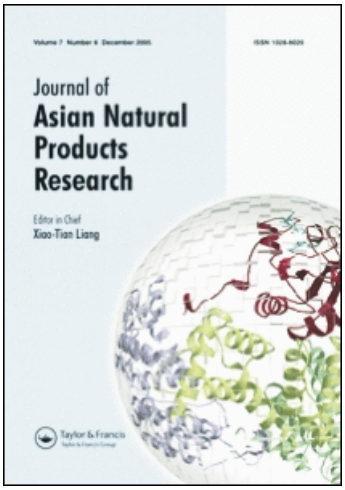

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A Novel Eleven-Membered-Ring Triterpene Dilactone, Pseudolarolide F and A Related Compound, Pseudolarolide E, from *Pseudolarix Kaempferi*

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A NOVEL ELEVEN-MEMBERED-RING TRITERPENE DILACTONE, PSEUDOLAROLIDE F AND A RELATED COMPOUND, PSEUDOLAROLIDE E, FROM *PSEUDOLARIX KAEMPFERI*

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A novel eleven-membered-ring triterpene dilactone, pseudolarolide **F** (**1**), and a related compound, pseudolarolide **E** (**2**), were isolated from the seeds of *Pseudolarix kaempferi*, a plant indigenous to eastern China. Their structures and stereochemistry were established by spectroscopic studies, which included UV, IR, HREIMS, 2D NMR correlation methods (^{1}H-^{1}H COSY, ^{13}C-^{1}H COSY, NOESY, HMQC, and HMBC), and single-crystal X-ray analysis.

Keywords: *Pseudolarix kaempferi* Gord.(Pinaceae); Triterpene; Pseudolarolide **F**; Pseudolarolide **E**

INTRODUCTION

The chemical studies on the seeds of *Pseudolarix kaempferi* Gord.(Pinaceae), whose root bark is used as a folk medicine in China for the treatment of skin disease caused by fungi, have led to discoveries of four triterpene lactones, pseudolarolide A (**3**), B, C, and D [1]. Pseudolarolide A (**3**) and B showed

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in vitro inhibition of HSV-2 plaque formation in vero cells, and pseudolarolide B was found to demonstrate good cytotoxicity in KB, A-549, HCT-8 and P-388 tumor cells [1]. Recently, we continued our research for more novel cytotoxic anti-tumor compounds. Further isolation of medium polar fraction of the Et_2O extract by silica gel column chromatography yielded a novel eleven-membered-ring triterpene dilactone, pseudolarolide **F** (**1**), and a related compound, pseudolarolide **E** (**2**), the latter was also found to show significant *in vitro* cytotoxicity against HCT-8 colon carcinoma cell [2]. We report herein on the isolation and structural elucidation of pseudolarolide **F** (**1**), and pseudolarolide **E**, from UV, IR, HREIMS, 2D ^{1}HNMR and ^{13}C NMR spectral data, and X-ray crystallographic analysis.

RESULTS AND DISCUSSION

Pseudolarolide **F** (**1**), obtained as colorless needles (mp256–258°C) from acetone, has the molecular formula $C_{30}H_{42}O_7$ as found from its HREIMS (*m/z*514.2949) and confirmed by ^{13}C-NMR spectrum. A Liebermann-Burchard test gave no reaction. The IR spectrum showed the presence of hydroxyl (3390 cm^{-1}), γ-lactone (1774 cm^{-1}, 1737 cm^{-1}), conjugated unsaturated lactone (1656 cm^{-1}) and double bond (1630 cm^{-1}) groups. The ^{1}H-NMR spectrum (Tab. I) showed signals for four tertiary (δ 0.62, 1.08, 1.47, and 1.49) and two secondary (δ 0.96 and 1.23) methyls, two olefinic protons (δ 5.55, d, 1.5 Hz and δ 6.35, d, 1.5 Hz), and one oxygenated methine proton (δ 3.88), and revealed the absence of a typical cyclopropyl methylene signal by comparison with known compound, pseudolarolide **A**(**3**). These data suggested that **1** was a triterpene which had a 9,10-seco-cycloartane carbon skeleton [2, 3].

