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CHLOROSILPHANOL A AND SILPHANEPOXOL, LABDANE DITERPENES FROM *SILPHIUM PERFOLIATUM*[1]

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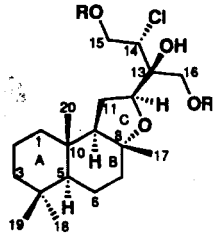
ABSTRACT.—Two carterochaetols, chlorosilphanol A and silphanepoxol, isolated from the leaves of *Silphium perfoliatum* were assigned structures **1** and **3**, respectively, from spectral studies and with absolute stereochemistry established by X-ray crystallography of **1**. Complete ^{1}H- and ^{13}C-nmr assignments for the parent compounds and their acetates **2** and **4** were made at high-field using 1D and 2D methods, and chlorosilphanol A was chemically converted via its acetate to silphanepoxol. Revision of structure for related carterochaetols in the literature is required, in particular with respect to the stereochemistry at C-12 and that of the side-chain.

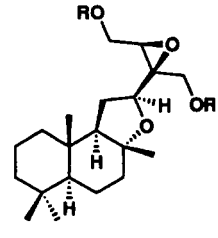
Silphium perfoliatum L. (Compositae) commonly known as "Cup Plant," is indigenous to the central and eastern parts of North America, and has been used medicinally by Native Americans (1). Previous phytochemical studies have revealed the presence of straight-chain polyenes, sesquiterpenes, triterpenes, and labdane diterpenes of the carterochaetol type (2,3), as well as triterpene glycosides (3). In this study on the leaves of *S. perfoliatum*, we report the isolation of chlorosilphanol A [**1**] and silphanepoxol [**2**] and their characterization by spectral and chemical means, with stereochemical confirmation and absolute configuration by X-ray crystallography.

RESULTS AND DISCUSSION

Chlorosilphanol A [**1**], mp 177–178°, was assigned the molecular formula $C_{20}H_{35}O_4Cl$ from high-resolution fabms using the "magic bullet" (5,6) as matrix; the eims showed no detectable molecular ion. An isotope ratio for ^{37}Cl:^{35}Cl of 1:3 confirmed the presence of the halogen and the molecular formula required three double-bond equivalents. Because the ir spectrum showed strong hydroxyl absorption, but none for carbonyl or olefinic groups, the compound must have three rings. From the ^{1}H-nmr spectrum (Table 1), three D_2O exchangeable protons were identified and from the ^{13}C-nmr spectrum (Table 2), the carbon multiplicities indicated only 32 protons bonded to carbon, thus also



1 R=H
2 R=Ac



3 R=H
4 R=Ac

[1]Taken in part from the Ph.D. dissertation of M.J.P. which was accepted by the Graduate School, The Ohio State University in June 1991.

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TABLE 1. ^{1}H-Nmr Assignments for Compounds **1–4**.[a]

