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Key indicators

Single-crystal X-ray study
T = 120 K
Mean $\sigma(\text{C}-\text{C}) = 0.003 \text{ \AA}$
R factor = 0.038
wR factor = 0.122
Data-to-parameter ratio = 9.5

For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.

A novel diterpene lactone

A highly rearranged novel dilactone, *ent*-5 α ,15 α -epoxy-9,10-friedo-10 β ,11 β -dihydroxy-16,11 α :19,10 β -diseco-17-norkauran-16,19-dioic acid 16 \rightarrow 11:19 \rightarrow 10-dilactone, C₁₉H₂₄O₅, was synthesized from *ent*-kaur-9(11)-en,16-nor,19-oic acid, which was obtained by oxidation of grandiflorencic acid, under Baeyer–Villiger rearrangement conditions. The structure of the final product was determined unambiguously by X-ray analysis.

Comment

Natural and synthetic diterpene lactones show many important and biological activities: anti-HIV (Chen *et al.*, 1992), anti-tumor (Ghisalberti, 1997) and allelopathic (*e.g.* the gibberellin phytohormones), among others. In an attempt to synthesize novel diterpene lactones from natural sources, for biological screening, the norketone (2), obtained from grandiflorencic acid (1), isolated from *Wedelia paludosa* (Asteraceae), was submitted to a Baeyer–Villiger oxidation (Anastasia *et al.*, 1985). The product was the highly rearranged dilactone (3), whose structure was unambiguously confirmed by X-ray analysis.

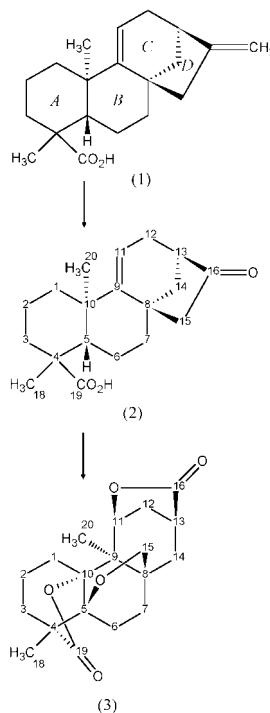


Fig. 1 shows an ORTEP-3 (Farrugia, 1997) view of (3). X-ray crystallographic analysis showed that a rearrangement

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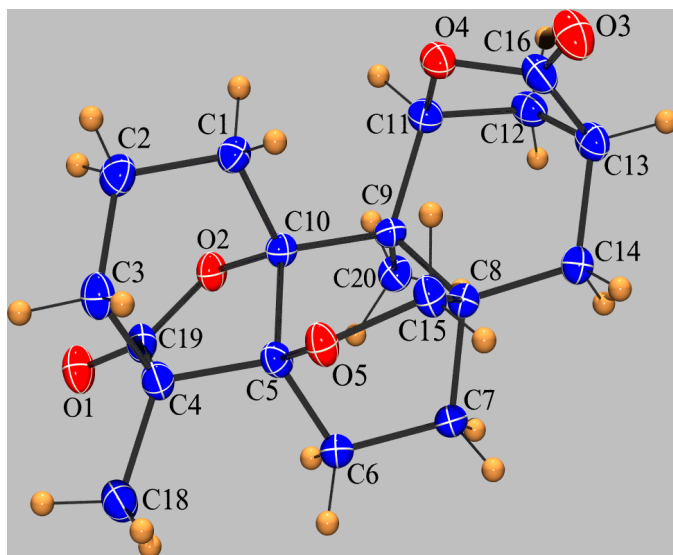


Figure 1
ORTEP-3 (Farrugia, 1997) view of the title compound, showing the atom and ring labeling, and 50% probability ellipsoids.

involving C20 occurred, leading to the formation of a lactone in ring *A*. This rearrangement is common in natural diterpenoids, such as tetrachirin (Zabel *et al.*, 1980; Vieira *et al.*, 2001) and eupatalbin (Herz *et al.*, 1979). Two other changes in the skeleton of (1) occurred: ring *D* rearrangement leading to the formation of a second lactone moiety, as well as an ether linkage on ring *B* between C5 and C15 in (3).

