# Fern Constituents: Sesterterpenoids Isolated from Fronds of *Aleuritopteris mexicana*

Rumiko KAMAYA,[a] Kazuo MASUDA,[a] Kiyomi SUZUKI,[a] Hiroyuki AGETA,*[,a] and Hong-Yen HSÜ[b,1)]

*Shôwa College of Pharmaceutical Sciences,[a] Machida, Tokyo 194, Japan and Brion Research Institute of Taiwan,[b] 116, Chung-Chang Rd., Taipei 10743, Taiwan, R. O. C.* Received October 2, 1995; accepted November 22, 1995

**Four sesterterpenoids, cheilanthenetriol (1) and three new compounds, were isolated from the fronds of *Aleuritopteris mexicana* together with the triterpenoids squalene, tirucalla-7,21-diene, neohop-12-ene, neohop-13(18)-ene, fern-7-ene, fern-8-ene, ferna-7,9(11)-diene, adian-5-ene and adian-5-ene ozonide, and the flavonoids 3,5-dihydroxy-7,4′-dimethoxyflavone and 5-hydroxy-7,4′-dimethoxyflavone. The structures of the three new compounds were established as (17*Z*)-13,19-epoxycheilanth-17-en-6α-ol (2), 18-episcalar-16-ene-6α,19-diol (3) and 16α,19-epidioxy-18-episcalar-17(25)-en-6α-ol (4) on the basis of detailed spectral analyses.**

**Key words** *Aleuritopteris mexicana*; sesterterpenoid; (17*Z*)-13,19-epoxycheilanth-17-en-6α-ol; 18-episcalar-16-ene-6α,19-diol; triterpenoid; flavonoid

The ferns belonging to the genus *Aleuritopteris*[2)] of Adiantaceae are widely distributed in the world as typical ferns on limestone, though only three species have been found in Japan. One of them, *Aleuritopteris mexicana* FÉE (=*Cheilanthes krameri* FR. *et* SAV., iwa-urajiro in Japanese)[2)] is a vulnerable species in Japan because of limestone mining. One of the authors found a big colony of this species in Taiwan in 1960, and Saiki[2)] concluded that Japanese, Formosan and Mexican specimens all belonged to the same species on the basis of morphological and chemical (TLC of the extracts) evidence. Thus, this species is widely distributed in Mexico, Guatemala, Costa Rica, Japan, Taiwan, China (central to south west and Tibet), Bhutan and India (south and Himalayas). In the course of studies on *Aleuritopteris* and *Cheilanthes*, we have reported one diterpenoid, alepterolic acid, from *A. argentea* FÉE (hime-urajiro),[3)] two sesterterpenoids, cheilanthenediol and cheilanthenetriol (**1**) from *A. khunii* CHING (miyama-urajiro),[4)] and neither diterpenoid nor sesterterpenoid from *C. chusana* HOOK. (ebigara-shida).[5)] Thus, the chemical investigation of diterpenoids, sesterterpenoids, triterpenoids and flavonoids in the genus is of chemotaxonomic interest. This paper concerns the isolation and characterization of the sesterterpenoids, triterpenoids and flavonoids from *A. mexicana* collected in Taiwan.

## Results and Discussion

The fresh fronds of the fern were extracted with *n*-hexane. The extract was subjected to silica gel and Sephadex LH 20 column chromatography followed by HPLC to give cheilanthenetriol (**1**) and three new sesterterpenoids (**2**—**4**), together with nine triterpenoids, namely squalene,[6)] tirucalla-7,21-diene,[7)] neohop-12-ene,[8)] neohop-13(18)-ene,[9)] fern-7-ene,[10)] fern-8-ene,[11)] ferna-7,9(11)-diene,[8)] adian-5-ene[10)] and adian-5-ene ozonide,[11)] and two flavonoids, namely 3,5-dihydroxy-7,4′-dimethoxyflavone[4)] and 5-hydroxy-7,4′-dimethoxyflavone.[12)] Compound **1** was identified by direct comparison with an authentic sample.[4)] This is the second time that adianene ozonide has been isolated from ferns.

Compound **2** was shown to have the molecular formula $C_{25}H_{42}O_2$ by high-resolution mass spectrometry (HRMS), indicating five degrees of unsaturation. The absorption at 3450 $cm^{-1}$ in the IR spectrum and the formation of a monoacetate (**2a**) indicated the presence