Proton	Compound					
	1	**1**[b]	**2**	**3**	**3**[b]	**4**
H-1	1.04α ddd (12.8, 12.8, 3.3)	0.90α ddd (13, 13, 4.4)	1.05α ddd (12.9, 12.9, 3.5)	1.02α ddd (12.8, 12.8, 3.4)	0.88α ddd (13.5, 13.5, 3.2)	1.01α ddd 12.9, 12.9, 3.4)
	1.49β br d (14.0)	1.32β hm	1.51β br d (12.9)	1.48β br d (14.1)	1.29β hm	1.46β hm
H-2	1.43α hm [br d] (13.8)	1.34α hm	1.45α hm	1.41α hm	1.30 hm	1.47α hm
	1.68β ddddd (13.2, 13.2, 13.2, 3.3, 3.3)	1.59β hm	1.67β hm	1.67β ddddd (14.0, 14.0, 14.0, 3.7, 3.7)	1.55β ddddd (13.6, 13.6, 13.6, 3.4, 3.4)	1.66β dddd (13, 13, 13, 3.3)
H-3	1.17α ddd (13.6, 13.6, 4.2)	1.12α ddd (13.3, 13.3, 4.0)	1.17α ddd (13.7, 13.7, 4.6)	1.17α ddd (13.5, 13.5, 4.0)	1.09α ddd (13.6, 13.6, 3.8)	1.16α ddd (14.2, 14.2, 4.6)
	1.42β hm [br d] (12.8)	1.32β hm	1.41β hm	1.41β hm [br d] (13.6)	1.31β hm	1.41β hm [br d] (14.3)
H-5	0.94 dd (12.5, 2.7)	0.88 hm [dd] (12.5, 2.5)	0.95 dd (12.5, 2.7)	0.95 dd (12.5, 2.7)	0.83 dd (12.6, 2.5)	0.94 dd (12.4, 2.6)
H-6	1.78α dddd (13.8, 3.3, 3.1, 3.1)	1.64α dddd (13.9, 2.9, 2.9, 2.9)	1.78α dddd (13.8, 3.2, 3.0, 3.0)	1.77α dddd (13.9, 3.3, 3.3, 3.3)	1.60α dddd (13.6, 3.2, 3.2, 3.2)	1.76α dddd (13.8, 3.1, 3.1, 3.1)
	1.29β dddd (13.2, 13.2, 13.2, 3.3)	1.22β dddd (13.0, 13.0, 13.0, 3.2)	1.28β dddd (13.1, 13.1, 13.1, 3.2)	1.29β dddd (13.2, 13.2, 13.2, 3.3)	1.17β dddd (13.2, 13.2, 13.2, 3.3)	1.28β dddd (13.1, 13.1, 13.1, 3.2)
H-7	1.42α hm [ddd] (12.4, 12.4, 3.7)	1.54α ddd (12.2, 12.2, 3.7)	1.42α hm	1.44α hm	1.47α hm	1.41α hm
	1.91β ddd (11.6, 3.1, 3.1)	1.97β ddd (11.7, 3.0, 3.0)	1.92β ddd (11.6, 3.1, 3.1)	1.93β ddd (11.6, 3.1, 3.1)	1.92β ddd (11.6, 3.2, 3.2)	1.93β ddd (11.6, 3.2, 3.2)
H-9	1.53 dd (13.7, 4.9)	1.57 hm [dd] (13.7, 5.2)	1.56 dd (13.7, 4.8)	1.52 dd (13.6, 5.0)	1.45 hm [dd] (13.5, 5.4)	1.51 dd (13.7, 5.4)
H-11	1.65α ddd (11.2, 5.6, 5.6)	1.82α ddd (10.8, 5.4, 5.4)	1.70α ddd (10.4, 5.2, 5.2)	1.70α ddd (12.2, 5.0, 5.0)	1.70α ddd (11.4, 5.9, 5.6)	1.65α hm
	1.94β ddd (14.0, 10.5, 10.5)	2.28β ddd (13.5, 10.4, 10.4)	1.86β ddd (13.6, 10.4, 10.4)	1.94β ddd (13.6, 11.6, 10.0)	2.16β ddd (13.5, 11.0, 9.6)	1.88β ddd (13.6, 11.2, 9.4)
H-12	4.30 dd (9.9, 5.8)	4.78 dd (9.8, 5.9)	4.16 dd (9.9, 5.8)	4.04 dd (9.8, 6.2)	4.46 dd (9.4, 6.5)	4.09 dd (9.2, 6.8)

TABLE 1. Continued.

Proton	Compound					
	1	1[b]	2	3	3[b]	4
H-14	4.08 dd (6.3, 4.5)	4.91 dd (7.0, 3.3)	4.23 m	3.33 dd (6.0, 6.0)	4.04 dd (6.6, 4.0)	3.33 dd (7.3, 3.5)
H-15	3.79 dd (12.3, 6.3)	4.45 dd (12.4, 7.1)	4.23 m	3.71 dd (12.3, 5.8)	4.19 dd (12.3, 6.7)	4.09 dd (12.5, 7.2)
	3.97 dd (12.4, 4.0)	4.63 dd (12.4, 3.3)	4.58 m	3.82 dd (12.3, 6.0)	4.26 dd (12.3, 4.0)	4.36 dd (12.5, 3.6)
H-16	3.64 br d (10.9)	4.40 d (11.0)	4.19 d (11.9)	3.82 d (12.7)	4.32 d (12.5)	4.40 d (12.6)
	3.99 d (11.3)	4.47 d (10.9)	4.56 d (11.8)	3.84 d (12.7)	4.35 d (12.5)	4.42 d (12.6)
H-17	1.19 s	1.37 s	1.17 s	1.19 s	1.24 s	1.16 s
H-18	0.86 s	0.81 s	0.86 s	0.86 s	0.79 s	0.86 s
H-19	0.82 s	0.77 s	0.82 s	0.82 s	0.75 s	0.82 s
H-20	0.85 s	0.81 s	0.85 s	0.86 s	0.74 s	0.84 s
Misc.	3.23 (13-OH) s		2.106 (Ac) s			2.06 s
	2.85 (15-OH) br s		2.110 (Ac) s			2.10 s
	3.49 (16-OH) br s					