Compound **1** has the same side chain moiety as known compound **3** because of similarities in the ^{1}H- and ^{13}C-NMR spectra. The presence of γ-lactone in ring F and a spiro-ketal attached to C_{16} and C_{23} was indicated by ^{1}H- and ^{13}C-NMR signals resonating for protons at δ 3.88 (td, J = 6.8, 10.4 Hz; H-16), 2.05 (m, H-20), 0.96 (d, 3 H, J = 6.4 Hz; Me-21), 1.38 (dd, J = 11.7, 14.0 Hz, H-22α), 1.88 (dd, J = 4.0, 14.1 Hz; H-22β), 2.36 (dd, J = 8.5, 12.9 Hz, H-24α), 1.70 (dd, J = 11.5, 12.9 Hz; H-24β), 2.90 (m, H-25), and 1.23 (3 H, d, J = 7.2 Hz, Me-27), and for carbons at δ 74.8 (C-16), 106.6 (C-23), 179.6 (C-26). In addition, in the mass spectrum the typical fragment at *m/z* 139.0745 ($C_8H_{11}O_2$), characteristic of the spiro E and F rings in these pseudolarolides [1, 2, 4–8], supported this conclusion.

TABLE I NMR data for pseudolarolide F (**1**) ($CDCl_3$, δppm, 400 MHz)

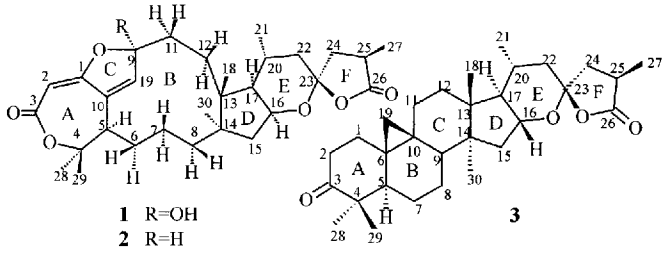
Position	δ^1H(*mult*, *J* = *Hz*)	^1H-^1HCOSY	$\delta^{13}C$(*HMQC*)	*HMBC*(*C*)	*NOESY*
1			166.7		
2	5.55(d,1.5)	19	95.0	1,3,10	Me-18,Me-28
3			166.6		
4			80.2		
5	2.42(dd,3.3,11.9)	6α,6β	48.3	1,3,6,7,10,19	6α,7α,19,Me-28,Me-29
6α	2.22(m)	5,6β,7α,7β	28.7	5	5,6β,7β,Me-29
6β	1.10(m)	5,6α,7α,7β		5,7,8	
7α	1.26(m)	6α,6β,7β,8α,8β	20.5	6,14,30	
7β	1.52(m)	6α,6β,7α,8α,8β		5,6	
8α	1.51(m)	7α,7β,8β	38.6	5,6,7,13	
8β	1.25(m)	7α,7β,8α		6,7,13,30	
9	4.19(s,-OH)		115.3	9,11,19	
10			138.2		
11α	2.23(ddd,14,7.3,2.2)	11β,12α,12β	36.0	9,12,13	11β,12β
11β	2.53(ddd,14,10,2)	11α,12α,12β		9,12,13,19	11α,Me-21
12α	2.07(m)	11α,11β,12β	32.0	9,11,13,14,17	12β,19
12β	1.51(m)	11α,11β,12α		9,13,17	
13			44.8		
14			47.9		
15α	1.31(dd,6.8,14.1)	15β,16	44.4	13,14,18,30	
15β	1.65(dd,10.4,14.1)	15α,16		8,14,16,17,30	
16	3.88(td,6.8,10.4)	15α,15β,17	74.8	14,20,23	15β,Me-18,20
17	1.35(t,10.4)	16,20	57.8	12,13,14,15,1 8,20,21,22,30	
18	0.62(s,CH_3)		17.8	12,13,14,15,17	2,8β,11β,16,20
19	6.35(d,1.5)	2	141.0	1,5,6,9,10	5,7α,12α,Me-30
20	2.05(m)	17,21,22α,22β	29.4	16,17,21	16,Me-18,Me-21,22β
21	0.96(d,6.4,CH_3)	20	20.1	17,20,22,23	11β,17,20,22β
22α	1.38(dd,11.7,14)	20,22β	44.6	17,20,21,24	
22β	1.88(dd,4,14)	20,22α		13,17,21,23	20,Me-21,22α,24β