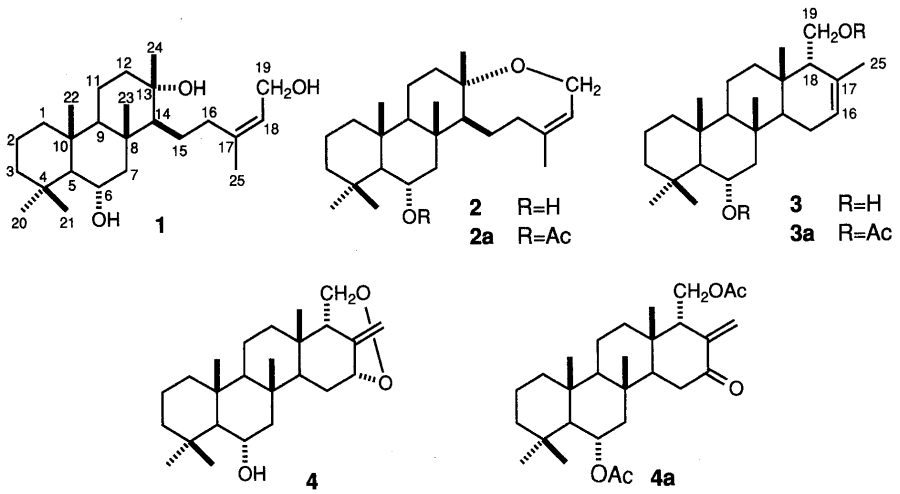



Chart 1

* To whom correspondence should be addressed.

Table 1. $^1$H-NMR Spectral Data (500 MHz, $CDCl_3$, $\delta$)

| | 1 | 2 | 2a | 3 | 3a | 4 | 4a |
|---|---|---|---|---|---|---|---|
| $H_3$-20 | 1.167 | 1.149 | 1.015 | 1.142 | 1.015 | 1.144 | 1.017 |
| $H_3$-21 | 1.014 | 1.008 | 0.856 | 1.008 | 0.863 | 1.003 | 0.865 |
| $H_3$-22 | 0.846[a] | 0.860 | 0.917 | 0.891 | 0.925 | 0.865 | 0.955 |
| $H_3$-23 | 0.859[a] | 0.959 | 1.015 | 0.971 | 1.035 | 0.888 | 1.017 |
| $H_3$-24 | 1.126 | 1.226 | 1.223 | 0.870 | 0.877 | 0.927 | 0.996 |
| $H_3$-25 | 1.780 | 1.673 | 1.680 | 1.720 | 1.720 | | |
| | | (d, 1.2) | (d, 1.6) | (d, 1.5) | (d, 1.5) | | |
| Ha-25 | | | | | | 5.050 | 5.159 |
| | | | | | | (d, 2.0) | (d, 1.8) |
| Hb-25 | | | | | | 5.224 | 5.929 |
| | | | | | | (d, 2.0) | (d, 1.8) |
| H-6$\beta$ | 3.962 | 3.945 | 5.209 | 3.942 | 5.218 | 3.95[b] | 5.208 |
| | (ddd, 10.7, 10.7, 3.6) | (dd, 10.3, 10.3) | (ddd, 11.1, 11.1, 3.8) | (ddd, 11.0, 11.0, 3.7) | (ddd, 12.0, 12.0, 4.0) | | (ddd, 11.0, 11.0, 3.9) |
| H-16 | | | | 5.538 | 5.394 | 4.535 | |
| H-18 | 5.464 | 5.139 | 5.132 | | | | |
| | (dd, 7.3, 7.3) | | | | | | |
| Ha-19 | 4.055 | 4.031 | 4.027 | 3.681 | 3.992 | 3.92[b] | 3.992 |
| | (dd, 11.7, 7.3) | (d, 18.7) | (d, 18.3) | (dd, 11.9, 4.9) | (dd, 12.0, 2.5) | | (dd, 11.2, 7.5) |
| Hb-19 | 4.129 | 4.233 | 4.209 | 3.727 | 4.008 | 3.97[b] | 4.335 |
| | (dd, 11.7, 7.3) | (d, 18.7) | (d, 18.3) | (dd, 11.9, 2.1) | (dd, 12.0, 6.7) | | (dd, 11.2, 4.5) |
| OAc | | | 2.049 | | 2.032 | | 2.001 |
| | | | | | 2.051 | | 2.036 |

Multiplicity and coupling constant ($J$ in Hz) are shown in parentheses. *a*) The assignments of H-22 and H-23 in the literature[3] were revised. *b*) Obscured by other signals.