[a]Taken at 500 MHz in $CDCl_3$ with data-point resolution of 0.3 Hz and chemical shifts (δ) in ppm as referenced to TMS with residual solvent peak ($CHCl_3$) taken as internal standard at 7.26 ppm. Stereochemical designations α and β following the chemical shift refer to the proton below and above the plane, respectively, of the illustrated drawing. Spin-coupled patterns are designated as follows: s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet, br=broadened, and h=hidden or overlapped. The spin coupling (J) is given in parentheses in Hz; and refers to separation values solely for characterization and may not be the true J as in non-first-order patterns. Some hidden patterns were clarified by nOe studies and by homonuclear decoupling and are reported after the hm designation in square brackets.

[b]In pyridine-d_5, with the upfield peak of pyridine-d_4 set at 7.19 ppm.

TABLE 2. ^{13}C-Nmr Data for Compounds **1–4**.[a]

Carbon	Compound						
	1	multiplicity	**1**[b]	**2**	**3**	**3**[b]	**4**
C-1	40.29	t	40.16	40.34	40.22	40.00	40.22
C-2	18.56	t	18.69	18.56	18.56	18.62	18.54
C-3	42.59	t	42.67	42.65	42.59	42.58	42.59
C-4	33.28	s	33.18	33.32	33.28	33.10	33.28
C-5	57.26	d	57.15	57.30	57.26	57.00	57.27
C-6	21.46	t	21.53	21.50	21.26	21.20	21.20
C-7	40.75	t	40.40	40.78	40.47	40.77	40.34
C-8	81.80	s	80.76	81.46	81.99	80.75	81.51
C-9	60.47	d	61.12	60.98	60.88	61.04	60.95
C-10	36.58	s	36.53	36.64	36.61	36.43	36.56
C-11	24.15	t	24.31	24.11	25.59	25.83	25.69
C-12	82.37	d	80.23	78.99	77.79	77.80	76.33
C-13	74.41	s	76.73	75.05	63.13	64.60	61.79
C-14	67.49	d	70.64	62.18	60.88	62.00	57.77
C-15	63.93	t	64.23	65.26	60.67	60.59	62.40
C-16	66.21	t	64.14	66.03	62.73	62.00	62.70
C-17	24.88	q	25.11	25.13	24.57	24.29	24.03
C-18	33.65	q	33.60	33.68	33.68	33.54	33.70
C-19	21.15	q	21.12	21.16	21.16	21.10	21.20
C-20	16.02	q	15.97	16.05	16.00	15.70	15.82
*Me*CO		q		21.01			10.95
*Me*CO		q		21.13			21.02
Me*C*O		s		170.81			170.58
Me*C*O		s		171.30			170.94

[a]Taken at 67.9 MHz in $CDCl_3$ or pyridine-d_5 with multiplicities determined by SFORD. The chemical shift (δ) in ppm was referenced to TMS with reference peak of solvent taken as 77.2 ppm (center) for $CDCl_3$ and 123.5 (center) for upfield carbon of pyridine-d_5. Abbreviations are s=singlet, d=doublet, t=triplet, and q=quartet.

[b]In pyridine-d_5.

supporting the presence of three hydroxyls. The fourth oxygen must be an ether oxygen since no carbon peaks were observed beyond 83 ppm, thus clearly eliminating carbonyl and olefinic groups. Acetylation of chlorosilphanol A [**1**] under mild conditions formed a diacetate **2** and required the third hydroxyl to be tertiary.

