

**Structure of 2-Acetoxy-2 α ,3 α -dihydro-4 α -hydroxy-3-(2-methylisocrotonoyloxy)-
(1 α H,5 α H,7 α H,8 β H)-guaia-10(14),11(13)-dien-8,12-olide, C₂₂H₂₈O₇, a Sesquiterpene
Lactone***

BY M. SORIANO-GARCÍA,† R. A. TOSCANO AND C. GUERRERO

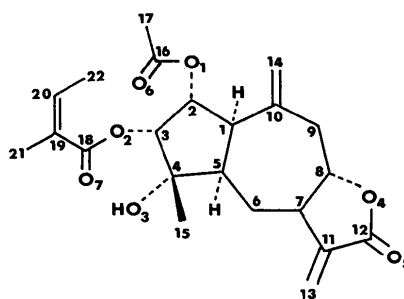
*Instituto de Química, Universidad Nacional Autónoma de México, Circuito Exterior, Ciudad Universitaria,
Coyoacán 04510, Mexico DF*

(Received 4 July 1984; accepted 19 October 1984)

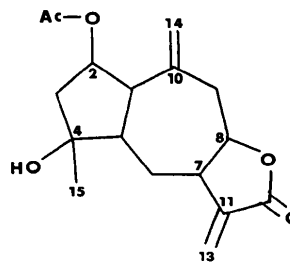
Abstract. $M_r = 404.5$, orthorhombic, $P2_12_12_1$, $a = 11.783$ (3), $b = 13.227$ (3), $c = 14.115$ (4) Å, $V = 2199.9$ (3) Å³, $Z = 4$, $D_x = 1.22$ Mg m⁻³, Cu $K\alpha$, $\lambda = 1.54178$ Å, $\mu = 0.71$ mm⁻¹, $F(000) = 864$, $T = 300$ K, $R = 0.072$ for 1395 observed reflections. The title compound, otoimbricatin A, is a guaianolide-type sesquiterpene lactone, containing a five-membered ring *cis*-fused to a seven-membered ring and a *trans*-fused α,β -unsaturated γ -lactone. The seven-membered ring has a deformed chair conformation, while the two five-membered rings adopt envelope conformations. The molecules in the crystal are held together by hydrogen bonds and van der Waals interactions.

Introduction. The germacranolides are naturally occurring sesquiterpene lactones whose structure is based on 1-isopropyl-3,7-dimethylcyclodecane (germacrane) (Fischer, Olivier & Fischer, 1979). These compounds are the biogenetic precursors of guaianolides (Sutherland, 1974). Two new guaianolides have been isolated from the aerial parts of *Otopappus imbricatus* (Guerrero, Quevedo & Toscano, 1984) and named otoimbricatin A (1) and otoimbricatin B (2). We now report the crystal and molecular structure of (1).

Experimental. Prismatic crystal 0.16 × 0.20 × 0.44 mm, Nicolet R3 four-circle diffractometer, graphite-monochromated Cu $K\alpha$, lattice parameters from 25 machine-centred reflections with $10.0 < 2\theta < 27.2^\circ$, 1703 reflections with $3 < 2\theta < 115^\circ$ for one octant, 1395 independent with $I > 2.5\sigma(I)$, index range h 0–12, k 0–14, l 0–15, ω -scan mode, variable scan speed, scan width 1.0° (θ), two standard reflections (111; 113) monitored every 50 measurements, Lp correction, absorption ignored. Direct methods gave structure. Least-squares refinement of all non-H atoms treated anisotropically; H atoms riding on bonded C with fixed isotropic temperature factor, $U = 0.06$ Å². $\sum w(\Delta F)^2$ minimized, $w = |\sigma^2(F_o) + 0.008(F_o)^2|^{-1}$,



(1)



(2)

$(\Delta/\sigma)_{\max} = 0.27$. Residual electron density within ± 0.2 e Å⁻³. Isotropic extinction parameter $X = 0.0014$. Final $R = 0.072$, $wR = 0.113$. Scattering factors from *International Tables for X-ray Crystallography* (1974). All computations performed on a Nova 4 computer and plots drawn on a Tektronix plotter with the *SHELXTL* system (Sheldrick, 1981).

