengths and angles are normal. The crystal structure is stabilized by intra- and intermolecular hydrogen bonds and C—H···O hydrogen-bond interactions.

Introduction. In a previous paper (Esquivel, Hernández, Ramamoorthy, Cárdenas & Rodríguez-Hahn, 1986) the isolation and structure determination of semiatrin (1) from *Salvia semiatratha* was described. The structure of (1) was assigned mainly on spectroscopic grounds. The *trans*-neoclerodane structure proposed for it and the 2*S* configuration at C(2) were deduced by careful analysis of the ^{1}H and ^{13}C NMR spectra and comparison with data reported for similar structures. The configuration at C(12) could not be ascertained from the proton resonance data (Pinhey, Simpson & Batey, 1971; Tschesche & Streuff, 1978; Esquivel, Méndez, Ortega, Soriano-García, Toscano & Rodríguez-Hahn, 1985; Bohlmann, Zdero & Huneck, 1985), although they suggested a 12*S* configuration. This prompted us to undertake the X-ray structure analysis of (1) in order to confirm the structure proposed for it and establish the configuration at C(12).



(1)

Experimental. Colourless transparent cube-shaped crystals prepared by slow evaporation of Me_2CO–hexane, dimensions $0{\cdot}36 \times 0{\cdot}38 \times 0{\cdot}38$ mm. Nicolet *R*3 four-circle diffractometer, graphite-monochromated Mo $K\alpha$, lattice parameters from 25 machine-centred reflections with $4{\cdot}0 < 2\theta < 20{\cdot}0°$ accurately measured on the diffractometer. 2430 independent measured reflections, $2\theta_{max}$ 55°, 1284 considered observed [$I >$

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$3\sigma(I)$], index range $h\,0\rightarrow 11$, $k\,0\rightarrow 13$, $l\,0\rightarrow 26$, ω-scan mode, variable scan speed, scan width 1·0 (°θ), two standard reflections (002, 0$\bar{2}$0) monitored every 50 measurements, statistical intensity variation of 0·5%, Lp correction, absorption ignored; structure solved by combination of direct methods and partial structure expansion by an iterative E–Fourier procedure using *SHELXTL* (Sheldrick, 1981). Least-squares refinement of all non-H atoms treated anisotropically; O(4) shows some disorder (see thermal parameters in Table 1); H atoms riding on the bonded C with fixed isotropic temperature factor, $U = 0{\cdot}06$ Å^2; H atoms bonded to O refined; 242 parameters refined, function minimized $\sum w(|F_o| - |F_c|)^2$, $w = [\sigma^2(F_o) + 0{\cdot}002(F_o)^2]^{-1}$. In the last cycle $(\Delta/\sigma)_{\max} = 0{\cdot}24$, $\Delta\rho$ from $-0{\cdot}20$ to $0{\cdot}40$ e Å^{-3}, $S = 1{\cdot}13$. Isotropic extinction parameter $X = 0{\cdot}0019$. Final $R = 0{\cdot}61$, $wR = 0{\cdot}072$. Scattering factors from *International Tables for X-ray Crystallography* (1974).

Discussion. Atomic coordinates are in Table 1.* Fig. 1 shows the conformation of the title compound (1). The bond lengths for non-H atoms are listed in Table 2.

The molecular structure of (1) determined from the X-ray data confirms the structure and establishes the configuration as 12*S*, previously assigned on the basis of spectroscopic evidence. The cyclohexene ring exhibits a half-chair conformation. The fusions to the γ-lactone and the cyclohexane rings are *cis* and *trans*, respectively.† The lactone ring has an α-envelope conformation with C(5) as the flap as in salvigenolide (Esquivel, Cárdenas, Toscano, Soriano-García & Rodríguez-Hahn, 1985). Δ and φ_m (Altona, Geise & Romers, 1968) are −32·6 (6) and −38·9 (6)° for the five-membered lactone ring. The cyclohexane ring exhibits a chair conformation. The average bond length and angle of 1·540 (8) Å and 111·1 (4)°, respectively, agree with that obtained for cyclohexane (Kahn, Fourme, André & Renaud, 1973). The average value of the ring-torsion angle is 55·6 (6)°.

The methyl substituent at C(9) is axial; the methyl group at C(8) and the side chain at C(9) occupy the more sterically favoured equatorial positions. The pertinent torsion angle C(17)—C(8)—C(9)—C(11) is −65·8 (6)°. The 13(16*H*)-furanone ring is almost planar, maximum deviation 0·022 (6) Å for O(3).