A series of high-field 2D nmr experiments [COSY (7) and CH-correlation (8–10)] allowed the identification of five proton-coupled units as partial structures: C-1 through C-3, C-5 through C-7, C-9 through C-12, and C-14 to C-15 and C-16. The COLOC experiment (11) located the quaternary carbons to which the coupled units are attached. For example, in $CDCl_3$, H-1α (1.04 ppm) and H-9 (1.53 ppm) both showed, in this experiment for the detection of long-range coupling, two-bond coupling to C-10 (36.58 ppm). Similarly, H-3α (1.17 ppm) and H-5 (0.94 ppm) coupled to C-4 (33.28), and H-3α also coupled to C-18 (33.65 ppm), and H-5 coupled to C-19 (21.15 ppm) and C-20 (167.02 ppm). The H-20 (0.85 ppm) coupling to C-9 (60.47 ppm) distinguished Me-20 from Me-19. Thus, three proton-coupled units were connected and three methyl groups assigned. In like manner, the details of which are not described in full here, the remaining units were assembled to reveal the carbon skeleton of chlorosilphanol A [**1**] to be the carterochaetol type. The fabms fragments supported this ring system by showing peaks at *m/z* 235 (16%, $C_{16}H_{27}O$) from cleavage of the side-chain and the base peak at *m/z* 191 ($C_{14}H_{23}$) from the loss of C-11, C-12, H-17, and the ether oxygen, the latter as previously reported (12).

Relative stereochemical assignments were based on results from nOe difference experiments (13,14); the most significant of which are shown in Figure 1. Thus, it was established that in the *trans*-decalin system of rings A and B, three of the methyl groups are on the same face of the molecule with H-5 on the opposite side. A trans-ring B/C junction was likewise indicated with the chlorohydrin-bearing side-chain disposed on the same face as Me-17. In addition, nOe experiments at 500 MHz provided clear multiplicity patterns, which in the normal spectrum are obscured by the overlapping of other patterns, and allowed the determination of accurate chemical shifts and coupling constants. Both the 1D and 2D nmr experiments were also run in pyridine-d_5 to shift hidden patterns for easier analysis.

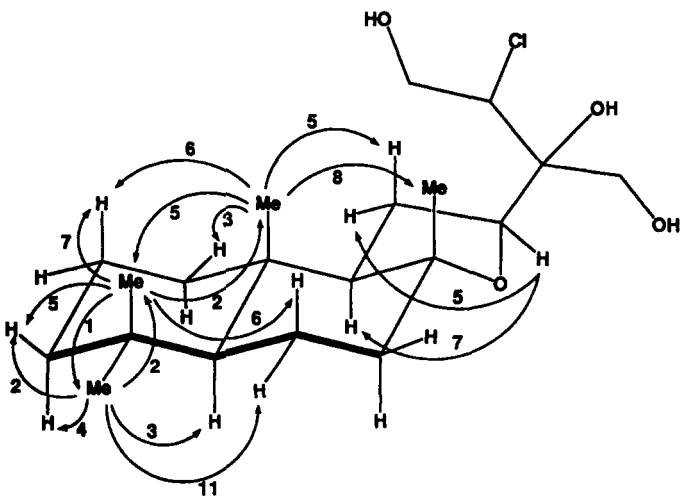

FIGURE 1. Percent NOe Enhancements by Difference Nmr Spectroscopy for Chlorosilphanol A [**1**] at 270 MHz in $CDCl_3$.

The preparation of epoxide **3** from chlorosilphanol A [**1**] was accomplished by treatment of the diacetate **2** with *t*-BuOH in THF. Use of the diacetate eliminated possible formation of the C-14, C-15-epoxide. In epoxide **3** the configuration of the hydroxyl-bearing carbon C-13 remains the same as the starting material, but the former chlorine-containing carbon (C-14) is inverted. The reaction conditions, although mild, were sufficient to also cleave the acetate protecting groups. Epoxide **3** was also isolated from the plant and was given the name silphanepoxol [**3**], and exhibited mp 141–142°. The spectral data supported the proposed structure; hrms showed a molecular ion at *m/z* 338 for the formula $C_{20}H_{34}O_4$, which has an additional double-bond equivalent consistent with an additional ring. The ir spectrum showed a peak at 1220 cm^{-1} for the epoxide. The same 1D and 2D nmr experiments as performed for chlorosilphanol A [**1**] were carried out with silphanepoxol [**3**], with the results recorded in Tables 1 and 2. NOe studies showed the epoxide to have C-15 and C-16 trans disposed, because irradiation of H-14 (3.33 ppm) enhanced one H-15 (3.71 ppm, 2%) and both H-16 signals (3.84 ppm 3% and 3.82 ppm, 2%). Preparation of silphanepoxol diacetate [**4**] confirmed the presence of the diol and supported the nmr assignments.