Table 2. $^{13}$C-NMR Spectral Data (125.65 MHz, $CDCl_3$, $\delta$)

| C | 1 | 2 | 2a | 3 | 3a | 4 | 4a |
|---|---|---|---|---|---|---|---|
| 1 | 40.05 | 40.17 | 40.01 | 39.85 | 39.74 | 39.93 | 39.71 |
| 2 | 18.52 | 18.49 | 18.37 | 18.51 | 18.38 | 18.50 | 18.34 |
| 3 | 43.56 | 43.60 | 43.30 | 43.69 | 43.36 | 43.58 | 43.23 |
| 4 | 33.73 | 33.64 | 33.21 | 33.69 | 33.25 | 33.72 | 33.27 |
| 5 | 61.45 | 61.13 | 58.41 | 61.47 | 58.71 | 61.68 | 58.70 |
| 6 | 68.17 | 68.61 | 71.10 | 68.54 | 71.00 | 68.47 | 70.38 |
| 7 | 52.82 | 53.87 | 49.09 | 53.51 | 48.84 | 53.37 | 48.28 |
| 8 | 40.09 | 39.34 | 39.21 | 38.76 | 38.46 | 38.61 | 38.65 |
| 9 | 60.07 | 60.23 | 60.20 | 60.98 | 60.99 | 61.20 | 60.33 |
| 10 | 39.24 | 39.31 | 39.49 | 39.51 | 39.67 | 39.48 | 39.61 |
| 11 | 19.48 | 19.00 | 18.94 | 17.74 | 17.59 | 17.64 | 17.56 |
| 12 | 44.25 | 36.07 | 36.04 | 37.70 | 37.44 | 37.66 | 36.88 |
| 13 | 74.08 | 79.58 | 79.51 | 36.24 | 36.13 | 38.04 | 36.82 |
| 14 | 61.62 | 50.82 | 50.75 | 48.81 | 47.99 | 45.74 | 49.73 |
| 15 | 24.50 | 23.34 | 23.44 | 23.00 | 22.99 | 25.91 | 36.88 |
| 16 | 35.47 | 29.04 | 28.99 | 124.05 | 122.95 | 85.65 | 201.82 |
| 17 | 142.53 | 133.58 | 133.65 | 131.20 | 131.47 | 142.59 | 144.74 |
| 18 | 123.43 | 123.54 | 123.48 | 57.67 | 53.84 | 57.82 | 54.61 |
| 19 | 58.45 | 61.69 | 61.68 | 61.22 | 64.36 | 62.27 | 63.88 |
| 20 | 36.58 | 36.51 | 36.06 | 36.59 | 36.13 | 36.52 | 36.07 |
| 21 | 22.06 | 21.98 | 22.02 | 21.99 | 22.05 | 21.90 | 22.02 |
| 22 | 17.69 | 17.87 | 17.76 | 18.04 | 17.92 | 17.82 | 17.76 |
| 23 | 18.08 | 18.29 | 17.98 | 18.36 | 17.97 | 18.62 | 17.64 |
| 24 | 23.98 | 23.76 | 23.71 | 22.93 | 22.58 | 23.14 | 22.93 |
| 25 | 23.71 | 26.22 | 26.31 | 22.98 | 23.08 | 120.23 | 123.08 |
| $OCOCH_3$ | | | 22.11 | | 22.09 | | 21.98 |
| | | | | | 21.29 | | 20.92 |
| $OCOCH_3$ | | | 170.32 | | 170.39 | | 170.27 |
| | | | | | 171.13 | | 170.87 |

of only one hydroxyl group. The $^1$H-NMR spectrum showed signals due to five tertiary methyl groups, an olefinic methyl group ($\delta$ 1.673), a methine proton on carbon bearing a hydroxyl group ($\delta$ 3.945), methylene protons on oxygenated carbon ($\delta$ 4.031 and 4.233) and a proton of a trisubstituted double bond ($\delta$ 5.139), as shown in Table 1. Furthermore, the carbon groups found in a distortionless enhancement by polarization transfer (DEPT) experiment were six methyl, nine methylene, four methine and four quaternary carbons, besides two carbons of a trisubstituted double bond. The other oxygen forms an ether linkage based on the presence of two more oxygenated carbons and the unsaturation degree.

The $^{13}$C-NMR chemical shifts (Table 2) of C-1 to C-10 and C-20 to C-23 are close to those of **1**. The fragment ion peaks in the electron impact (EI)-MS were observed at $m/z$ 276, 261, 258 and 243, which coincided with those of **1** due to the left portion of the molecule. Thus, the comparison of the above data with those of **1** suggested **2** to be a cheilanthane-type sesterterpenoid having a hydroxyl group (6$\alpha$), a trisubstituted double bond and an ether linkage. In the heteronuclear multiple bond correlation (HMBC) spectrum (Table 3), two- and three-bond correlations among six methyl groups ($H_3$-20—$H_3$-25) and peripheral carbons supported the above skeleton. Moreover, the long-range C–H correlations from H-18 and $H_2$-19 indicated the presence of a $\Delta^{17}$ double bond and 13,19-epoxy linkage, respectively. The results of the nuclear Overhauser enhancement (NOE) interactions, as depicted in Fig. 1, were as follows: the interactions of H-6$\beta$ with $H_3$-21, $H_3$-22, $H_3$-23 and H-7$\beta$ supported H-6 axial configuration; those of H-18 with $H_3$-25 indicated the $Z$ configuration of the $\Delta^{17}$ double bond; those of H-19$\alpha$ ($\delta$ 4.233) with H-12$\alpha$ and H-14$\alpha$, and of $H_3$-24 with H-15$\beta$, H-16$\beta$ ($\delta$ 3.361) and $H_3$-23 suggested the conformation of the eight-membered ring to be as shown in Fig. 2.[13] Consequently, the structure of compound **2** was concluded to be (17$Z$)-13,19-epoxycheilanth-17-en-6$\alpha$-ol.