Table 1. *Atomic coordinates* (×10^4) *and equivalent isotropic temperature factors* (Å^2 ×10^3)

$$U_{\rm eq} = (U_{11}U_{22}U_{33})^{1/3}.$$

	x	y	z	$U_{\rm eq}$
O(1)	5575 (4)	−103 (5)	4390 (2)	51 (1)
O(2)	6472 (5)	−759 (5)	5673 (2)	64 (2)
O(3)	8018 (5)	−945 (5)	7608 (2)	73 (2)
O(4)	8165 (7)	757 (7)	8191 (2)	110 (3)
O(5)	−825 (4)	676 (5)	4150 (2)	62 (2)
O(6)	165 (6)	1594 (5)	3264 (2)	76 (2)
C(1)	3325 (7)	−1203 (5)	4777 (2)	40 (2)
C(2)	4131 (7)	−667 (5)	4182 (2)	45 (2)
C(3)	3061 (7)	226 (6)	3833 (3)	47 (2)
C(4)	1839 (6)	745 (5)	4130 (3)	39 (2)
C(5)	1418 (5)	608 (5)	4841 (2)	33 (2)
C(6)	1196 (7)	1901 (5)	5175 (3)	46 (2)
C(7)	807 (7)	1678 (6)	5898 (3)	55 (2)
C(8)	2034 (7)	933 (5)	6259 (2)	42 (2)
C(9)	2451 (6)	−365 (5)	5936 (2)	37 (2)
C(10)	2744 (5)	−100 (5)	5195 (2)	29 (1)
C(11)	3934 (6)	−906 (5)	6253 (2)	38 (2)
C(12)	5498 (6)	−183 (6)	6150 (2)	42 (2)
C(13)	6441 (6)	−199 (6)	6778 (3)	45 (2)
C(14)	6665 (9)	724 (7)	7194 (3)	66 (3)
C(15)	7604 (8)	268 (8)	7736 (3)	76 (3)
C(16)	7267 (8)	−1332 (8)	7013 (3)	67 (3)
C(17)	1570 (8)	803 (7)	6983 (3)	65 (2)
C(18)	1145 (7)	−1366 (6)	6024 (3)	49 (2)
C(19)	−204 (6)	13 (7)	4734 (3)	53 (2)
C(20)	368 (7)	1094 (6)	3784 (3)	54 (2)

Table 2. *Bond lengths* (Å) *with e.s.d.'s in parentheses*

O(1)—C(2)	1·437 (7)	O(2)—C(12)	1·422 (7)
O(3)—C(15)	1·354 (10)	O(3)—C(16)	1·436 (8)
O(4)—C(15)	1·169 (9)	O(5)—C(19)	1·482 (7)
O(5)—C(20)	1·341 (7)	O(6)—C(20)	1·202 (7)
C(1)—C(2)	1·510 (7)	C(1)—C(10)	1·528 (7)
C(2)—C(3)	1·496 (8)	C(3)—C(4)	1·328 (8)
C(4)—C(5)	1·505 (7)	C(4)—C(20)	1·490 (8)
C(5)—C(6)	1·537 (7)	C(5)—C(10)	1·541 (7)
C(5)—C(19)	1·540 (7)	C(6)—C(7)	1·536 (8)
C(7)—C(8)	1·506 (8)	C(8)—C(9)	1·562 (8)
C(8)—C(17)	1·538 (7)	C(9)—C(10)	1·561 (7)
C(9)—C(11)	1·536 (7)	C(9)—C(18)	1·549 (8)
C(11)—C(12)	1·555 (8)	C(12)—C(13)	1·517 (7)
C(13)—C(14)	1·307 (9)	C(13)—C(16)	1·470 (9)
C(14)—C(15)	1·451 (10)		

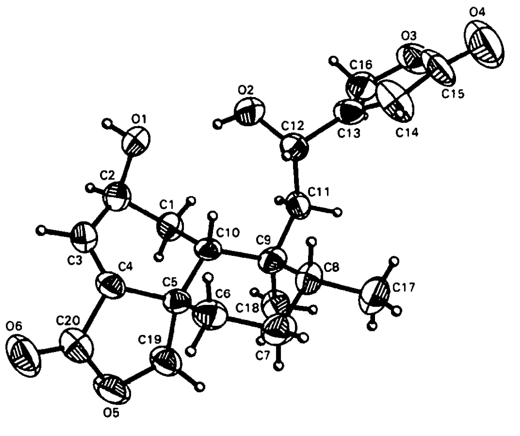

Fig. 1. The molecular conformation of (1), showing atom numbering. The thermal ellipsoids are drawn at the 50% probability level.

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* Lists of structure amplitudes, anisotropic thermal parameters, H-atom coordinates, bond angles and least-squares-planes calculations have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 43361 (13 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

† Torsion angles: C(3)—C(4)—C(5)—C(10) = 6·9 (7), C(20)—C(4)—C(5)—C(19) = 37·0 (5), C(4)—C(5)—C(10)—C(1) = −42·1 (5), C(6)—C(5)—C(10)—C(9) = 60·4 (5)°.

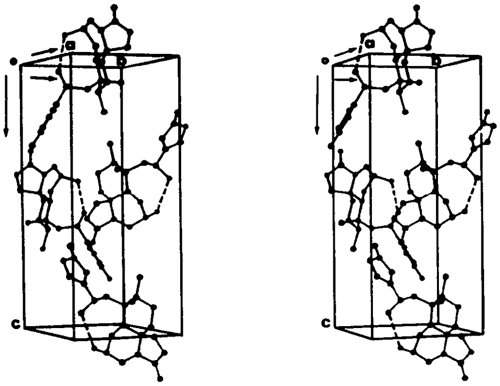

Fig. 2. Stereoview illustrating the intramolecular hydrogen-bonding interaction and crystal packing.