A single crystal X-ray crystallographic study revealed the structure of chlorosilphanol A [**1**] as shown in Figure 2. This confirmed the relative disposition of the substituents on the decalin system as established by the nOe experiments and that of the side-chain

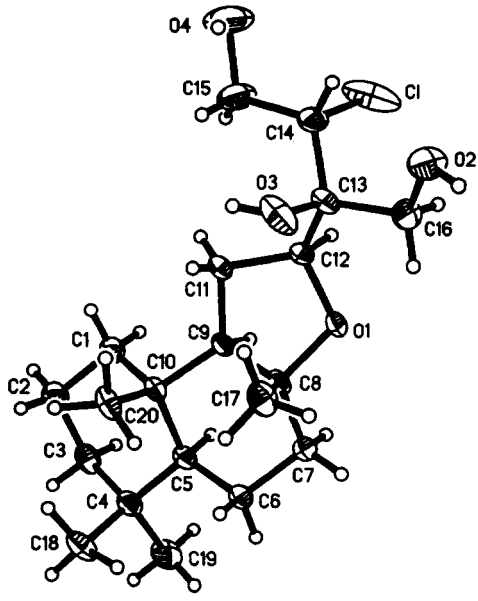

FIGURE 2. ORTEP Drawing of the Final X-Ray Model for Chlorosiphanol A [**1**]. (Ellipsoids at 30% probability level).

for which no data were available. Furthermore, the absolute stereochemistry became known.[3]

The literature (2) records, from the same plant source, a compound which undoubtedly is silphanepoxol [**3**], and comparison of our physical data with the limited values reported for it and its acetate (stated to contain 10% of an isomer) would suggest their co-identity. However, the published structure has opposite configuration at C-12 and has a β-epoxide with C-15 and C-16 drawn cis. The epoxide apparently was formed by treatment of the corresponding olefin where C-15 and C-16 are drawn trans, and the two products separated by tlc, but no supporting evidence is given for the α- or β-stereochemical assignment. Our work indicates that the C-12 stereochemistry should be reversed for all of the carterochaetols reported before from *S. perfoliatum* (2), as well as those isolated from *Carterothamnus anomalochaeta* R.M. King (12). For the first time the absolute stereochemistry has been established for this class of diterpenes and complete ^{1}H- and ^{13}C-nmr spectral assignments made. Compound **1** is one of a handful of chlorine-containing diterpenes reported from higher plants (15).

EXPERIMENTAL

GENERAL EXPERIMENTAL PROCEDURES.—Mps are uncorrected and were taken on a Thomas-Hoover Unimelt or a Fisher-Johns hot-stage apparatus. Ft-ir spectra were obtained on AgCl plates as films using a Laser Precision RFX-40 instrument; specific rotations were determined on a Perkin-Elmer Model 241 polarimeter; uv spectra were obtained using a Beckman UV-5260 spectrophotometer; and the ms determined at 70 eV on a Kratos MS-30 instrument or a VG 70-2505 mass spectrometer with fabms utilizing Xe and glycerol, "magic bullet" [dithiothreitol-dithioerythritol (3:1) in MeOH] or *m*-nitrobenzyl alcohol as matrix. Nmr analyses were performed at 6.35 Tesla on an IBM AF-270 instrument and at 11.75

[3]Crystallographic parameters for this compound have been deposited with the Cambridge Crystallographic Data Centre, and may be obtained on request from Dr. Olga Kennard, University Chemical Laboratory, 12 Union Road, Cambridge CB2 1EZ, UK.

Tesla on a Bruker AM-500 spectrometer equipped with an Aspect 3000 data system, using the automation sequences in the Bruker collection, specifically COSY.AU for ^{1}H-nmr shift correlation. XHCORRD.AU for CH-correlation with homonuclear ^{1}H decoupling, COLOC.AU for long-range (2- to 4-bond) CH-correlation with polarization delay (D2 0.06 msec) set for 8 Hz coupling, and NOEMULT.AU for nOe difference. Si gel 60 was used for tlc and column chromatography, with reversed-phase tlc plates (RP-8 and RP-18), and prepacked Lobar RP-8 columns were from E. Merck. Sephadex LH-20 was from Pharmacia. Solvents were Reagent Grade and redistilled before use.

