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# SESQUITERPENES FROM *PITYROGRAMMA CALOMELANOS*

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**Key Word Index**—*Pityrogramma calomelanos*; Gymnogrammaceae; silver fern; sesquiterpenes; structural analysis.

**Abstract**—Pterosin Z has been obtained from *Pityrogramma calomelanos*. A related compound calomelanolactone has also been isolated and its structure assigned from chemical, spectral, biogenetic and X-ray evidence.

## INTRODUCTION

*Pityrogramma calomelanos* L., 'silver fern', is quite common throughout the Caribbean and surrounding tropical areas. In Guyana an aqueous extract of this fern is used as a cure for venereal diseases. Previous investigations of the plant have yielded chalcones and related compounds [1]. We have investigated this plant collected on the lowlands of Timheri, Guyana. From the aerial parts we have isolated, by repeated column and preparative layer chromatography, two major constituents pterosin Z (**1**) and calomelanolactone (**2**).

## RESULTS AND DISCUSSION

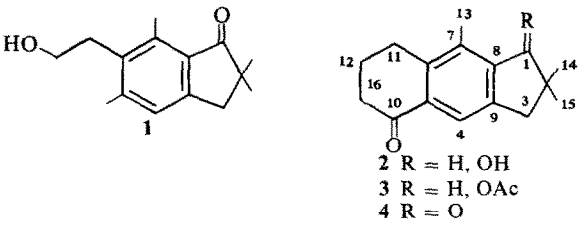
Pterosin Z (**1**) was previously reported from *Pteridium aquilinum* [2] and *Hypolepis punctata* [3] two members of the Pteridaceae, a family closely related to the Gymnogrammaceae. Although we failed to crystallize (**1**), its IR spectrum showed all the major peaks previously reported for pterosin Z, the UV was similar, and the NMR was virtually identical. In addition, acetylation yielded a monoacetate whose physical characteristics compared well with the monoacetate of pterosin Z as prepared by Hayashi *et al.* [3].

The second compound calomelanolactone (**2**), mp 160–162°, analysed for $C_{15}H_{18}O_3$ (*m/e* 246) and its IR spectrum revealed both hydroxy (3490 $cm^{-1}$) and C=O (1710 $cm^{-1}$) absorption. In addition, the UV gave $\lambda_{max}^{MeOH}$ nm (log ε): 260 (3.4); 293 (3.4). The PMR spectrum showed similarities with pterosin Z indicating that (**2**) was related to the pterosins [2]. There were two quaternary methyls (δ 1.02, 3H, *s* and δ 1.22, 3H, *s*), and one aromatic proton (δ 7.73). However only one aromatic methyl group (δ 2.37) was present as well as a proton attached to a hydroxyl bearing carbon [(δ 4.62, *s*, shifting to lower field (δ 6.01 *s*) on formation of the acetate (3); (δ 2.10, 3H, *s*)].

The $A_2B_2$ system, so typical of this group of compounds, was quite apparent, but the lower field triplet was significantly deshielded (δ 4.47). In addition, the compound on treatment with base could only be reisolated from the reaction mixture on acidification, suggesting that the absorption band at $\nu_{max}^{CHCl_3}$ 1710 $cm^{-1}$ was due to a lactone in conjugation with the aromatic ring.

The above evidence coupled with biogenetic considerations lead to either structure (**2**) or an isomer with Me at C-5 for calomelanolactone in which one of the aromatic methyl groups has been oxidized to the level of a carboxylic acid and lactonized on to the hydroxyethyl side chain. Both aromatic methyl groups are known to occur as hydroxymethyls in this group of compounds, e.g. pterosins S, T and U [4].

Characterization of the ketone (**4**) obtained from




Scheme 1. Sesquiterpenes from *Pityrogramma calomelanos*.

reaction of calomelanolactone with Jones reagent allowed us to distinguish between the two structures. Calomelanolactone showed the aromatic methyl group at δ 2.37 in the PMR spectrum. The oxidation product (**4**) (no —OH absorption in the IR but $\nu_{max}^{CHCl_3}$ 1722, 1705 $cm^{-1}$) showed in the PMR spectrum a marked down field shift of its aromatic methyl to δ 2.67 indicating the relation of the newly created carbonyl to the aromatic methyl as in (**2**) and simultaneously eliminating the possibility of the hydroxyl group in the parent compound being at carbon 3.