Discussion. Atomic coordinates are in Table 1.‡ A perspective molecular drawing and selected torsion angles are shown in Fig. 1. The bond lengths and angles for non-H atoms are listed in Table 2.

‡ Lists of structure factors, anisotropic thermal parameters and H-atom coordinates have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 39861 (12 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

* Contribution No. 708 of the Institute de Química, UNAM.

† To whom correspondence should be addressed.

The five-membered ring C(1)–C(5) occurs in an envelope conformation with C(3) as the flap -0.26 (1) Å out of the best plane formed by the other four ring atoms. The fusion to the cycloheptane ring is *cis* with torsion angles in the five- and seven-membered rings of -9.5 (6) and -10.4 (8)°, respectively.

The cycloheptane ring has a deformed chair conformation. This type of conformation has been observed in bromohelenalin (Mazhar-ul-Haque & Caughlan, 1969) and in eregoyazidin (Asakawa, Taira, Toyota, Takemoto, Herz & Sakai, 1981).

Table 1. Atomic coordinates ($\times 10^4$) and equivalent isotropic temperature factors ($\text{Å}^2 \times 10^3$) for the non-H atoms

	$U_{\text{eq}} = (U_{11}U_{22}U_{33})^{1/3}$.			
	<i>x</i>	<i>y</i>	<i>z</i>	U_{eq}
O(1)	6345 (4)	11556 (3)	3195 (3)	70 (1)
O(2)	4965 (4)	10449 (3)	2068 (3)	80 (2)
O(3)	2748 (4)	10105 (4)	2492 (3)	81 (2)
O(4)	4774 (5)	8442 (4)	6723 (3)	95 (2)
O(5)	3974 (7)	6991 (5)	7146 (4)	124 (3)
O(6)	6165 (5)	13246 (4)	3191 (5)	102 (2)
O(7)	5291 (8)	11545 (7)	935 (6)	179 (4)
C(1)	5145 (5)	10505 (4)	4148 (4)	61 (2)
C(2)	5245 (6)	11427 (5)	3505 (5)	69 (2)
C(3)	4402 (6)	11176 (5)	2670 (4)	70 (2)
C(4)	3424 (5)	10639 (5)	3146 (5)	68 (2)
C(5)	4056 (5)	9936 (5)	3849 (4)	62 (2)
C(6)	3279 (5)	9469 (5)	4637 (4)	63 (2)
C(7)	3928 (6)	8750 (5)	5249 (4)	66 (2)
C(8)	4522 (6)	9253 (6)	6053 (5)	75 (2)
C(9)	5551 (6)	9853 (6)	5853 (5)	80 (3)
C(10)	5301 (5)	10742 (5)	5205 (5)	71 (2)
C(11)	3296 (8)	7947 (6)	5760 (5)	81 (3)
C(12)	4026 (8)	7716 (7)	6606 (5)	96 (3)
C(13)	2350 (8)	7487 (6)	5606 (6)	92 (3)
C(14)	5279 (8)	11649 (6)	5575 (6)	104 (3)
C(15)	2667 (6)	11402 (6)	3623 (5)	84 (3)
C(16)	6756 (6)	12518 (5)	3036 (5)	75 (2)
C(17)	7878 (7)	12523 (7)	2664 (7)	107 (4)
C(18)	5339 (9)	10698 (8)	1220 (6)	106 (4)
C(19)	6026 (13)	9797 (13)	804 (7)	153 (6)
C(20)	6258 (19)	9521 (16)	25 (20)	302 (16)
C(21)	6679 (9)	9131 (7)	1604 (11)	165 (6)
C(22)	5519 (17)	10020 (13)	-625 (13)	236 (11)

