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A rearranged labdane diterpene glycoside

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Key indicators

Single-crystal X-ray study
T = 293 K
Mean σ(C–C) = 0.004 Å
R factor = 0.038
wR factor = 0.082
Data-to-parameter ratio = 10.3

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

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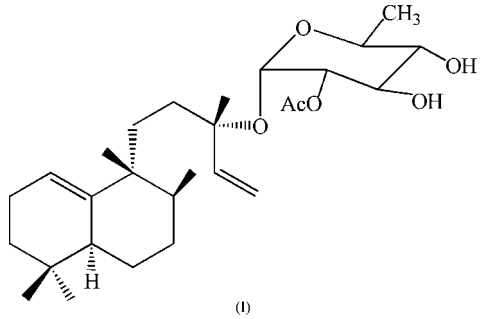
The title compound, 13(R)-9β-methyl-1(10),14-dienefriedlabda-13-O-α-L-2′-acetylrhamonopyanoside or 3-methyl-5-(1,2,5,5-tetramethyl-1,2,3,4,4a,5,6,7-octahydronaphthyl)pent-1-en-3-yl 2-O-acetylrhamnopyanoside, $C_{28}H_{46}O_6$, is a bicyclic diterpenoid glycoside. The rearranged methyl group (from C10 to C9) is in a β orientation and a double bond is formed between C1 and C10 in the rearrangement. The L-rhamnose group on the cyclohexane ring is equatorial and the configuration of the C atom to which the methylene group is attached is R. The cyclohexene, cyclohexane and L-rhamnose rings in the molecule adopt half-chair, chair and chair conformations, respectively. In the crystal structure, molecules are linked by O—H···O hydrogen bonds. The L-2′-acetylrhamnose hydroxy groups serve as hydrogen-bond donors, forming molecular chains along the b axis.

Comment

Labdane diterpenoids are among the most common types of diterpenes isolated from terrestrial higher plants and sponges (Hanson, 1997, 1998, 1999, 2000, 2001; Tanaka, *et al.*, 2001). Many of these terpenoids possess significant pharmacological properties, such as cytotoxic, antibacterial, antifungal, anti-inflammatory, analgesic, antitumor and antimutagenic (Ahsan *et al.*, 2003; Itokawa & Morita, 1988; Dimas *et al.*, 1998; Kittakoop *et al.*, 2001; Kubo *et al.* 2003; Minami *et al.*, 2002; Miyazawa *et al.*, 1995). Therefore, the semisynthesis of minor components from other abundant natural products is of long-standing interest. To date, a number of semisyntheses of these biologically active labdane-type diterpenoids have been reported (Pathak *et al.* 2005). The current interest of our group in the phytochemical study of northwest Chinese plants aims to find new natural compounds with interesting biological activities. In this connection we have studied labdane diterpenoids (Wang *et al.*, 2002; Yang, *et al.*, 2005).



(I)

In this paper, we report the crystal structure and relative stereochemistry of a diterpenoid glycoside, (I), with a rear-

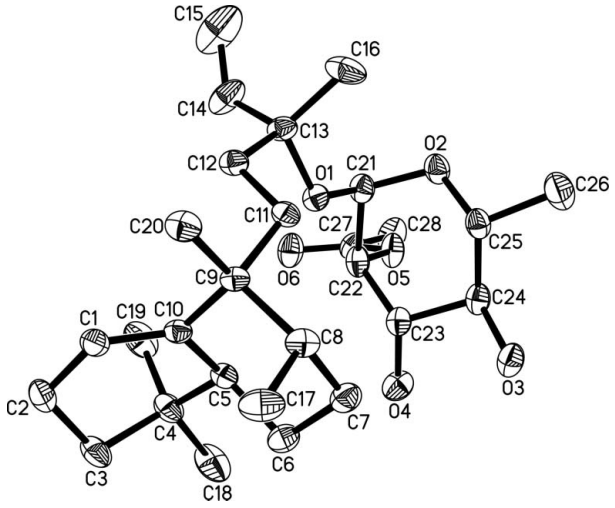


Figure 1
The molecular structure of (I). Displacement ellipsoids are drawn at the 50% probability level. H atoms have been omitted.