TABLE I (Continued)

Position	δ^1H(*mult*, $J = Hz$)	^1H-^1HCOSY	$\delta^{13}C$(*HMQC*)	*HMBC*(*C*)	*NOESY*
23			106.6		
24α	2.36(dd,8.5,12.9)	24β,25	42.6	23,25,26	24β,25
24β	1.70(dd,11.5,12.9)	24α,25		22,23,25,27	24α,Me-27
25	2.90(m)	24α,24β,27	34.1	24,26,27	24α,Me-27
26			179.6		
27	1.23(d,7.2,CH_3)	25	15.0	24,25,26	
28	1.49(s,CH_3)		26.1	3,4,5,29	2,5
29	1.47(s,CH_3)		28.6	3,4,5,28	
30	1.08(s,CH_3)		24.6	8,13,14	15α,17,19

The presence of unsaturated seven-membered-lactone ring A, was deduced from UV, IR, NMR data and biogenetic consideration [1, 2, 5, 6]. The K band absorption of **1** in UV spectrum, $\lg\varepsilon$ 4.18, was remarkably strong, suggested that an α β, γ δ-conjugated unsaturated lactone system was present, and the UV spectrum exhibited a λ_{max} at 286.21 nm suggested that an —OR group replaced olefinic proton at C_1 because the UV λ_{max} of no substituted compound at C_1, was calculated at 261 nm, while the UV λ_{max} of analogous compound, CH_2=CH—C(OR)=CH—C(OR), was estimated at 291 nm, close to the UV λ_{max} of compound **1**. The absorption at 1656 cm^{-1}(lactone) and 1630 cm^{-1} (double band) in IR spectrum also showed the existence of unsaturated ring A. Compound **1** contained seven oxygen atoms in the molecular formula, of which five had been assigned, that was, the side chain moiety accounting for three oxygen atoms, the A-ring lactone accounting for two oxygen atoms. Of the remaining two oxygen atoms, one was assigned to attach to C_1 because of only long distance couple between two olefinic protons in ^{1}H-NMR spectrum (δ 5.55, d, J=1.5, H-2 and δ 6.35, d, J=1.5, H-19), and another was assigned to located at C_9 because of the signal of half-ketal carbon (115.3 C-9), and other signals resonating at 166.7 (s, C-1), 95.0 (d, C-2), 166.6 (s, C-3), 80.2 (s, C-4), 138.2 (s, C-10), 141.0 (d, C-19) in ^{13}C-NMR spectrum. These results together with biogenetic consideration suggested that an epoxy group was located between C_1 and C_9, forming a five-membered-ring C, adjacent to seven-membered conjugated unsaturated lactone ring A as shown in Figure 1, and a hydroxyl group was located at C_9.

The structure of C_8–C_9 bond cleavage was suggested by consideration of degrees of unsaturation and DEPT experiment of ^{13}C-NMR. Of ten degrees of unsaturation, nine had been assigned, the side chain and ring D accounting for four, the conjugated unsaturated lactone ring A system accounting for five. Last one, therefore, must be assigned to an eleven-membered-ring B as shown in Figure 1, which presume a C_8–C_9 bond



1 R=OH
2 R=H

3

FIGURE 1

cleavage occurred. DEPT experiment in ^{13}C-NMR spectrum of **1** revealed the presence of nine quanternary carbons, seven methine carbons, eight methylene carbons, and six methyl carbons, and among eight methylenes, three were located in side chain (CH_2-22, and CH_2-24) and ring D (CH_2-15), while the other five methylenes must be possessed by the skeleton. This result also confirmed the structure of C_8-C_9 bond cleavage.