PLANT MATERIAL.—The leaves of *Silphium perfoliatum* L. were collected in July 1989, in Fairfield County, Ohio, along Deer Creek. A voucher specimen of the entire plant is on deposit at The Ohio State University Herbarium in Columbus, Ohio. The dried leaves (40° for 72 h in a forced-draft oven) were ground in a Wiley mill to pass through a 2-mm sieve.

EXTRACTION AND INITIAL FRACTIONATION.—EtOH percolation of 3.5 kg of ground leaves yielded 404 g of residue after extraction to exhaustion and removal of the solvent at reduced pressure. Partitioning of the residue between $CHCl_3$ (3×) and H_2O using 2 liters of each solvent gave 211 g of $CHCl_3$-solubles, which were partitioned between hexane (3×) and MeOH-H_2O (9:1) using 1 liter of each solvent.

The MeOH solubles (110 g) were passed through a Sephadex LH-20 column in MeOH using about 1 g material for 10 g of absorbent. Effluent fractions were analyzed by tlc on Si gel with $CHCl_3$-MeOH (20:1) and detected by spraying with *p*-anisaldehyde reagent (5 ml in 90 ml MeOH and 5 ml H_2SO_4) and heating (110–120°) for color development. The fractions with blue and purple zones were pooled to give 80.5 g of total terpenes.

The terpene fraction (45 g) was mixed with 45 g of Si gel added to a 600 g Si gel (70–230 mesh) column poured in $CHCl_3$. Elution was with mixtures of MeOH in $CHCl_3$ (0.5, 1, 2, 5, 10, 20, and 30%) and the 15-ml effluent fractions were analyzed by tlc using $CHCl_3$-MeOH (20:1) to give 20 pooled fractions containing similar mixtures.

X-RAY DIFFRACTION.—Chlorosilphanol A crystallized from MeOH and EtOAc in the orthorhombic space group $P2_12_12_1$ with a=6.102(2), b=13.284 (7), c=24.700(3) Å and one molecule of composition $C_{20}H_{35}ClO_4$ in the asymmetric unit. Two octants of data were collected at room temperature using θ:ω scans and CuKα radiation (1.54178 Å). After Lorentz, polarization, and background corrections, a total of 2633 (95.3%, 3.0σ) Friedel-redundant data were judged observed and used in all subsequent calculations. The structure was solved by direct methods and refined by full-matrix least-squares using the SHELXS system of programs. Anisotropic thermal parameters were employed for non-hydrogen atoms, and hydrogens were fixed geometrically with riding constraints. The final discrepancy index (R-factor) is 7.66% and the absolute configuration of chlorosilphanol A was established by the η-method (1.10 (8) for the final X-ray model shown in Figure 2. The same absolute stereochemistry was also indicated by Hamilton's test (16) since the R-factor for the correct stereoisomer, given in Figure 2, is 0.077 while its enantiomer has an R-factor of 0.084. The final model has two trans-fused cyclohexane rings (A and B) and one trans-fused tetrahydrofuran ring (C). The axial methyl groups at C-8 and C-10 are on the same side of the molecule. In addition, both cyclohexanes have chair conformations while the tetrahydrofuran ring has an envelope conformation.

CHLOROSILPHANOL A [**1**].—A 0.9 g sample of column fraction 3 was chromatographed on 100 g of Si gel using mixtures of MeOH in PhMe (2, 4, and 5%) as eluents. The clear oil (347 mg) eluted with the second solvent gave from $CHCl_3$/hexane, 122 mg of chlorosilphanol A as colorless needles: mp 177–178°; $[\alpha]^{21}D$ −4.97° (c=0.1, MeOH); ir (film) ν max 3386 (OH), 1074 (C-O), 1041, 1010, and 748 (C-Cl) cm^{-1}; uv (MeOH) λ (end abs) 201 nm (log ϵ 3.15); fabms ("magic bullet") m/z 377.2254 (MH^+, 18, $C_{20}H_{35}O_4Cl^{37}$ requires 377.2254), 375.2266 (MH^+, 54, $C_{20}H_{35}O_4Cl^{35}$ requires 375.2243), 357 (MH^+-H_2O, 9), 339 (MH^+-HCl, 4), 235 (16), 191 (99), 163 (17), 137 (53), 95 (57) and 69 (100); ^{1}H- and ^{13}C-nmr spectral data shown in Tables 1 and 2, respectively.

