X-Ray Crystal Structure of the Sesquiterpene Lactone Scorpioidine

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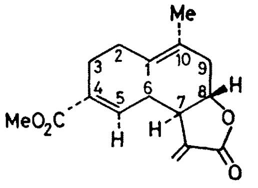
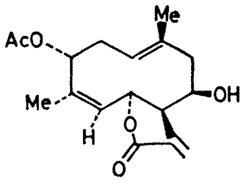
Summary A new germacranolide from *Vernonia scorpioides* has been isolated and its stereostructure elucidated on the basis of spectroscopic data and an *X*-ray analysis; it has a unique conformation for a cyclodecadiene.

Scorpioidine (**1**), m.p. 120—122 °C, $C_{16}H_{20}O_4$ (M^+ 276), $[\alpha]^{20}_{546}$ + 133° ($CHCl_3$), was isolated from the aerial parts of the Brazilian plant *Vernonia scorpioides* (Lam.) Pers. (170 mg from 4 kg of dried plant tissue). The i.r. [ν_{max} (Nujol) 1750 (lactone), 1700 (ester), and 1635 (C=C) cm^{-1}], 100 MHz n.m.r. [$\delta(CDCl_3)$ 1·74 (10-Me), 2·82 (dd, H-7), 3·76 (s, CO_2Me), 4·13 (m, H-8), 5·38 br (t, H-1), 5·65 (d, *J* 3 Hz, $=CH_2$), 6·24 (d, *J* 3 Hz, $=CH_2$), and 6·92 (q, H-5)], and u.v. spectra [λ_{max} (MeOH) 218 nm (ϵ 15,200)], and c.d. {$[\theta]_{246}$ + 710 (MeOH)} indicated that the compound was a germacranolide with a *trans*-fused C-7, 8-lactone ring. Our tentative assignment of structure (**1**) with the rather unusual *cis* (with respect to the C-chain)-4,5 double bond was confirmed by *X*-ray analysis.

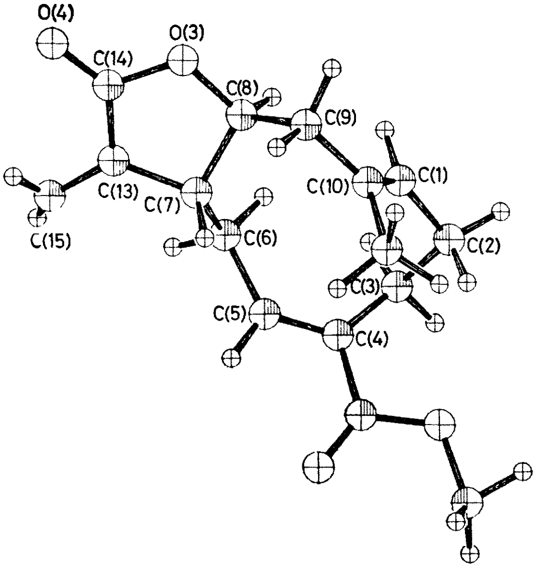


(1)



(2)

Crystal data: $C_{16}H_{20}O_4$, $M = 276{\cdot}2$, monoclinic, $a = 9{\cdot}200(5)$, $b = 7{\cdot}835(6)$, $c = 20{\cdot}264(14)$ Å, $\beta = 95{\cdot}5(1)°$, $U = 1454{\cdot}0$ Å^3, $Z = 4$, $\mu = 6{\cdot}95$ cm^{-1}, $D_m = 1{\cdot}26$, $D_c = 1{\cdot}26$ g cm^{-3}, $\lambda = 1{\cdot}5418$ Å. Systematic absences $0k0$, $k = 2n+1$, space group $P2_1$. The structure was solved by direct methods using SHELX-76.[1] 2786 Independent reflections with $I > 3\sigma(I)$ measured on a diffractometer were refined by full matrix least-squares (carbon, oxygen anisotropic, hydrogen isotropic) to R 0·050. Hydrogen parameters were refined with no constraints apart from methyl hydrogens, which were refined as rigid groups. There are two molecules (A and B) in the asymmetric unit, but they have equivalent geometries.†



Figure

The structure (Figure) contains the well known cyclodeca-1,5-diene ring with the lactone ring fused on C(7)–C(8). The conformation of the ring is shown by the torsion angles in the Table, and is unique for a cyclodeca-1,5-diene. Indeed, in a recent study[2] by molecular mechanics of such rings, eight possible conformations were considered, but not the present one. Of these eight, only three have been ob-

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† The atomic co-ordinates for this work are available on request from the Director of the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.

TABLE

	Torsion angles (°)[a]	Molecule	
		A	B
(a)	In decadiene ring		
	C(10)–C(1)–C(2)–C(3)	97·9	98·7
	C(1)–C(2)–C(3)–C(4)	−65·7	−67·1
	C(2)–C(3)–C(4)–C(5)	90·7	90·3
	C(3)–C(4)–C(5)–C(6)	2·9	3·8
	C(4)–C(5)–C(6)–C(7)	−121·1	−121·2
	C(5)–C(6)–C(7)–C(8)	108·3	110·6
	C(6)–C(7)–C(8)–C(9)	−96·3	−98·6
	C(7)–C(8)–C(9)–C(10)	60·1	60·0
	C(8)–C(9)–C(10)–C(1)	50·0	50·9
	C(9)–C(10)–C(1)–C(2)	−166·5	−167·2
(b)	In lactone ring		
	O(3)–C(8)–C(7)–C(13)	18·3	17·0
	O(4)–C(14)–C(13)–C(15)	5·2	5·3

[a] Atom numbering as in the Figure.

served so far in crystal structures [namely (a), (e), and (h) of Figure 6, ref. 1], and only one, eupaformonin (**2**),[3] has the *cis,trans* double bond arrangement observed for (**1**). Our molecular mechanics calculations show that these two conformations have comparable energy.‡

Unlike most other known sesquiterpene lactones, the lactone ring in (**1**) is *trans*-fused across the C(7)–C(8) bond, rather than the C(6)–C(7) bond [numbering as in structure (**1**)]. In molecules that are *trans*-fused across C(6)–C(7), the C_α–C_β–C_γ–O and C=C–C=O torsion angles are negative, and this is thought to cause the observed negative Cotton effect.[4] However in (**1**) the Cotton effect is positive at 246 nm, and we have therefore tentatively assigned the absolute configuration (Figure) so that the above two torsion angles are positive.

The lactone exhibited excellent locust anti-feedant activity [98% reduction of feeding at 1% (dry weight) of diet; 93% at 0·1%] and also had interesting larvicidal and anthelmintic activities. These results will be reported separately.

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‡ From models we have predicted yet another *cis,trans*-conformation, and this has been confirmed by molecular mechanics calculations as being of low energy, comparable to that of (**1**) and (**2**). Torsion angles are respectively: −67, −49, 97, 4, −130, 54, 71, −72, −58, 159°, in the order given in the Table.

[1] G. M. Sheldrick, 1976, personal communication.
[2] D. N. J. White and M. J. Bovill, *J. Chem. Soc., Perkin Trans.* 2, 1977, 1610.
[3] A. T. McPhail and K. D. Onan, *J. Chem. Soc., Perkin Trans.* 2, 1976, 578.
[4] P. J. Cox and G. A. Sim, *J. Chem. Soc., Perkin Trans.* 2, 1977, 255.