A high-field proton signal in ^{1}H-NMR spectrum, δ 0.62 (s, 3 H), and a high-field carbon signal in ^{13}C-NMR spectrum, δ 17.8, was assigned to C_{18} methyl protons and carbon, respectively, because C_{18} methyl group located in front of planar ring C, causing strong electronic shielding effect [2]. An olefinic carbon signal, δ 95.0, observed at comparatively high field in ^{13}C-NMR spectrum, was assigned to C_2, because of super-conjugated effect caused by the oxygen atom in ring C. All the assignment noted above were confirmed by ^{1}H-^{1}H COSY and ^{13}C-^{1}H COSY (HMQC) spectra. ^{1}H-^{1}H COSY, 2D NOESY and HMQC spectra were used for assignment of all proton resonance (Tab. I), and HMBC and DEPT experiments were used for assignment of all carbon resonance as shown in Table I.

The structure of compound **1** was confirmed by single-crystal X-ray diffraction that showed the skeletal arrangement and relative stereochemistry in accord with the NMR-derived structure **1** (Fig. 2). Compound **1** therefore was established as 25*R*-9*S*-hydroxyl-1 (9), 16*R* (23*S*)-diepoxy-8 (9), 9 (10)-diseco-1, 10 (19)-diencycloartan-3 (4), 26 (23)-diolide which represent a new group of lanostane triterpenes that characteristically bear an

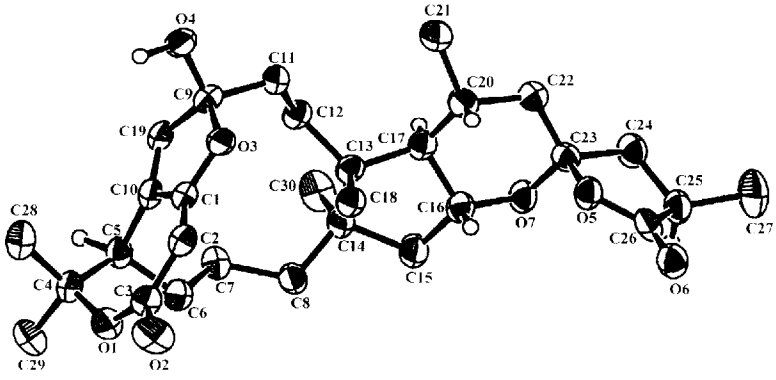


FIGURE 2 Computer-general perspective drawing of the final X-ray model of pseudolarolide F (**1**). Small circles represent hydrogen atoms and all hydrogen atoms were omitted except those which attached to C_5, C_{16}, C_{17}, and C_{20}.

TABLE II NMR data for Pseudolarolide **E** (**2**) ($CDCl_3$, δppm, 400 MHz)