The main bond lengths and angles are given in Table 1. The mean value of the C—C single bond distances is 1.54 (2) Å, in good agreement with the expected value for formal single bonds (Allen *et al.*, 1987). The C—O single-bond lengths are very similar [mean 1.46 (2) Å], except for O2—C19 and O4—C16, whose values are 1.364 (2) and 1.367 (2) Å, respectively. This decrease in bond length is a consequence of resonance involving the trio O=C—O localized in the two lactone rings. The O1=C19 and O3=C16 bond lengths of the two carbonyls are 1.202 (3) and 1.205 (3) Å, respectively. The three C—O—C angles are also similar [mean 109 (1)°]. The two lactone rings are in envelope conformations, with atoms C5 and C12 in the flap positions (Cremer & Pople, 1975). No intra- or intermolecular hydrogen bonds occur in the structure of (3).

Experimental

Grandiflorenic acid, (1), was reacted with NaIO₄ and catalytic amounts of OsO₄ (Castellaro *et al.*, 1990). The product was norketone (2). Under Baeyer–Villiger rearrangement conditions, 2.5 ml of hydrogen peroxide (30%), dissolved in anhydrous dichloromethane (15 ml), and 14 ml of anhydrous trifluoroacetic acid were added to a solution of 0.66 mmol (200 mg) of ketoacid (2) in anhydrous dichloromethane (10 ml). The reaction mixture was left at room temperature for 1 h. The unexpected novel compound (3) was isolated, in 19% yield, after column chromatography (hexane–ethyl acetate, 7:3). Colorless, well-shaped single crystals were obtained by recrystallization from chloroform.

Crystal data

C₁₉H₂₄O₅
M_r = 332.38
 Orthorhombic, *P*2₁2₁2₁
a = 6.6980 (2) Å
b = 13.6063 (3) Å
c = 17.2155 (5) Å
V = 1568.85 (7) Å³
Z = 4
D_x = 1.407 Mg m⁻³

Mo *K*α radiation
 Cell parameters from 2081 reflections
 θ = 1.0–27.5°
 μ = 0.10 mm⁻¹
T = 120 (2) K
 Prism, colorless
 0.25 × 0.05 × 0.05 mm

Data collection

Nonius KappaCCD diffractometer
 ω and φ scans with κ offsets
 3592 measured reflections
 2074 independent reflections
 1857 reflections with *I* > 2σ(*I*)

*R*_{int} = 0.023
 θ_{\max} = 27.5°
h = 0 → 8
k = 0 → 17
l = -22 → 22

Refinement

Refinement on *F*²
R[*F*² > 2σ(*F*²)] = 0.038
wR(*F*²) = 0.122
S = 1.19
 2074 reflections
 219 parameters
 H-atom parameters constrained

$w = 1/[\sigma^2(F_o^2) + (0.0794P)^2 + 0.0434P]$
 where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\max} < 0.001$
 $\Delta\rho_{\max} = 0.43 \text{ e } \text{Å}^{-3}$
 $\Delta\rho_{\min} = -0.52 \text{ e } \text{Å}^{-3}$

Table 1

Selected geometric parameters (Å, °).

O1—C19	1.208 (3)	C4—C19	1.526 (3)
O2—C19	1.364 (3)	C4—C5	1.545 (3)
O2—C10	1.474 (3)	C5—C10	1.548 (3)
O3—C16	1.204 (3)	C8—C15	1.551 (3)
O4—C16	1.365 (3)	C11—C12	1.529 (3)
O4—C11	1.466 (3)	C12—C13	1.530 (3)
O5—C5	1.417 (3)	C13—C16	1.507 (3)
O5—C15	1.459 (3)		
C19—O2—C10	108.32 (16)	O3—C16—O4	121.0 (2)
C16—O4—C11	108.93 (18)	O1—C19—O2	120.6 (2)
C5—O5—C15	109.62 (16)		

Since the anomalous scattering was not large enough to permit determination of the absolute configuration, the intensities of the Friedel pairs were averaged before refinement. The H atoms were positioned stereochemically and were refined using a riding model, with C—H = 0.99 Å. The H atoms of the rings were set isotropically, with displacement parameters 20% greater than the equivalent isotropic displacement parameter of the atom to which each was bonded; this value was set to 50% for methyl H atoms.

Data collection: *COLLECT* (Nonius, 1997–2000); cell refinement: *HKL SCALEPACK* (Otwinowski & Minor, 1997); data reduction: *HKL DENZO* (Otwinowski & Minor, 1997) and *SCALEPACK*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEP-3* for Windows (Farrugia, 1997); software used to prepare material for publication: *WinGX* (Farrugia, 1999).

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