This structure has been confirmed by X-ray analysis.* Crystals of calomelanolactone are monoclinic with systematic extinctions conforming to the common chiral space group $P2_1$. Accurate cell constants determined from a least-squares fit of fifteen high angle reflections, were: $a = 9.676(4)$, $b = 5.822(2)$, $c = 12.034(4)$ Å and $\beta = 97.40(3)°$. A density of 1.22 g/cc indicated one

* Supplemental material available on request, from Prof. Jon Clardy, Department of Chemistry, Iowa State University.

molecule of $C_{15}H_{18}O_3$ formed the asymmetric unit. All unique diffraction maxima with $2\theta \leqslant 114.1°$ were recorded on a four-circle diffractometer using graphite monochromated $CuK_\alpha$ radiation (1.54178 Å) and a 1° $\omega$-scan. Of the 996 unique reflections surveyed, 834 (84%) were judged observed after correction for Lorentz, polarization and background effects.

The structure was determined uneventfully by a multisolution weighted tangent formula approach [5]. All hydrogen atoms save those attached to C(11) and C(12) were located on difference electron density syntheses and included in subsequent calculations [6]. Full matrix least-squares refinement with anisotropic temperature factors for the nonhydrogen atoms and isotropic temperature factors for hydrogen converged to a conventional crystallographic discrepancy index of 0.065. Fig. 1 is a computer generated perspective drawing of the final X-ray model. The absolute configuration was not determined by the X-ray experiment.

All bond distances and angles agree well with generally accepted values save those involving C(12) which has a large apparent thermal motion perpendicular to the best ring plane. This may indicate two similar conformers exist in the crystal and the X-ray experiment shows only an unrealistic average. The five membered ring is in an envelope conformation; C(1), C(8), C(9) and C(3) are coplanar within 0.002 Å and C(2) is 0.47 Å out of this plane. The lactone ring also appears to have an envelope form; C(11), C(6), C(5), C(10) and O(16) are coplanar within 0.02 Å and C(12) is 0.22 Å out of the plane. This may not be significant due to the large estimated standard deviations of C(12). There are no intermolecular contacts less than 3.34 Å save one C—OH···O=C distance of 2.80 Å, which corresponds to hydrogen bond.

Calomelanolactone has a unique oxidation pattern in that it is a pterosin skeleton in which the carbonyl normally present at $C_1$ (the 1-indanone structure) has been reduced to a hydroxyl and the aromatic methyl at $C_5$ has been oxidized to the level of a carboxy function. The list of pterosins and the related pterosides continue to grow [7], and evidence for their terpenoid origin has been obtained recently [8]. The 1-indanone skeleton now shows a wide variety of oxidation levels including phenolic members [9, 10], and in addition to pterosides with the glucoside residue at the oxygen atom in the ethanol side chain as well as on the oxygen function at C-3 [7], we now have examples of the glycosidic residue being arabinose [11]. These compounds are, so far, confined to three closely related fern families Pteridaceae [7], Cryptogrammataceae [10] and now the Gymnogrammaceae.

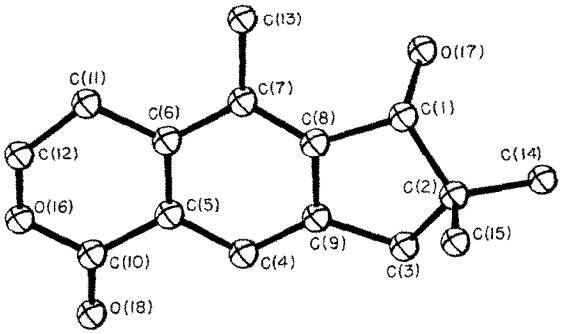



Fig. 1. A computer generated perspective drawing of a calomelanolactone. Hydrogen atoms are not shown and no absolute configuration is implied.

## EXPERIMENTAL

Mps are uncorr. PMR spectra of $CDCl_3$ solns with TMS as int. stand. Column chromatography was performed on neutral $Al_2O_3$ and TLC on Si gel Merck 60 $PF_{254/366}$.