The crystal structure contains both intra- and intermolecular hydrogen bonds which play an important role in the stabilization. Fig. 2 shows the intramolecular hydrogen bonds which play an important role in the stabilization. The O(2)···O(1) and H···O(1) distances are 2·820 (6) and 2·11 (5) Å and the O(2)—H···O(1) angle is 162 (5)°. In addition, the O(1)—H hydroxyl group participates in an intermolecular hydrogen bond involving the O(4) carbonyl group ($1\cdot5-x$, $-y$, $-0\cdot5+z$). The O(1)···O(4) and H(1)···O(4) distances are 2·767 (6) and 2·11 (5) Å and the O(1)—H···O(4) angle is 150 (5)°. There are two intermolecular approaches <3·3 Å involving non-H atoms: C(2)···O(4)($1\cdot5-x$, $-y$, $-0\cdot5+z$) 3·08 (1) Å and C(14)···O(6)($0\cdot5+x$, $0\cdot5-y$, $1-z$) 3·25 (1) Å. The H(14)···O(6) distance is 2·31 Å, indicating a possible C—H···O hydrogen bond.

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References

Altona, C., Geise, H. J. & Romers, C. (1968). *Tetrahedron*, **24**, 13–32.
Bohlmann, F., Zdero, Ch. & Huneck, S. (1985). *Phytochemistry*, **24**, 1027–1030.
Esquivel, B., Cárdenas, J., Toscano, A., Soriano-García, M. & Rodríguez-Hahn, L. (1985). *Tetrahedron*, **41**, 3213–3217.
Esquivel, B., Hernández, M., Ramamoorthy, T. P., Cárdenas, J. & Rodríguez-Hahn, L. (1986). *Phytochemistry*. In the press.
Esquivel, B., Méndez, A., Ortega, A., Soriano-García, M., Toscano, R., & Rodríguez-Hahn, L. (1985). *Phytochemistry*, **24**, 1769–1772.
International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press. (Present distributor D. Reidel, Dordrecht.)
Kahn, R., Fourme, R., André, D. & Renaud, M. (1973). *Acta Cryst.* B**29**, 131–138.
Pinhey, J. T., Simpson, R. F. & Batey, I. L. (1971). *Aust. J. Chem.* **24**, 2621–2637.
Sheldrick, G. M. (1981). *SHELXTL*. Revision 3. *An Integrated System for Solving, Refining and Displaying Crystal Structures from Diffraction Data*. Univ. of Göttingen.
Tschesche, R. & Streuff, B. (1978). *Chem. Ber.* **111**, 2130–2142.

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The Structures of Epinine-*O*-sulfates

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Abstract. $C_9H_{13}NO_5S$, 2-hydroxy-5-[2-(methylamino)ethyl]phenyl hydrogen sulfate (epinine-3-*O*-sulfate): $M_r = 247\cdot27$, triclinic, $P\bar{1}$, $a = 7\cdot610\ (1)$, $b = 10\cdot387\ (2)$, $c = 7\cdot195\ (2)$ Å, $\alpha = 101\cdot33\ (2)$, $\beta = 104\cdot38\ (2)$, $\gamma = 74\cdot50\ (1)$°, $V = 525\cdot6\ (4)$ Å^3, $Z = 2$, D_m(flotation in $CHCl_3/CCl_4$) = 1·54 (2), $D_x = 1\cdot563$ Mg m^{-3}, Mo $K\alpha$ radiation ($\lambda K\alpha_{1,2} = 0\cdot70926$, $0\cdot71354$ Å), $\mu = 0\cdot2996$ mm^{-1}, $F(000) = 260$, $T = 293$ K, $R = 0\cdot035$ for 2613 observations, $I > 3\sigma(I)$. $C_9H_{13}NO_5S.0\cdot33H_2O$, 2-hydroxy-4-[2-(methylamino)ethyl]phenyl hydrogen sulfate 0·33 hydrate (epinine-4-*O*-sulfate): $M_r = 253\cdot27$, monoclinic, $P2_1/c$, $a = 7\cdot481\ (2)$ $b = 7\cdot473\ (1)$, $c = 21\cdot023\ (5)$ Å, $\beta = 96\cdot23\ (2)$°, $V = 1168\cdot4\ (8)$ Å^3, $Z = 4$, D_m(flotation in $CHCl_3/C_2H_4Cl_2$) = 1·42 (2), $D_x = 1\cdot440$ Mg m^{-3}, Mo $K\alpha$ radiation, $\mu = 0\cdot2696$ mm^{-1}, $F(000) = 530\cdot67$, $T = 293$ K, $R = 0\cdot039$ for 2136 observations, $I \geq 3\sigma(I)$. Both epinine sulfate molecules crystallize as zwitterions with the sulfate group ionized and the amino group protonated.

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