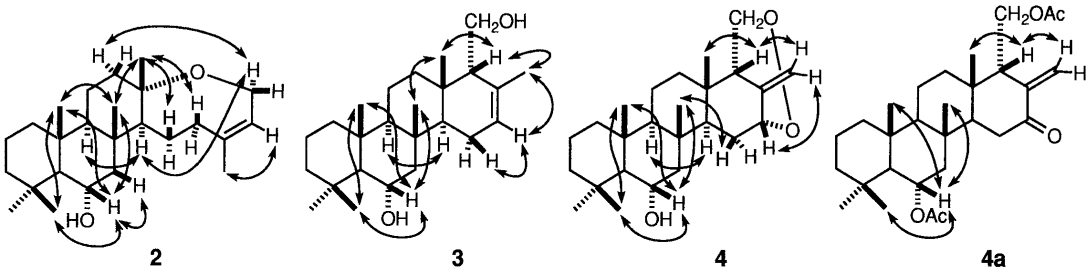
Compound **3**,[14] $C_{25}H_{42}O_2$, showed strong hydroxyl absorption at 3400 cm$^{-1}$ in the IR spectrum and was acetylated to give a diacetate (**3a**), indicating the presence of two hydroxyl groups. The $^1$H-NMR spectrum showed signals due to five tertiary methyl groups, an

Table 3. C–H Long-range Correlations of **2**—**4** and **4a** by HMBC in $CDCl_3$

| | $^1$H Signals | Correlated carbons |
|---|---|---|
| **2** | 1.149 ($H_3$-20) | C-3 C-4 C-5 C-21 |
| | 1.008 ($H_3$-21) | C-3 C-4 C-5 C-20 |
| | 0.860 ($H_3$-22) | C-1 C-5 C-9 C-10 |
| | 0.959 ($H_3$-23) | C-7 C-8 C-9 C-14 |
| | 1.226 ($H_3$-24) | C-12 C-13 C-14 |
| | 1.673 ($H_3$-25) | C-16 C-17 C-18 |
| | 0.925 (H-5) | C-1 C-4 C-6 C-9 C-10 C-20 C-21 C-22 |
| | 3.945 (H-6) | C-5 C-7 |
| | 2.102 ($H_{eq}$-7) | C-5 C-6 C-8 C-9 C-23 |
| | 0.824 (H-9) | C-1 C-5 C-8 C-10 C-11 C-12 C-14 C-22 C-23 |
| | 1.808 ($H_{ax}$-12) | C-11 C-13 C-24 |
| | 3.361 (Hb-16) | C-15 C-17 C-25 |
| | 5.139 (H-18) | C-16 C-17 C-19 C-25 |
| | 4.031 (Ha-19) | C-13 C-17 |
| | 4.233 (Hb-19) | C-13 C-17 |
| **3** | 1.142 ($H_3$-20) | C-3 C-4 C-5 C-21 |
| | 1.008 ($H_3$-21) | C-3 C-4 C-5 C-20 |
| | 0.891 ($H_3$-22) | C-1 C-5 C-9 C-10 |
| | 0.971 ($H_3$-23) | C-7 C-8 C-9 C-14 |
| | 0.870 ($H_3$-24) | C-12 C-13 C-14 C-18 |
| | 1.720 ($H_3$-25) | C-16 C-17 C-18 |
| | 1.510 (H-14) | C-8 C-13 C-15 C-23 C-24 |
| | 5.538 (H-16) | C-14 C-15 C-18 C-25 |
| | 3.681 (Ha-19) | C-13 C-17 C-18 |
| | 3.727 (Hb-19) | C-13 C-17 C-18 |
| **4** | 1.144 ($H_3$-20) | C-3 C-4 C-5 C-21 |
| | 1.003 ($H_3$-21) | C-3 C-4 C-5 C-20 |
| | 0.865 ($H_3$-22) | C-1 C-5 C-9 C-10 |
| | 0.888 ($H_3$-23) | C-7 C-8 C-9 C-14 |
| | 0.927 ($H_3$-24) | C-12 C-13 C-14 C-18 |
| | 5.050 (Ha-25) | C-16 C-18 |
| | 5.224 (Hb-25) | C-16 C-18 |
| | 4.535 (H-16) | C-14 C-18 |
| | 3.92 (Ha-19) | C-17 C-18 |
| | 3.97 (Hb-19) | C-17 C-18 |
| **4a** | 1.017 ($H_3$-20) | C-3 C-4 C-5 C-21 |
| | 0.865 ($H_3$-21) | C-3 C-4 C-5 C-20 |
| | 0.955 ($H_3$-22) | C-1 C-5 C-9 C-10 |
| | 1.017 ($H_3$-23) | C-7 C-8 C-9 C-14 |
| | 0.996 ($H_3$-24) | C-12 C-13 C-14 C-18 |
| | 5.159 (Ha-25) | C-16 C-18 |
| | 5.929 (Hb-25) | C-16 C-18 |
| | 1.222 (H-5) | C-1 C-4 C-6 C-7 C-10 C-20 C-21 C-22 |
| | 1.87 ($H_{eq}$-7) | C-5 C-6 C-8 C-9 C-23 |
| | 1.68 (H-14) | C-8 C-12 C-13 C-23 C-24 |
| | 2.26 (Ha-15) | C-8 C-13 C-14 C-16 |
| | 2.43 (Hb-15) | C-8 C-13 C-14 C-16 |
| | 2.32 (H-18) | C-12 C-13 C-14 C-16 C-17 C-19 C-24 C-25 |
| | 3.992 (Ha-19) | C-13 C-17 C-18 $OCO\underline{C}H_3$ |
| | 4.335 (Hb-19) | C-13 C-17 C-18 $OCO\underline{C}H_3$ |