Position	δ^1H	^1H-^1HCOSY	$\delta^{13}C(HMQC)$	*HMBC(C)*	*NOESY*
1			170.4		
2	5.44(d,1)	19	92.3	1,10	Me-18,Me-28
3			166.4		
4			79.5		
5	2.42(dd,3.7,11.2)	6α,6β	48.1	1,6,7,10,19	6α,7α,19,Me-28,Me-29
6α	2.14(m)	5,6β,7α,7β	27.8	5	6β,29,7β
6β	1.06(m)	5,6α,7α,7β		5,7,8	
7α	1.18(m)	6α,6β,7β,8α,8β	20.3	5,6,8,14	
7β	1.46(m)	6α,6β,7α,8α,8β		4,6,14	
8α	1.47(m)	7α,7β,8β	39.4	6,7,13,14	
8β	1.13(m)	7α,7β,7α		7,13,30	
9	5.49(dd,5,7,0.9)	11α,11β	88.8	10,19	2,11α,19
10			136.5		
11α	2.10(m)	9,11β,12α,12β	29.6	9,13	9,11β,19
11β	2.22(m)	9,11α,12α,12β		9,12,13,19	11α,Me-21,Me-18
12α	2.10(m)	11α,11β,12β	32.9	9,11,13,14,17	7α,12β,19,30
12β	1.50(m)	11α,11β,12α		13,14,17,18,20	
13			44.1		
14			47.6		
15α	1.30(dd,7,14)	15β,16	44.2	14,16,17,18,30	
15β	1.58(dd,10.4,14)	15α,16		8,14,16,20,30	15α,16
16	3.79(td,7.1,10.3)	15α,15β,17	74.4	13,15,20,23	15β,Me-18,20
17	1.27(t,10.3)	16,20	58.6	16,18,20,21	
18	0.52(s,CH_3)		17.1	12,13,14,17	2,8β,11β,16,20
19	6.52(d,1)	2	142.7	1,5,9,10	5,7α,9,12α,28
20	1.97(m)	17,21,22α,22β	29.0	21,22	16,Me-18,Me-21,22β
21	0.90(d,6.4)	20	20.1	13,17,20,22,23	11β,17,20,22α,22β
22α	1.33(dd,11.6,14.1)	20,22β	44.5	20,21,24	
22β	1.82(dd,14.1,4)	20,22α		17,20,21,23	20,Me-21,22α
23			106.4		
24α	2.31(dd,8.5,12.9)	24β,25	42.4	23,25,26	24β,25
24β	1.65(dd,11.5,12.9)	24α,25		22,25,27	22β,24α,Me-27

TABLE II (Continued)

Position	δ^1H	^1H-^1HCOSY	$\delta^{13}C(HMQC)$	*HMBC(C)*	*NOESY*
25	2.85(m)	24α,24β,27	34.0	24,27,26	24α,Me-27
26			179.4		
27	1.18(d,7.2,CH_3)	25	14.8	24,25,27	24β,25
28	1.41(s,CH_3)		26.0	3,4,5,10,29	2,5
29	1.43(s,CH_3)		28.5	3,4,5,10,28	5,6α
30	1.01(s,CH_3)		24.1	8,13,15	12α,15α,17

eleven-membered ring framework and biosynthetically derived from cleavage of C_9-C_{10} bond and C_8-C_9 bond in structure **3**.

Pseudolarolide E (**2**), easily soluble in benzene, obtained as needles from ether, and cubes (mp 209–211°C) from methanol, has the molecular formula $C_{30}H_{42}O_6$ found from its HRMS (*m/z* 498.3049). The UV spectrum (λ_{max}292.8, lg ε 4.21) revealed that **2** contained a conjugated unsaturated system the same as that of **1**. A Liebermann-Burchard test gave no reaction. The IR spectrum showed the presence of γ-lactone (1770 cm^{-1}, 1754 cm^{-1}), conjugated unsaturated lactone (1668 cm^{-1}) and double bond (1640 cm^{-1}, 1612 cm^{-1}) groups, but lack of signal of hydroxyl group found in **1**. The ^{1}H-NMR spectrum (Tab. II) showed signals for four tertiary (δ0.52, 1.01, 1.41 and 1.43), and two secondary (δ0.90 and 1.18) methyls, two olefinic protons (δ5.44, d, $J=1$ Hz and 6.52, d, $J=1$ Hz), and two oxygenated methine protons (δ 3.79, td, $J=7.1$ Hz, 10.3 Hz and 5.49, dd, $J=5.7$ Hz, 0.9 Hz). Compared ^{1}H-NMR and ^{13}C-NMR spectra of **2** (Tab. II) with that of **1** revealed that compound **2** lacked a half-ketal carbon, and had one more oxygenated methine carbon. These data suggested that 9-OH in **1** was replaced by a proton in **2** and the structure of C_8-C_9 bond cleavage shown in **2** in Figure 1 was also established, forming a same eleven-membered-ring B as in **1**. The signal at *m/z* 139.0745 ($C_8H_{11}O_2$) in HRMS spectrum also revealed that **2** had the same side chain moiety as **1** and **3** [1, 2, 4–8]. The final structure of **2** therefore was designated as 9*S*, 25*R*-1 (9), 16*R* (23*S*)-diepoxy-8 (9), 9 (10)-diseco-1, 10 (19)-diencycloartan-3 (4), 26 (23)-diolide.