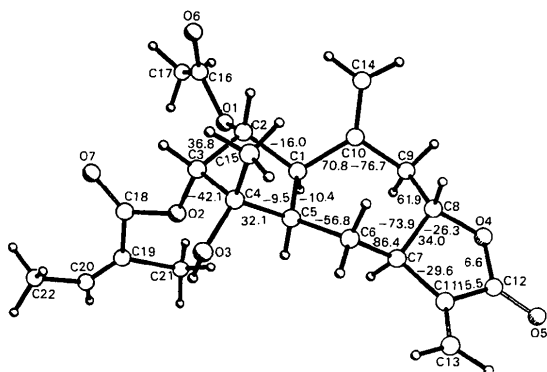


Fig. 1. The molecular structure of the title compound (1) showing the atom labelling and selected torsion angles; e.s.d.'s are 0.6–0.9°.

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

The e.s.d.'s are given in parentheses.

O(1)–C(2)	1.379 (8)	O(1)–C(16)	1.381 (8)
O(2)–C(3)	1.444 (8)	O(2)–C(18)	1.318 (10)
O(3)–C(4)	1.409 (8)	O(4)–C(8)	1.460 (9)
O(4)–C(12)	1.314 (11)	O(5)–C(12)	1.227 (11)
O(6)–C(16)	1.207 (9)	O(7)–C(18)	1.191 (14)
C(1)–C(2)	1.525 (9)	C(1)–C(5)	1.546 (9)
C(1)–C(10)	1.534 (9)	C(2)–C(3)	1.577 (9)
C(3)–C(4)	1.511 (9)	C(4)–C(5)	1.550 (9)
C(4)–C(15)	1.506 (10)	C(5)–C(6)	1.567 (9)
C(6)–C(7)	1.495 (9)	C(7)–C(8)	1.490 (9)
C(7)–C(11)	1.484 (10)	C(8)–C(9)	1.477 (10)
C(9)–C(10)	1.519 (10)	C(10)–C(14)	1.308 (11)
C(11)–C(12)	1.502 (11)	C(11)–C(13)	1.288 (13)
C(16)–C(17)	1.422 (11)	C(18)–C(19)	1.556 (19)
C(19)–C(20)	1.191 (29)	C(19)–C(21)	1.625 (19)
C(20)–C(22)	1.426 (31)		
C(2)–O(1)–C(16)	119.7 (5)	C(3)–O(2)–C(18)	121.4 (6)
C(8)–O(4)–C(12)	108.5 (6)	C(2)–C(1)–C(5)	106.9 (5)
C(2)–C(1)–C(10)	113.9 (5)	C(5)–C(1)–C(10)	117.7 (5)
O(1)–C(2)–C(1)	111.1 (5)	O(1)–C(2)–C(3)	112.4 (5)
C(1)–C(2)–C(3)	103.2 (5)	O(2)–C(3)–C(2)	106.9 (5)
O(2)–C(3)–C(4)	107.4 (5)	C(2)–C(3)–C(4)	104.3 (5)
O(3)–C(4)–C(3)	112.0 (5)	O(3)–C(4)–C(5)	113.0 (5)
C(3)–C(4)–C(5)	101.6 (5)	O(3)–C(4)–C(15)	107.0 (5)
C(3)–C(4)–C(15)	109.6 (5)	C(5)–C(4)–C(15)	113.6 (6)
C(1)–C(5)–C(4)	106.4 (5)	C(1)–C(5)–C(6)	118.9 (5)
C(4)–C(5)–C(6)	114.2 (5)	C(5)–C(6)–C(7)	111.2 (5)
C(6)–C(7)–C(8)	113.3 (6)	C(6)–C(7)–C(11)	118.7 (6)
C(8)–C(7)–C(11)	100.7 (5)	O(4)–C(8)–C(7)	105.1 (6)
O(4)–C(8)–C(9)	110.6 (6)	C(7)–C(8)–C(9)	118.7 (6)
C(8)–C(9)–C(10)	111.8 (6)	C(1)–C(10)–C(9)	116.8 (6)
C(1)–C(10)–C(14)	125.0 (7)	C(9)–C(10)–C(14)	118.2 (7)
C(7)–C(11)–C(12)	104.1 (7)	C(7)–C(11)–C(13)	133.6 (7)
C(12)–C(11)–C(13)	122.3 (7)	O(4)–C(12)–O(5)	121.7 (8)
O(4)–C(12)–C(11)	109.6 (7)	O(5)–C(12)–C(11)	128.6 (8)
O(1)–C(16)–O(6)	120.2 (6)	O(1)–C(16)–C(17)	113.0 (6)
O(6)–C(16)–C(17)	126.8 (7)	O(2)–C(18)–O(7)	121.7 (9)
O(2)–C(18)–C(19)	109.0 (8)	O(7)–C(18)–C(19)	128.1 (10)
C(18)–C(19)–C(20)	134.6 (16)	C(18)–C(19)–C(21)	113.6 (9)
C(20)–C(19)–C(21)	111.5 (16)	C(19)–C(20)–C(22)	108.2 (19)