*Extraction and isolation.* The aerial parts of the freshly harvested plant were ground, percolated with petrol (bp 40–60°) and then with $Me_2CO$. The $Me_2CO$ extract on evaporation gave a gum A (92.1%) which was run on a column of $Al_2O_3$ (Grade I, Brockmann). The EtOAc fractions yielded a gum B (14% of original gum A) which on PLC ($Me_2CO$–petrol, 1:3) gave two constituents one of slower $R_f$ (7% of gum B) and a higher $R_f$ band (36% gum B). The band of slower $R_f$ (Pterosin Z) (1) analyzed for C, 76.52; H, 8.67. Calcd for $C_{15}H_{20}O_2$: C, 77.55; H, 8.68%. IR $\nu_{max}^{CHCl_3}$ 3510, 1690, 1600 $cm^{-1}$; $\lambda_{max}^{MeOH}$ nm (log $\varepsilon$): 215 (3.9); 259 (3.6); 305 (2.9); PMR $\delta$, 7.03 (1H, *s*), 3.73 (2H, *t*, $J$ = 7 Hz), 3.00 (2H, *t*, $J$ = 7 Hz), 2.97 (1H, exch. $D_2O$), 2.83 (2H, *s*), 2.67 (3H, *s*), 2.43 (3H, *s*), 1.20 (6H, *s*). *Pterosin Z monoacetate.* Found: C, 74.43, H, 8.99. Calcd for $C_{17}H_{22}O_3$: C, 74.42, H, 8.08%; IR, $\nu_{max}^{CHCl_3}$ 1730, 1690, 1600, 1200 $cm^{-1}$; PMR, $\delta$ 7.08 (1H, *s*); 4.15 (2H, *t*, $J$ = 8 Hz); 3.03 (2H, *t*, $J$ = 8 Hz); 2.87 (2H, *s*); 2.70 (3H, *s*); 2.43 (3H, *s*); 2.06 (3H, *s*); 1.20 (6H, *s*). The band of higher $R_f$ (calomelanolactone) (2) mp 160–162° (EtOAc–petrol); analysed for C, 72.78; H, 7.20. $C_{15}H_{18}O_3$ requires: C, 73.15; H, 7.37%. IR $\nu_{max}^{CHCl_3}$ 3490, 3050, 1710, 1610, 1470, 1445, 1260 $cm^{-1}$; $\lambda_{max}^{MeOH}$ nm (log $\varepsilon$): 260 (3.4); 293 (3.4); 307.5 (2.6); PMR $\delta$ 7.73 (1H, *s*); 4.62 (1H, *s*); 4.47 (2H, *t*, $J$ = 6 Hz); 2.93 (2H, *t*, $J$ = 6 Hz); 2.83 (1H, *s*); 2.68 (1H, *s*); 2.37 (3H, *s*); 2.00 (1H, exch. with $D_2O$); 1.22 (3H, *s*); 1.02 (3H, *s*). $CrO_3$ oxidation of calomelanolactone with Jones reagent gave (4) IR $\nu_{max}^{CHCl_3}$ 1722, 1705, 1605, 1292, 1200 $cm^{-1}$; $\lambda_{max}^{MeOH}$ nm (log $\varepsilon$): 235 (3.4); 257 (3.4); 346 (2.7); PMR, $\delta$ 8.03 (1H, *s*); 4.55 (2H, *t*, $J$ = 6 Hz); 3.03 (4H, *m*); 2.67 (3H, *s*); 1.23 (6H, *s*). $\delta$[$C_6D_6$–$CDCl_3$ (3:1)] 8.00 (1H, *s*); 3.88 (2H, *t*, $J$ = 6 Hz); 2.53 (2H, *s*); 2.40 (3H, *s*); 2.22 (2H, *t*, $J$ = 6 Hz); 2.53 (2H, *s*); 2.40 (3H, *s*); 2.22 (2H, *t*, $J$ = 6 Hz); 1.07 (6H, *s*). Calomelanolactone monoacetate (3). Found: C, 71.34; H, 7.34. $C_{17}H_{20}O_4$ requires C, 70.81; H, 6.99; IR $\nu_{max}^{CHCl_3}$, 1715, 1610, 1470, 1237, 1210. PMR, $\delta$ 7.87 (1H, *s*); 6.01 (1H, *s*); 4.52 (2H, *t*, $J$ = 6 Hz); 2.90 (4H, *m*); 2.33 (3H, *s*); 2.10 (3H, *s*), 1.17 (3H, *s*); 1.10 (3H, *s*).

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