EXPERIMENTAL SECTION

General Experiment Procedures

Melting points were determined on a Kofler micro-melting point apparatus and are uncorrected. IR spectra were recorded as KBr pellets on a Perkin-Elmer 983 spectrophotometer. CD and UV spectra were measured on a JASCO 500-C and a Shimazu UV-260 spectrophotometer, respectively, in absolute EtOH. HRMS was determined on a JMSO-D 300S mass spectrometer. ^{1}H- and ^{13}C-NMR spectra were measured on Bruker AM-400 with TMS as an internal standard. Silica gel H (10–40 μ, Qingdao) was used for preparative CC under 0.5–2 kg/cm^2. Analytical TLC was performed on silica gel plates (prepared with silica gel G and 0.01% carboxymethylcellulose) with benzene-acetone (5 : 1). Pseudolarolides were

detected by spraying with a 50% H_2SO_4 solution containing 1% anisaldehyde in 95% EtOH, followed by heating.

Plant Material

The seeds of *P. kaempferi* were collected at Changle Forest Center, Zhejiang Province, China. A voucher specimen is deposited at the Shanghai Institute of Materia Medica, Academia Sinica, Shanghai, China.

Extraction and Isolation

The seeds of *P. Kaempferi* (3800 g) were pulverized and extracted with Et_2O (5000 ml) for 30 h using a Soxhlet extraction apparatus. After evaporation of the Et_2O, the oily extract was added to 6.5 liters of petroleum ether, resulting in 150 g of precipitate. The precipitate was chromatographed on silica gel under low pressure, employing a petroleum-Et_2O gradient (100 : 0 to 0 : 100) and EtOAc as eluent. Fractions of Et_2O and EtOAc were combined and further purified by flash chromatography with a benzene : acetone gradient (15 : 1 to 1 : 1) as eluent to afford 260 mg (0.0068% yield) of pseudolarolide F (**1**) and 200 mg of pseudolarolide E (**2**) (0.0053% yield).

Pseudolarolide F(1)

Colorless needles (acetone): mp 256.0–258.0°C; Rf 0.18; CD $\Delta\varepsilon$ (nm) 0.88 (203), 8.60 (230), 5.17 (285) (c = 0.585); UV (nm) (lg ε) 204.2 (3.57), 240 (shoulder, 3.76), 286.2 (4.18); IR 3390, 2936, 1774, 1737, 1656, 1630 (shoulder), 1457, 1378, 1300, 1214, 1082, 1030, 994, 969, 923, 895 cm^{-1}; ^{1}H-NMR see Table I; ^{13}C-NMR see Table I; EIMS *m/z* $[M]^+$ 514.2949 ($C_{30}H_{42}O_7$, calcd 514.2930) (3.9%), 496 (5.4), 478 (4.1), 470 (21.0), 201 (21.0), 149 (26.1), 147 (27.1), 139 (60), 137 (25.9), 135 (30.0), 133 (27.1), 131 (21.4), 125 (22.0), 123 (36.1), 121 (51.0), 119 (31.4), 109 (39.4), 107 (50.8), 105 (36.9), 95 (100), 91 (64.9), 81 (59.2), 69 (97.1), 55 (71.0), 43 (91.8).