olefinic methyl group ($\delta$ 1.720), methylene protons on carbon bearing a hydroxyl group ($\delta$ 3.681 and 3.727), a methine proton on carbon bearing a hydroxyl group ($\delta$ 3.942) and a proton of a trisubstituted double bond ($\delta$ 5.538). The $^{13}$C-NMR chemical shifts of C-1 to C-10 and C-20 to C-23 are very similar to those of **2**, indicating that at least the left part of **3** is the same as that of **2**, but **3** has no oxygenated quaternary carbon equivalent to C-13 in **2**. Therefore, C-13 in **3** must be connected with another carbon, which also implies that **3** has a different carbon skeleton from cheilanthane. The HMBC spectrum indicated two- and three-bond correlations from $H_3$-23, $H_3$-24, $H_3$-25, H-16 and $H_2$-19, which suggested the carbon connectivities of the right part to be as shown in the structure **3** (Chart 1). The configuration of H-18 was determined to be $\beta$, based on the interactions of H-18 with $H_3$-24 and $H_3$-25 in the nuclear Overhauser enhancement spectroscopy (NOESY) spectrum. Considering other NOEs and carbon connectivities from HMBC, **3** was deduced to have a C-18 epimeric scalarane skeleton. All the above data led to 18-episcalar-16-ene-6$\alpha$,19-diol for the structure of **3**.

Compound **4**, $C_{25}H_{40}O_3$, showed a hydroxyl absorption in the IR spectrum. The $^{13}$C-NMR chemical shifts of C-1 to C-12 and C-20 to C-24 are in good agreement with those of **3**, but **4** has an oxygenated methine and a terminal methylene carbon instead of the olefinic methyl and trisubstituted olefin carbons in **3**. This is consistent with the $^1$H-NMR signals of an oxygenated methine proton ($\delta$ 4.535) and terminal methylene protons ($\delta$ 5.050 and 5.224). In the HMBC spectrum, two- and three-bond correlations from $H_3$-23, $H_3$-24, $H_3$-25, H-16 and $H_2$-19 suggested the carbon connectivities of the right part to be as shown in the structure of **4** (Chart 1). In addition, the presence of a 16,19-epidioxy linkage was deduced because the molecular formula of **4**, given by HRMS, indicated five degrees of unsaturation and the $^1$H-NMR signals of $H_2$-19 appeared at lower magnetic field ($\Delta$ 0.24 ppm) than those in **3**. The configurations of H-16 and H-18 were both determined to be $\beta$, based on the NOESY result that H-18 interacted with $H_3$-24 and Ha-25 ($\delta$ 5.050), and H-16 with Hb-25 ($\delta$ 5.224). Furthermore, compound **4a**, derived from **4** by acetylation, was elucidated to be 16-oxo-18-episcalar-17(25)-ene-6$\alpha$,19-diol diacetate on nearly the same bases as mentioned above. The stabilization of the C-16 carbanion by the $\Delta^{17(25)}$ double bond is considered to have favored the cleavage of the epidioxy linkage. From the foregoing evidence, the structure of compound **4** was concluded to be 16$\alpha$,19-