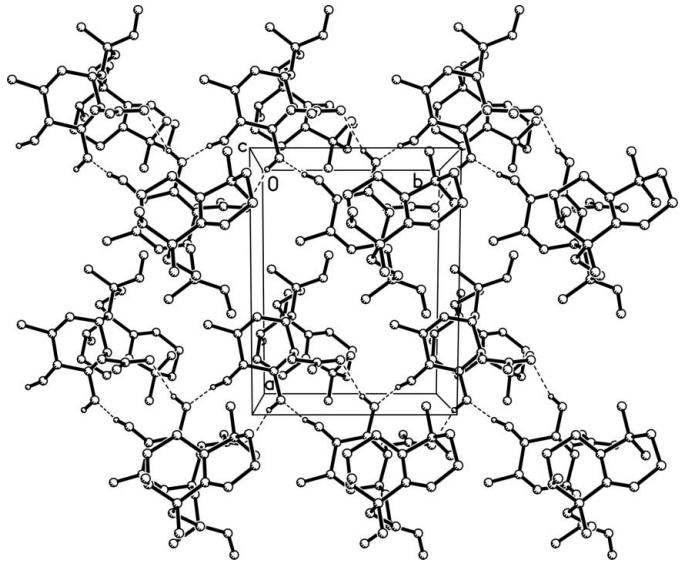


Figure 2
The molecular packing of (I), viewed along the *c* axis. Dashed lines indicate hydrogen bonds. H atoms not involved in hydrogen bonding have been omitted.

ranged labdane skeleton, from *Aster homochlamydeus* Handmazz. Crystal structures of typical labdane-type diterpenoids have previously been reported (Nagashima *et al.*, 1995; Bernardinelli *et al.*, 1988; Tavanaiepour *et al.*, 1987; Bjåmer *et al.*, 1968).

Compound (I) has the molecular formula $C_{28}H_{46}O_6$, established by FAB-MS, which gave [*M*+Na] at *m*/*z* 501 and [*M*+Li] at 485. Its IR spectrum showed the presence of hydroxyl functionalities (3483 and 3373 cm^{-1}). Since compound (I) has five degrees of unsaturation, it must contain one glycoside, two olefin bonds and two carbocyclic rings.

As shown in Fig. 1, compound (I) is a bicyclic diterpene glycoside of a C_{20} skelton with a terminal double bond, C14═C15. It is slightly different from typical labdane diterpenes. The methyl group (C20) normally located at C10 is moved to C9 and the C1—C10 bond length indicates double-bond character. The methyl group at C9 is in the β-orientation. Thus compound (I) is a diterpenoid with a rearranged labdane-type skelton (Urones *et al.*, 1994; Feresin *et al.*, 2003).

The bond distance between C9 and C20 is 1.532 (3) Å. The olefin bond distance in a carbocyclic ring, between C1 and C10, is 1.328 (4) Å, and corresponding bond angles show the characteristics of an olefin [C2—C1—C10 = 125.4 (3) and C1—C10—C5 121.2 (3)°]. The bond distance between C14 and C15 is 1.264 (4) Å, with C13—C14—C15 = 128.8 (5)°. The structure demonstrates that an equatorial L-2′-acetylrhamnose group and a methyl group are attached at C13. The bond lengths to these substituents [C13—C16 = 1.509 (4) Å and C13—O1 = 1.455 (3) Å] are in good agreement with the standard values observed for C—C (methyl) and C—O (sugar hydroxyl) distances, respectively (Allen *et al.*, 1987). The *R* configuration at C13 is confirmed unambiguously (Bernardinelli *et al.*, 1988). Furthermore, the relative configurations at C4, C5, C8 and C9 were also determined, as shown in Fig. 1.