Pseudolarolide E(2)

Easily soluble in benzene, colorless cubes (methanol): mp 209.0-211.0°C; Rf 0.52; CD $\Delta\varepsilon$ (nm) 22.21 (225), −2.14 (262), −2.78 (302); UV (nm) (lg ε) 200 (3.67), 229 (3.65), 292.8 (4.21); IR 3070, 2970, 2930, 2870, 1770, 1754, 1668, 1640, 1612, 1453, 1376, 1270, 1210, 1143, 1134, 1078, 965, 918, 890, 868, 839 cm^{-1}; ^{1}H-NMR see Table II; ^{13}C-NMR see Table II; EIMS *m/z* $[M]^+$

498.3049 ($C_{30}H_{42}O_6$, calcd 498.3052) (8.4%), 480 (12.3), 454 (12.9), 452 (14.6), 257 (10.0), 215 (9.4), 206 (19.3), 189 (16.1), 187 (15.5), 175 (18.4), 174 (17.1), 173 (14.5), 161 (18.3), 147 (19.4), 139 (38.1), 133 (19.0), 121 (19.4), 109 (21.5), 95 (35.7), 91 (66.8), 81 (24.9), 69 (50.0), 55 (39.0), 44 (100).

X-ray Crystallographic Analysis

A colorless lath fragment of dimension 0.6 × 0.7 × 3.5 mm was used for data collection on a Rigaku AFC7R diffractometer, with graphite monochromated Mo-Kα radiation and 12 kW rotating anode generator. Crystal data are: $C_{30}H_{42}O_7$, F.M. = 514.66, monoclinic space group P 2_1 2_1 2_1 (#19). Cell constants and an orientation matrix for data collection, obtained from a least-squares refinement using the setting angles of 20 carefully centered reflections in the range $13.64 < 2\theta < 21.39°$ corresponded to a primitive orthorhombic cell with dimension: a = 12.012(2) Å, b = 23.257(5) Å, c = 9.764(2) Å, V = 2727.5(10) Å^3, Z = 4, d_c = 1.25 gcm^{-3}, The data were collected at a temperature of 20 ± 1°C using the $\omega-2\theta$ scan technique to a maximum 2θ value of 54.9°. Omega scans of several intense reflections, made prior to data collection, had an average width at half-height of 0.13° with a take-off angle of 6.0°. Scans of $(1.05+0.30\tan\theta)°$ were made at a speed of 16.0°/min (in omega). The weak reflections [$I < 13.0\delta(I)$] were rescanned (maximum of 4 scans) and the counts were accumulated to ensure good counting statistics. Stationary background counts were recorded on each side of the reflection. The ratio of peak counting time to background counting time was 2:1. The diameter of the incident beam collimator was 1.0 mm, the crystal to detector distance was 235 mm, and the computer controlled detector aperture was set to 9.0 × 13.0 mm (horizontal vertical). Data reductions are as follow: A total of 2955 reflections were collected. The intensities of three representative reflections were measured after every 200 reflections. Over the course of data collection, the standards increased by 0.2%. A linear correction factor was applied to the data to account for this phenomenon. The linear absorption coefficient, μ, for Mo-Kα radiation is 0.9 cm^{-1}. An empirical absorption correction based on azimuthal scans of several reflections was applied which resulted in transmission factors ranging from 0.97 to 1.00. The data were corrected for Lorentz and polarization effects. A correction for secondary extinction was applied (coefficient = 1.01332e-06). Structure solution and refinement are as follow: The structure was solved by direct methods [9] and expanded using Fourier techniques [10]. The non-hydrogen atoms were refined anisotropically. Hydrogen atoms were included but not refined. The final cycle of full-matrix

least-squares refinement was based on 1882 observed reflections [$I > 1.50\delta(I)$] and 335 variable parameters and converged (largest parameter was 0.00 times its esd) with unweighted and weighted agreement factors of $R = 0.049$, $Rw = 0.051$. The standard deviation of an observation of unit weight was 1.543. The weighting scheme was based on counting statistics and included a factor($p = 0.030$) to downweight the intense reflection. Plots of $\Sigma w(|Fo| - |Fc|)^2$ *versus* $|Fo|$, reflection order in data collection, $\sin\theta/\lambda$ and various classes of indices showed no unusual trends. The maximum and minimum peaks on the final difference Fourier map corresponded to 0.18

TABLE III Position parameters and their estimated s.d.s for pseudolarolide **F** in single-crystal X-ray analysis