The lactone ring has an envelope conformation with C(7) as the flap. The fusion to the seven-membered ring is *trans* with torsion angles of -73.9 (8) and 34.0 (7)°. Δ and ϕ_m (Altona, Geise & Romers, 1968) are 12.2 (6)° and 34.2 (6)° for the five-membered lactone ring.

Apart from the methylisocrotonate group, which is affected by high thermal vibrations, there are no unusual bond lengths or angles. The C=O bonds agree well with the accepted value of 1.215 (5) Å (Sutton, 1965).

The acetate and methylisocrotonate groups are oriented to minimize transannular repulsions between their O atoms and the cyclopentene ring. The pertinent torsion angles are: C(16)–O(1)–C(2)–C(1) = -147.4 (6); C(16)–O(1)–C(2)–C(3) = 97.6 (6); C(18)–O(2)–C(3)–C(2) = -108.9 (7); C(18)–O(2)–C(3)–C(4) = 139.7 (7)°, placing the C=O groups *syn* to the C(2)–H and C(3)–H bonds, respectively (Mathieson, 1965; Chothia & Pauling, 1970).

The molecular packing is shown in Fig. 2. The arrangement of molecules in the crystal appears to be determined by a hydrogen bond as the dominant

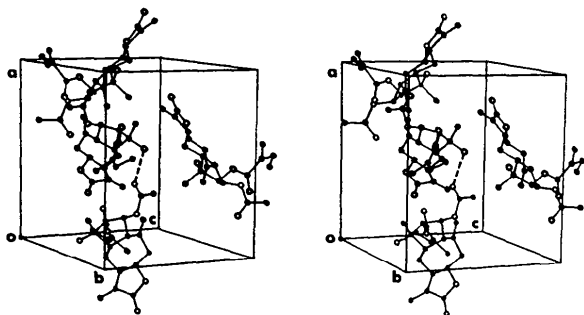


Fig. 2. Stereoscopic view of the unit cell showing the intermolecular hydrogen bonding.

intermolecular interaction and by van der Waals interactions. The hydrogen bond is between the O(3)—H hydroxyl group of the molecule at $(1-x, \frac{1}{2}+y, \frac{1}{2}-z)$ and the O(6) carbonyl group. The O(3)···O(6) and H(3A)···O(6) distances are 2.936 (9) and 2.06 Å and the O(3)—H(3A)···O(6) angle is 155.9°.

We are greatly indebted to Consejo Nacional de Ciencia y Tecnología de México, CONACYT, for

support, Project No. PCCBBNA-101810. We thank Mr Abelardo Cuellar for his technical assistance.