The endocyclic torsion angles (Table 1) show that the cyclohexene ring is in the half-chair conformation (Daux *et al.*, 1974, 1976), which has an approximate twofold axis passing through the mid-point of the C3—C4 bond and the mid-point of the C1—C10 bond, with an asymmetry parameter ΔC_2 of 0.88°. The cyclohexane ring and L-2′-acetylrhamnose groups are in approximate chair conformations (Daux *et al.*, 1974, 1976); their conformations are similar to others in the literature (Tavanaiepour *et al.*, 1987). The molecules of (I) are associated in the crystal state by O—H···O hydrogen bonds between the hydroxyl functions in the L-2′-acetylrhamnose group (Table 2). As shown in Fig. 2, the molecules form columns along the *b* axis.

Experimental

The extraction and isolation of compound (I) have already been described (Yang *et al.*, 2005). Compound (I) was dissolved in chloroform and acetone (1:1 *v*/*v*), and slow evaporation gave crystals suitable for X-ray diffraction. The optical rotation is $[\alpha]_D^{25}$ = +33.0° (c 0.4, $CHCl_3$) and its melting point is 420 K.

Crystal data

$C_{28}H_{46}O_6$
M_r = 478.65
Monoclinic, $P2_1$
a = 11.542 (2) Å
b = 8.793 (2) Å
c = 14.095 (2) Å
β = 102.14 (1)°
V = 1398.6 (4) Å^3
Z = 2
D_x = 1.137 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 42 reflections
θ = 2.7–14.3°
μ = 0.08 mm^{-1}
T = 293 (2) K
Prism, colourless
0.58 × 0.40 × 0.16 mm

Data collection

Siemens P4 diffractometer
ω scans
Absorption correction: none
3583 measured reflections
3289 independent reflections
1841 reflections with $I > 2\sigma(I)$
R_{int} = 0.020
θ_{max} = 27.1°
$h = 0 \rightarrow 14$
$k = 0 \rightarrow 11$
$l = -18 \rightarrow 17$
3 standard reflections
every 97 reflections
intensity decay: 3.0%

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.04P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$R[F^2 > 2\sigma(F^2)] = 0.038$	$(\Delta/\sigma)_{max} < 0.001$
$wR(F^2) = 0.082$	$\Delta\rho_{max} = 0.12$ e Å^{-3}
$S = 0.81$	$\Delta\rho_{min} = -0.13$ e Å^{-3}
3289 reflections	Extinction correction: *SHELXL97*
320 parameters	Extinction coefficient: 0.0125 (13)
H-atom parameters constrained	

Table 1
Selected torsion angles (°).

C10—C1—C2—C3	15.5 (4)	C4—C5—C10—C1	17.8 (3)
C1—C2—C3—C4	−44.8 (4)	C6—C5—C10—C9	62.0 (3)
C2—C3—C4—C5	60.4 (3)	C8—C9—C10—C5	−59.5 (3)
C3—C4—C5—C10	−45.6 (3)	C25—O2—C21—C22	−59.6 (3)
C10—C5—C6—C7	−55.5 (3)	O2—C21—C22—C23	52.9 (3)
C5—C6—C7—C8	52.5 (3)	C21—C22—C23—C24	−50.6 (3)
C6—C7—C8—C9	−50.3 (3)	C22—C23—C24—C25	52.8 (3)
C7—C8—C9—C10	51.3 (3)	C21—O2—C25—C24	60.2 (3)
C2—C1—C10—C5	−2.1 (4)	C23—C24—C25—O2	−55.0 (3)

Table 2
Hydrogen-bond geometry (Å, °).

D—H···A	D—H	H···A	D···A	D—H···A
O3—H3O···O4^{i}	0.82	1.91	2.714 (3)	165
O4—H4O···O6^{i}	0.82	2.17	2.968 (3)	163

Symmetry code: (i) $-x, y-\frac{1}{2}, -z+1$.

All H atoms were refined as riding on their parent atoms with C—H distances of 0.93–0.98 Å and O—H = 0.82 Å, and with U_{iso}(H) = 1.2U_{eq}(C,O). In the absence of significant anomalous scattering, Friedel pairs were merged and the absolute configuration is arbitrary.

Data collection: *XSCANS* (Siemens, 1994); cell refinement: *XSCANS*; data reduction: *SHELXTL* (Sheldrick, 1994; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *SHELXTL*; software used to prepare material for publication: *SHELXTL*.

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