Atom	*x*	*y*	*z*	$B_{eq}(Å^2)$
O-1	−0.4045(3)	0.1685(1)	−0.8589(4)	4.06(8)
O-2	−0.5359(3)	0.2226(1)	−0.7771(4)	5.8(1)
O-3	−0.5173(2)	0.0537(1)	−0.5244(3)	3.51(7)
O-4	−0.4055(3)	0.0041(1)	−0.3712(3)	4.26(8)
O-5	−1.0169(3)	−0.1328(1)	−0.7534(4)	4.15(8)
O-6	−1.1827(3)	−0.1126(2)	−0.8428(5)	5.4(1)
O-7	−0.8627(3)	−0.1725(1)	−0.8620(4)	4.11(8)
C-1	−0.4762(4)	0.0846(2)	−0.6315(5)	3.2(1)
C-2	−0.5168(4)	0.1367(2)	−0.6582(5)	3.6(1)
C-3	−0.4851(4)	0.1777(2)	−0.7646(5)	3.9(1)
C-4	−0.3069(4)	0.1314(2)	−0.8431(5)	3.7(1)
C-5	−0.3404(4)	0.0673(2)	−0.8330(5)	3.6(1)
C-6	−0.4261(4)	0.0478(2)	−0.9417(5)	4.0(1)
C-7	−0.4381(4)	−0.0182(2)	−0.9450(5)	4.1(1)
C-8	−0.5578(4)	−0.0982(2)	−0.9783(5)	4.1(1)
C-9	−0.4499(4)	0.0017(2)	−0.5038(5)	3.6(1)
C-10	−0.3853(4)	0.0521(2)	−0.6959(5)	3.3(1)
C-11	−0.5258(4)	−0.0523(2)	−0.5063(5)	3.9(1)
C-12	−0.5313(4)	−0.0878(2)	−0.6402(5)	3.6(1)
C-13	−0.6319(4)	−0.0802(2)	−0.7390(5)	3.3(1)
C-14	−0.6005(4)	−0.0925(2)	−0.8949(5)	3.9(1)
C-15	−0.7145(5)	−0.1124(2)	−0.9589(6)	4.8(1)
C-16	−0.7935(4)	−0.1218(2)	−0.8414(5)	3.9(1)
C-17	−0.7222(4)	−0.1275(2)	−0.7146(5)	3.8(1)
C-18	−0.6849(4)	−0.0202(2)	−0.7241(5)	3.6(1)
C-19	−0.3659(4)	0.0061(2)	−0.6176(5)	3.6(1)
C-20	−0.7965(5)	−0.1312(2)	−0.5897(5)	4.2(1)
C-21	−0.7394(5)	−0.1434(3)	−0.4527(7)	6.2(2)
C-22	−0.8797(4)	−0.1809(2)	−0.6142(5)	4.4(1)
C-23	−0.9357(4)	−0.1809(2)	−0.7525(5)	3.9(1)
C-24	−1.0082(5)	−0.2330(2)	−0.7828(6)	5.1(1)
C-25	−1.1074(4)	−0.2099(2)	−0.8623(6)	4.3(1)
C-26	−1.1098(5)	−0.1475(2)	−0.8225(6)	4.2(1)
C-27	−1.2197(5)	−0.2383(2)	−0.8334(8)	6.7(2)
C-28	−0.2389(4)	0.1505(2)	−0.7196(6)	5.2(2)
C-29	−0.2436(5)	0.1431(2)	−0.9752(6)	4.9(1)
C-30	−0.5161(5)	−0.1416(2)	−0.9107(6)	5.3(1)

and 0.15 e/Å^3, respectively. Neutral atom scattering factors were taken from Cromer and Waber [11]. Anomalous dispersion effects were included in Fcalc [12]; the values for Δf and Δf were those of Creagh and McAuley [13]. The values for the mass attenuation coefficients are those of Creagh and Hubbel [14]. All calculations were performed using the teXsan [15] crstallographic software package of Molecular Structure Corporation. The molecular structure is illustrated in Figure 2, and its coordinates are tabulated in Table III.

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