CHLOROSILPHANOL A 15,16-DIACETATE [**2**].—Chlorosilphanol A [**1**] (10 mg) was treated with 1 ml each of Ac_2O and pyridine at room temperature. After 20 h the mixture was evaporated under reduced pressure and the residue, after treatment 3 times with $CHCl_3$ and similar evaporation, was dissolved in 1 ml of $CHCl_3$ and extracted 3 times with 1 ml of H_2O. Evaporation of the $CHCl_3$ layer to dryness gave 7 mg of the diacetate **2** as a heavy oil: $[\alpha]^{21}D$ −17.7° (c=0.04, MeOH); ir (film) ν max 3556 (OH), 1742 (C=O), 1231 (C-O), 1097, 1044, and 1011 cm^{-1}; uv (MeOH) λ (end abs) 202 nm (log ϵ 2.72); eims m/z 460.2406 (M^+, 0.13, $C_{24}H_{39}O_6Cl^{37}$ requires 460.2395), 458.2435 (M^+, 0.02, $C_{24}H_{39}O_6Cl^{35}$ requires 458.2425), 407 (8), 287 (4), 235 (14), 217 (18), 191 (92), 137 (75), 109 (53) and 69 (100); ^{1}H- and ^{13}C-nmr data shown in Tables 1 and 2, respectively.

CONVERSION OF CHLOROSILPHANOL A [**1**] TO SILPHANEPOXOL [**3**].—Chlorosilphanol A diacetate [**2**] (65 mg) was dissolved in 2 ml of dry THF and 8 mg of *t*-BuOK were added. After 2 h the reaction mixture was

evaporated under reduced pressure, taken up in 2 ml of $CHCl_3$, and extracted with H_2O (3×). The $CHCl_3$ solution on evaporation under reduced pressure gave 41 mg of residue that was chromatographed on a Si gel column (0.25×28 cm) with $CHCl_3$ to give 24 mg of an oil that was crystallized from $CHCl_3$/hexane to give 20 mg of silphanepoxol [**3**] as colorless needles: mp 141–142°; $[\alpha]^{21}D$ −7.2° (*c*=0.3, MeOH); ir (film) ν max 3357 (OH), 1220, 1091, 1079, 1066, 1041, and 1001 cm^{-1}; uv (MeOH) λ (end abs) 203 nm (log ε 2.91); eims *m/z* 338.2454 (M^+, 2, $C_{20}H_{34}O_4$ requires 338.2457), 287 (63), 263 (82), 191 (83), 137 (93), 109 (90), 95 (100) and 69 (87); ^1H- and ^{13}C-nmr data shown in Tables 1 and 2, respectively.

SILPHANEPOXOL DIACETATE [**4**].—Silphanepoxol [**3**] (5 mg) was acetylated and the reaction mixture worked up as described for chlorosilphanol A. The 4 mg of diacetate **4** was obtained as a heavy oil: $[\alpha]^{21}D$ +8.5° (*c*=0.2, MeOH); ir (film) ν max 1743 (C=O), 1234, 1043, and 1010 cm^{-1}; eims *m/z* 423.2721 (MH^+, 0.3, $C_{24}H_{39}O_6$ requires 423.2746), 235 (25), 191 (100) and 137 (25); ^1H- and ^{13}C-nmr data shown in Tables 1 and 2, respectively.

ISOLATION OF SILPHANEPOXOL [**3**].—A 6.7 g sample of the MeOH-H_2O (9:1)-soluble partition fraction was chromatographed on 400 g of Si gel with a $CHCl_3$ to 10% MeOH in a $CHCl_3$ linear continuous gradient solvent system (5.4 liters). The 3% MeOH effluent (160 ml) gave 240 mg of a residue that yielded from hexane/MeCOEt 53 mg of silphanepoxol [**3**], which was identical (tlc, mp, ir, ms, ^1H and ^{13}C nmr) with the compound prepared from chlorosilphanol A diacetate [**2**].

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