(19), 119 (19), 109 (12), 108 (11), 107 (56), 106 (31), 105 (39), 96 (30), 95 (52), 94 (59), 93 (49), 92 (18), 91 (49), 87 (19), 82 (29), 81 (86), 80 (100), 79 (95), 77 (36), 69 (40), 67 (24).

(1β,5β)-4β-Methyl-6α,10α-epoxy-7α-(2-(2-chloropropyl))-bicyclo[5.3.0]decane (13). Chloro ether 11 (10 mg) was dissolved in 5 mL of ethanol containing 2 mg of PtO_2 and hydrogenated with a Parr hydrogenator (16 psi, 1 h). The catalyst was removed by filtration of the solution through 1 g of silica (flash chromatography grade) using hexane and 97:3 hexane–Et_2O as eluants. Evaporation gave quantitative yield of 13: IR ($CHCl_3$) 1100, 1000; ^1H NMR ($CDCl_3$) 1.07 (d, 3 H, J = 7), 1.58 (s, 3 H), 1.61 (s, 3 H), 1.2–1.8 (m, 8 H), 1.95 (m, 1 H), 2.05 (m, 1 H), 2.42 (t, 1 H, J = 7), 2.86 (t, 1 H, J = 7), 3.99 (s br, 1 H), 4.47 (s br, 1 H); ^{13}C NMR ($CDCl_3$) 14.8 (CH_3), 18.2 (CH_2), 29.7 (CH_2), 30.7 (CH_3), 31.1 (CH_3), 32.7 (CH_2), 34.1 (CH_2), 37.5 (CH), 47.3 (CH), 47.9 (CH), 51.6 (CH), 71.9 (C), 77.0 (CH), 83.7 (CH); mass spectrum (70eV), *m/e* (relative intensity) 206 (M^+ − HCl) (34), 191 (21), 151 (20), 150 (13), 149 (18), 135 (38), 125 (100), 124 (46), 123 (71), 121 (22), 109 (49), 107 (52), 96 (27), 95 (86), 94 (33), 93 (50), 83 (37), 82 (82), 81 (99), 80 (20), 79 (57), 77 (32), 71 (21), 69 (98), 68 (63), 62 (97).

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Registry No. 4, 97635-09-1; 5, 97635-10-4; 6, 97635-11-5; 7a, 97635-12-6; 7b, 97673-25-1; 8a, 97635-13-7; 8b, 97673-26-2; 8c, 97673-28-4; 8d, 97673-29-5; 9a, 97635-14-8; 9b, 97673-27-3; 9c, 97673-30-8; 9d, 97673-31-9; 9e, 97635-18-2; 10, 97635-15-9; 11, 97635-16-0; 13, 97635-17-1; $Li(CH_2)_2CH{=}C(CH_3)_2$, 64504-53-6; $ClCOCH_2CO_2Me$, 37517-81-0; sorbyl aldehyde, 142-83-6.

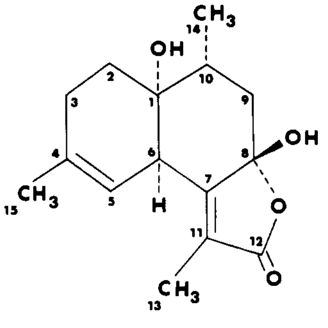
Communications

Verocephol, a Unique Amorphane Sesquiterpene γ-Lactol

Summary: The investigation of *Verbesina sphaerocephala* afforded an amorphane γ-lactol; the structure was established by interpretation of spectral data and X-ray diffraction analysis.

Sir: In our continuing search for biologically active sesquiterpene lactones from the Compositae family, we have isolated from the leaves of *Verbesina sphaerocephala* Asa Gray, collected in Soyotlán, Jalisco, México, a new γ-lactol. Verocephol (1) is the first representative having an amorphane skeleton[1] with a γ-lactol which, under acetylation conditions, is epimerized into the more common cadinane sesquiterpene framework.