**2** **3** **4** **4a**

Fig. 1

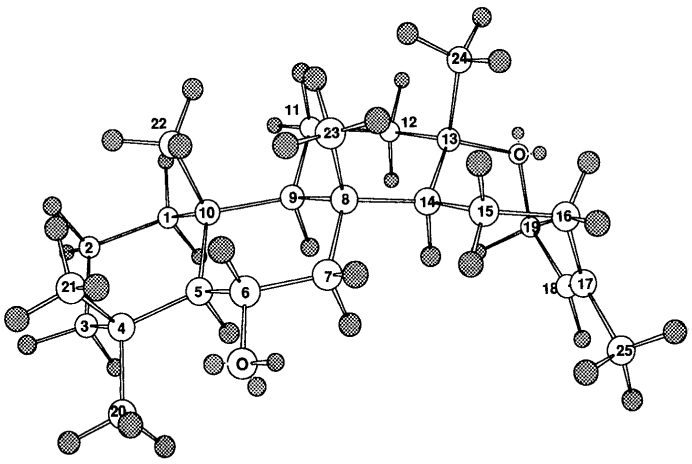


Fig. 2

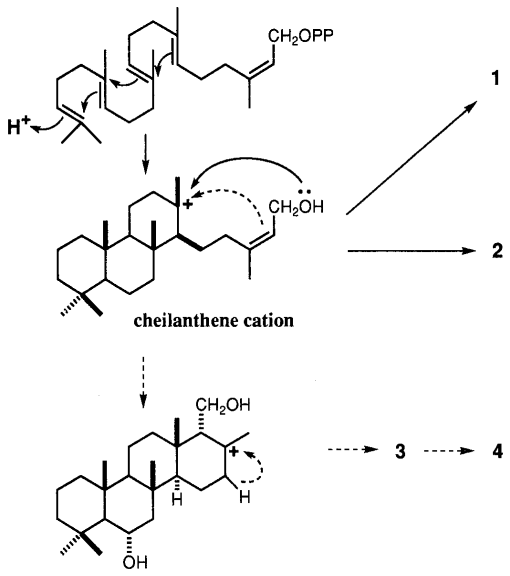



Chart 2

epidioxy-18-episcalar-17(25)-en-6α-ol.

To our knowledge, this is the first report of scalarane-type sesterterpenoids[14] such as **3** and **4** occurring in ferns. The current view regarding the biogenesis of these compounds is as follows: cyclization provides a tertiary cation at C-13, which is attacked by water or the hydroxyl group (C-19) to produce compound **1** or **2**. In the case of **3** and **4**, a double bond in a prenyl chain attacks the carbonium ion (C-13) to produce the scalarane skeleton (Chart 2), because cheilanthane-type sesterterpenoids such as **1** and **2** coexist with them in the same fern.

## Experimental

**General Procedures** Melting points were measured with a Yanagimoto micro apparatus and are uncorrected. Measurement of optical rotation was carried out on a JASCO DIP-140. IR spectra were recorded on a JASCO A-102. $^1$H- and $^{13}$C-NMR spectra were recorded on a JEOL A500 spectrometer using tetramethylsilane as an internal standard. The chemical shifts are expressed on the $\delta$ scale. For 1D $^1$H-NMR (500 MHz), 32 K data points and a frequency width of 10000.0 Hz were used, giving a digital resolution of 0.3 Hz per point. For 1D $^{13}$C-NMR (125.65 MHz), 32 K data points and a frequency width of 33898.3 Hz were used, giving a digital resolution of 1.1 Hz per point. Proton and carbon signal assignments were based on the results of $^1$H–$^1$H and $^{13}$C–$^1$H correlation spectroscopy (COSY), NOESY and HMBC. EI-MS and HRMS were measured at 30 eV (direct inlet) with a JEOL JMS D300 or a JEOL JMS HX110 and the relative intensities of peaks were reported with reference to the most intense peak higher than $m/z$ 100. GC was run on a Hitachi 163 apparatus using a glass column containing Chromosorb G HP coated with SE-30 (1.4%) at 260 °C in a flow of $N_2$. Cholestane was used as an internal reference, and its retention time was set at 3.0 min. GC-MS was run on a JGC20K-JMS D300 system using the same absorbent as described above in a flow of He. HPLC was performed on a JASCO PU-980 equipped with a JASCO RI-930 detector. The following column and solvents were used for elution: Senshu Pak ODS-3251-D (5 $\mu$, 8 × 250 mm) with $CH_3OH$–$CHCl_3$ (8 : 2) for hydrocarbons, and $CH_3CN$ for sesterterpenoids. Column chromatography (CC) was carried out on Silica gel 60 (0.063—0.2 mm, Merck), Silica Woelm TSC (silica gel for dry-column chromatography, Woelm) and Sephadex LH 20 (25—100 $\mu$m, Pharmacia). TLC was carried out on precoated Silica gel 60 and Silica gel 60 $F_{254}$ plates (Merck) with $n$-hexane-EtOAc and $CHCl_3$–MeOH as the solvent system.