References

- ALTONA, C., GEISE, H. J. & ROMERS, C. (1968). *Tetrahedron*, **24**, 13–32.
 ASAKAWA, Y., TAIRA, Z., TOYOTA, M., TAKEMOTO, T., HERZ, W. & SAKAI, T. (1981). *J. Org. Chem.* **46**, 4602–4604.
 CHOTHIA, C. & PAULING, P. J. (1970). *Nature (London)*, **226**, 541–542.
 FISCHER, N. H., OLIVIER, E. J. & FISCHER, H. D. (1979). *Fortschr. Chem. Org. Naturst.* **38**, 47–390.
 GUERRERO, C., QUEVEDO, F. & TOSCANO, A. (1984). *Rev. Latinoam. Quím.* In the press.
International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press. (Present distributor D. Reidel, Dordrecht.)
 MATHIESON, A. McL. (1965). *Tetrahedron Lett.* pp. 4137–4144.
 MAZHAR-UL-HAQUE & CAUGHLAN, C. N. (1969). *J. Chem. Soc. B*, pp. 956–960.
 SHELDRICK, G. M. (1981). *SHELXTL*. Revision 3. *An Integrated System for Solving, Refining and Displaying Crystal Structures from Diffraction Data*. Univ. of Göttingen.
 SUTHERLAND, J. K. (1974). *Tetrahedron*, **30**, 1651–1660.
 SUTTON, L. E. (1965). *Tables of Interatomic Distances and Configuration in Molecules and Ions*. Spec. Publ. No. 18. London: The Chemical Society.

Acta Cryst. (1985). **C41**, 540–542

3-Oxograndolide, a Guaiane Type of Sesquiterpene Lactone, C₁₅H₂₀O₄

BY URSZULA RYCHLEWSKA

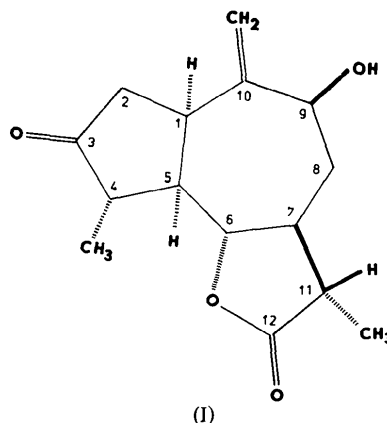
Faculty of Chemistry, A. Mickiewicz University, ul. Grunwaldzka 6, 60–780 Poznań, Poland

(Received 23 August 1984; accepted 23 November 1984)

Abstract. $M_r = 264.3$, orthorhombic, $P2_12_12_1$, $a = 6.2941$ (9), $b = 7.6749$ (7), $c = 28.278$ (4) Å, $V = 1366.0$ (3) Å³, $Z = 4$, $D_m = 1.26$, $D_x = 1.28$ Mg m⁻³, $\lambda(\text{Cu K}\alpha) = 1.54184$ Å, $\mu = 0.76$ mm⁻¹, $F(000) = 568$, $T = 295$ K, $R = 0.047$ for 1051 observed reflections. The three-ring guaianolide system contains a twist-chair *exo*-methylenecycloheptane moiety *cis*-fused with the cyclopentanone [at C(1)—C(5)] and *trans*-annulated with the γ -lactone at C(6)—C(7). The secondary hydroxyl group is at C(9) and is β -oriented; it participates in an intermolecular hydrogen bond with the cyclopentane keto group, O···O 2.976 (3) Å.

Introduction. The sesquiterpene lactone 3-oxograndolide was isolated from the aerial part of the species *Arctotis grandis* Thunb. (family Compositae, tribe Arctoteae) and *Vernonia angusticeps* Michaux. (family Compositae, tribe Vernonieae). On the basis of physical methods, mainly ¹H NMR spectroscopy, the structure (I) for 3-oxograndolide was deduced (Phuong,

Perez, Buděšinský, Šaman, Grabarczyk, Drożdż, Rychlewska & Holub, 1984). Since substitution at C(9) is relatively rare in sesquiterpene lactones, it was essential to check the proposed structure of this native lactone by X-ray structural analysis.



0108-2701/85/040540-03\$01.50

© 1985 International Union of Crystallography