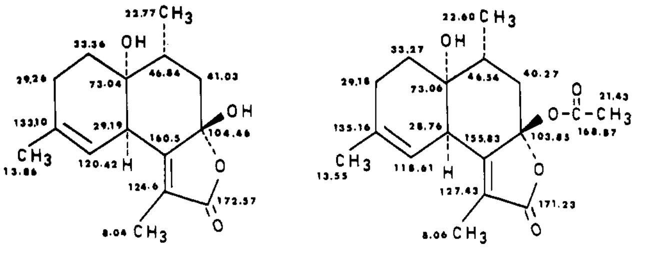
Verocephol (1) [$C_{15}H_{20}O_4$, M^+ 264, mp 198–200 °C, $[\alpha]^{20}_D$ +316° (c 1.0, MeOH)] was isolated from air-dried plant material extracted with $CHCl_3$, after exhaustive silica gel chromatography, preparative silica gel GF-254 TLC, and crystallization with ethyl acetate–hexane.



1

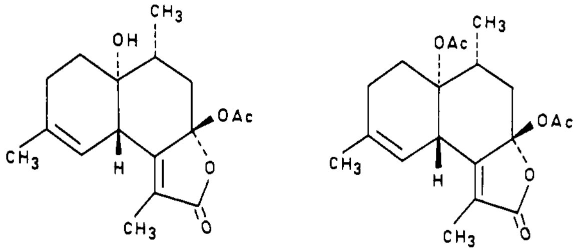
The presence of an α,β-unsaturated γ-lactone was indicated by UV (EtOH) absorption at 220 nm (ε 19600) and by an IR band (Nujol suspension) at 1750 cm^{-1}. Also hydroxyl groups absorptions were observed at 3470 and 3250 cm^{-1}.

Chart I



1
(^{13}C NMR in $CDCl_3$+DMSO-d_6)

2
(^{13}C NMR in $CDCl_3$)



3

4

Table I. ^1H NMR Spectral Data of Verocephol and Derivatives[a]

		1	2	3	4	
CH_3 14	d	0.91	0.95	0.97	1.00	J = 7.0 Hz
CH_3 15	br s	1.65	1.67	1.67	1.68	
CH_3 13	s	1.79	1.87	1.76	1.83	
H 6	m	3.43	3.49	4.97	4.90	$w_{1/2}$ = 9 Hz
H 5	br s	5.08	4.94	5.07	4.95	$w_{1/2}$ = 6 Hz
$CH_3C(O)$–	s		1.93	1.91	1.94	
$CH_3C(O)$–					1.96	

[a] 80 MHz, $CDCl_3$, and 1 in $CDCl_3$-DMe_2SO-d_6; d, doublet; br s, broad singlet; s, singlet; δ from Me_4Si.

On treatment with acetyl chloride and pyridine, compound 1 (Chart I) was converted into the monoacetate derivative 2 whereas acetylation upon reflux with acetic anhydride–pyridine produced the mono- and diacetate β H-6 epimers 3 and 4 with a cadinane skeleton where the

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[1] Coates, R. M. *Fortschr. Chem. Org. Naturst.* 1976, 33, 73.

0022-3263/85/1950-4171$01.50/0 © 1985 American Chemical Society

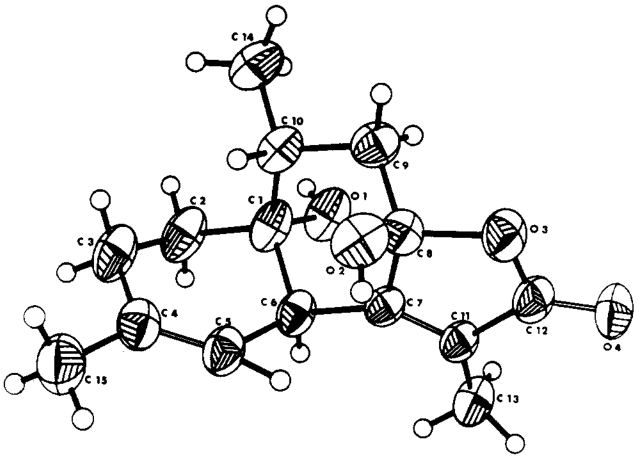

Figure 1. Molecular conformation of verocephol. Thermal ellipsoids are drawn at 50% probability level.

A/B ring junction was epimerized to trans.