**Plant Materials** The fronds of *A. mexicana* were collected in August 1988 at Tataka pass, Alishan, Taiwan. A voucher specimen has been deposited in the Herbarium of Shôwa College of Pharmaceutical Sciences, Tokyo.

**Extraction and Separation** The fresh fronds (220 g) were extracted with $n$-hexane to give the extract (6.7 g) and water (130 ml). The $n$-hexane extract was chromatographed on silica gel (Merck) and the column was eluted to afford six triterpenoid hydrocarbons with $n$-hexane, ferna-7,9(11)-diene, squalene and adian-5-ene ozonide with $n$-hexane–benzene (4 : 1), **2** and two flavonoids with benzene–$Et_2O$ (19 : 1), **3** and **4** with benzene–$Et_2O$ (9 : 1), and **1** with $Et_2O$. Each compound was further purified by repeated chromatography (silica gel CC, Sephadex LH 20 CC and HPLC) and/or recrystallization.

**Triterpenoid Hydrocarbons** Each of the hydrocarbon fractions [frac. 1 (180 mg), frac. 2 (0.8 mg) and frac. 3 (37 mg)] was subjected to HPLC: frac. 1, tirucalla-7,21-diene (1 mg), neohop-13(18)-ene (5 mg), adian-5-ene (12 mg), fern-8-ene (8 mg), neohop-12-ene (4 mg), fern-7-ene (4 mg); frac. 2, ferna-7,9(11)-diene (0.3 mg); frac. 3, squalene (10 mg). These compounds were identical (GC, GC-MS and $^1$H-NMR) with authentic samples.

**Adian-5-ene Ozonide** Colorless needles (6 mg) (from $Et_2O$–MeOH), mp 152—154 °C. Identical (IR, MS and $^1$H-NMR) with an authentic sample.

**3,5-Dihydroxy-7,4′-dimethoxyflavone** Yellow needles (93 mg) (from benzene), mp 182—184 °C. Identical (IR, MS and $^1$H-NMR) with an authentic sample.

**5-Hydroxy-7,4′-dimethoxyflavone** Yellow needles (86 mg) (from benzene), mp 172—173 °C (lit. mp 174 °C).[11] IR $\nu_{max}^{KBr}$ cm$^{-1}$: 3445, 1669, 1607, 1510, 1271, 1163, 835. EI-MS (rel. int.) $m/z$: 298 (100), 269 (39), 255 (26), 166 (25), 132 (31). $^1$H-NMR $\delta$: 3.877, 3.889 (3H each, 4′-OC$\underline{H}_3$, 7′-OC$\underline{H}_3$), 6.360 (1H, d, $J$ = 2.4 Hz, H-6), 6.475 (1H, d, $J$ = 2.4 Hz, H-8), 6.567 (1H, H-3), 7.009 (2H, d, $J$ = 9.2 Hz, H-3′, H-5′), 7.834 (2H, d, $J$ = 9.2 Hz, H-2′, H-6′), 12.807 (1H, 5-O$\underline{H}$). $^{13}$C-NMR $\delta$: 55.52, 55.79 (4′-O$\underline{C}H_3$, 7′-O$\underline{C}H_3$), 92.62 (C-8), 98.05 (C-6), 104.35 (C-3), 105.58 (C-10), 114.52 (C-3′, C-5′), 123.60 (C-1′), 128.05 (C-2′, C-6′), 157.72 (C-9), 162.23, 162.61 (C-5, C-4′), 164.02 (C-2), 165.45 (C-7), 182.45 (C-4).

**Cheilanthenetriol (1)** Colorless needles (153 mg) (from $Me_2CO$), mp 179—180 °C, $[\alpha]_D^{23}$ +30.2 ° ($c$ = 0.37, $CHCl_3$). IR $\nu_{max}^{KBr}$ cm$^{-1}$: 3350, 2950,

1660, 1450, 1395, 1000, 980, 860.

**(17*Z*)-13,19-Epoxycheilanth-17-en-6α-ol (2)** Colorless solid (35 mg) (from $Et_2O$–$CH_3CN$), mp 156—158 °C, $[\alpha]_D^{23}$ −28.1° ($c$=0.35, $CHCl_3$). IR $\nu_{max}^{KBr}$ $cm^{-1}$: 3450, 2960, 1450, 1390, 1130, 1110, 1050, 1030. EI-MS (rel. int.) $m/z$: 356 ($M^+-H_2O$, 24), 341 (12), 338 (13), 275 (15), 273 (16), 258 (60), 243 (22), 191 (45), 189 (28), 134 (100). HRMS $m/z$: 374.3191 ($M^+$, Calcd for $C_{25}H_{42}O_2$: 374.3185).