As shown in Table I, the ^1H NMR chemical shifts are very similar in all compounds **1–4**. Unfortunately all attempts to use a shift reagent ($Eu(fod)_3$), to resolve the overlapped signals in derivative **2** were unsuccessful. Consequently, only the signals of two vinylic methyl groups at δ 1.67 (CH_3-15, br s) and δ 1.87 (CH_3-13, s) were assigned. One of them is attached to a trisubstituted double bond where there is a vinylic proton at δ 5.08 (H-5, br s). The other was located on the α carbon of the α,β-unsaturated lactone. The allylic proton at δ 3.43 (H-6, m; $w_{1/2}$ = 9 Hz) with a long-range coupling with CH_3-15 was assigned to the proton of the A/B cis ring fusion.

The cis–trans epimerization was suggested by the downfield shift of the allylic proton resonance of H-6 which was shifted from δ 3.49 in **2** to ca. δ 4.9 in compounds **3** and **4**.

The actual fixing of the absolute configuration of **1** was done only after the structure was determined and in our case is uniquely determined by the space group $P4_32_12$. Crystals are tetragonal, $a = b = 9.763$ (2) Å, $c = 28.893$ (5) Å; $V = 2754$ Å^3; $D_c = 1.28$ g cm^{-3}; $F(000) = 1136$, $Z = 8$, (Cu K_α) = 7.11 cm^{-1}. Intensity data, 2164 reflections, were collected on a Nicolet R3m four-circle automated diffractometer with monochromatic Cu K_α radiation, λ = 1.5418 Å, and $2\theta/\theta$ scans.

The data were corrected for Lorentz and polarization factors. No absorption correction was applied. Anomalous dispersion corrections were applied to the scattering factors for oxygen and carbon atoms. The structure was solved by direct methods (SHELXTL program[2]). The positional and anisotropic thermal parameters for non-hydrogen atoms were refined by the cascade-matrix procedure. All hydrogen atoms were found on a difference Fourier map at an advanced stage of the anisotropic refinement and forced to ride on the bonded C atom with a fixed isotropic temperature factor $U = 0.06$ Å^2. The final discrepancy factor is $R = 0.046$. The function minimized was $w\sum|\Delta F|^2$ with a weighting scheme $w = |\sigma^2(F_o) + G(F_o)^2|^{-1}$, where σ is the standard deviation of the observed amplitudes, based on counting statistics, and G is a variable to be adjusted after each cycle, final G value was 0.00191.

The perspective drawing of the X-ray structure of verocephol in Figure 1 displays two six-membered rings with a cis junction. The cyclohexene ring A exhibits a half-chair conformation with a methyl group in a quasi-equatorial configuration and a double bond between C_4 and C_5 carbon atoms. The more substituted cyclohexene ring B showed a chair conformation with C_1 and C_8 hydroxyl groups in axial positions, while the C_{10} methyl group occupies an equatorial site. The five-membered ring lactone is essentially planar.

In the tricyclic system of verocephol, the junction between A and B rings is cis type with −49.4° and −51.0°, respectively, whereas the junction between B and C rings is quasi cis type[3] with torsion angles of −55.6° and −3.0°.

The molecule is highly strained with sp^3–sp^3 C_1–C_2 and C_3–C_4 bonds slightly shorter than the ideal value[4] of 1.537 Å, while the sp^2–sp^2 carbon–carbon single bond showed a 1.536 Å value, different from the accepted value[5] of 1.502 Å.

The position of the acetate group at C_8 rather than at C_1 in compound **2** (Chart I) was established by comparison of the ^{13}C NMR data between verocephol (**1**) and its acetyl derivative **2**. In the spectrum of **2**, the differences observed in ^{13}C NMR values of some of the carbon atoms (C_5, C_6, C_7, C_8, C_9, C_{11}, and C_{12}) of compounds **1** and **2** establish the acetate on the γ-lactol hydroxyl group.

The reported amorphane sesquiterpene γ-lactol represents a very rare type of carbon skeleton which can be transformed into the more ordinary cadinane framework.

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Registry No. 1, 98064-70-1; 2, 98064-71-2; 3, 98167-29-4; 4, 98064-72-3.

Supplementary Material Available: Isolation procedure of verocephol, Tables I–IV listing atom coordinates, bond lengths, bond angles, hydrogen coordinates, and anisotropic temperature factors of verocephol (8 pages). Ordering information is given on any current masthead page.

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