**Acetylation of 2** Compound **2** (21 mg) in pyridine and $Ac_2O$ was allowed to stand at 5 °C overnight. The product was chromatographed on silica gel (Woelm) [*n*-hexane–EtOAc (9 : 1)] to give the acetate (**2a**) as a colorless solid (20 mg). IR $\nu_{max}^{KBr}$ $cm^{-1}$: 1740, 1250, 1030.

**18-Episcalar-16-ene-6α,19-diol (3)** Colorless solid (29 mg), mp 118 °C from MeOH–$CH_3CN$, $[\alpha]_D^{23}$ −20.2° ($c$=0.25, $CHCl_3$). IR $\nu_{max}^{KBr}$ $cm^{-1}$: 3400, 1060, 1040, 1000. EI-MS (rel. int.) $m/z$: 356, ($M^+-H_2O$, 42), 341 (23), 326 (64), 258 (68), 243 (25), 205 (39), 189 (60), 121 (100). HRMS $m/z$: 356.3073 ($M^+-H_2O$, Calcd for $C_{25}H_{40}O$: 356.3076).

**Acetylation of 3** Compound **3** (13 mg) in pyridine and $Ac_2O$ was allowed to stand at room temperature overnight. The product was chromatographed on silica gel (Merck) [*n*-hexane–EtOAc (9 : 1)] to give the acetate (**3a**) as a colorless solid (6 mg). IR $\nu_{max}^{KBr}$ $cm^{-1}$: 1730, 1240, 1020.

**16α,19-Epidioxy-18-episcalar-17(25)-en-6-ol (4)** Colorless solid (3 mg). IR $\nu_{max}^{KBr}$ $cm^{-1}$: 3350, 1640, 1040, 1030, 910. EI-MS (rel. int.) $m/z$: 388 ($M^+$, 12), 370 (26), 355 (28), 352 (18), 342 (56), 324 (37), 275 (29), 274 (31), 258 (67), 257 (74), 243 (46), 203 (39), 191 (83), 189 (71), 109 (100). HRMS $m/z$: 388.2973 ($M^+$, Calcd for $C_{25}H_{40}O_3$: 388.2974).

**Acetylation of 4** Compound **4** (2 mg) in pyridine and $Ac_2O$ was allowed to stand at room temperature overnight. The product was chromatographed on silica gel (Merck) [*n*-hexane–EtOAc (9 : 1)] to give the diacetate (**4a**) as a colorless solid. IR $\nu_{max}^{KBr}$ $cm^{-1}$: 1730, 1680, 1240, 1020. EI-MS (rel. int.) $m/z$: 472 ($M^+$, 4), 412 ($M^+-AcOH$, 70), 352 (92), 337 (42), 257 (100), 243 (39), 203 (33), 191 (92). HRMS $m/z$: 472.3140 ($M^+$, Calcd for $C_{29}H_{44}O_5$: 472.3185).

**Acknowledgments** We thank Mr. Y. Takase and Mr. H. Suzuki of the Central Analytical Center of our college for the measurements of MS and NMR.

**References and Notes**

1) Deceased.
2) *a*) Saiki Y., *J. Phytogeog. & Taxon.*, **32**, 1 (1984); *b*) *Idem*, *ibid.*, **32**, 81 (1984); *c*) *Idem*, *ibid.*, **32**, 91 (1984).
3) Ageta H., Shiojima K., Masuda K., The 95th Annual Meeting of the Pharmaceutical Society of Japan, Nishinomiya, April 1975; Wollenweber E., Ruedi P., Seigler D. S., *Z. Naturforsch*, **37c**, 1283 (1982).
4) Kamaya R., Ageta H., *Chem. Pharm. Bull.*, **38**, 342 (1990).
5) Kamaya R., Nakamura M., Tamaru K., Takahata C., Ageta H., *Shoyakugaku Zasshi*, **47**, 200 (1993).
6) A pure sample was purchased from Tokyo Kasei Co., Ltd.
7) Masuda K., Shiojima K., Ageta H., *Chem. Pharm. Bull.*, **31**, 2530 (1983).
8) Ageta H., Iwata K., Natori S., *Tetrahedron Lett.*, **1963**, 3413.
9) Pandy G., Mitra C. R., *Tetrahedron Lett.*, **1967**, 4683.
10) Ageta H., Shiojima K., Arai Y., *Chem. Commun.*, **1968**, 1105.
11) Ageta H., Shiojima K., Kamaya R., Masuda K., *Tetrahedron Lett.*, **10**, 899 (1978).
12) Rangaswami S., Iyer R. T., *Indian J. Chem.*, **7**, 526 (1969).
13) Chem3D Plus 3.0 and Allinger N. L., MM2 Params, Cambridge Scientific Computing Inc.
14) The numbering of **3** and **4** conforms to that of cheilanthenetriol (**1**).