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(25*R*)-1*α*,2*α*-Epoxy-3*α*-hydroxy-5*α*-spirostan-6-one

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Key indicators

Single-crystal X-ray study
T = 298 K
Mean *σ*(C–C) = 0.005 Å
R factor = 0.042
wR factor = 0.114
Data-to-parameter ratio = 7.8

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

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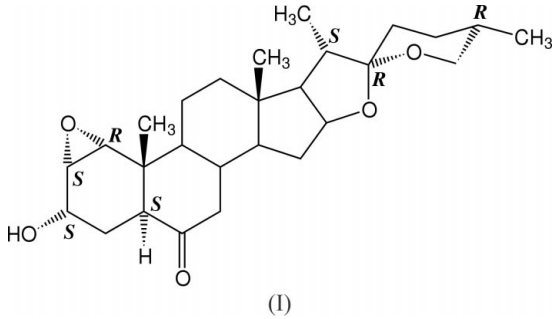
The title compound, $C_{27}H_{40}O_5$, obtained through a four-step synthesis starting from diosgenin, has an oxirane ring fused with ring *A* of the steroid nucleus. As a consequence, ring *A* adopts an envelope conformation.

Comment

Steroids with an oxirane ring at position 1*α*,2*α* are suitable frameworks for the generatation of 1- and 2-substituted steroid derivatives. For example, this functionality has been used to obtain 1- and 2-oxygenated vitamin D analogues (Zhu & Okamura, 1995). The usual way to achieve such an oxirane ring at this position is through the oxidation of a double bond at C1. This synthetic step is generally performed using OsO_4, but because it is an expensive, difficult to handle and hazardous material, we changed to permanganate ammonium salts, according to reports on the use of these reagents as oxidants (Bhushan *et al.*, 1984; Hazra *et al.*, 1994; Hazra *et al.*, 1997). By applying this synthetic step to (25*R*)-5*α*-spiro-2-ene-6-one, we obtained the expected 2*α*,3*α*-dihydroxy derivative, but also a by-product, (I), which was identified by its crystal structure as (25*R*)-1*α*,2*α*-epoxy-3*α*-hydroxy-5*α*-spirostan-6-one (see *Experimental*). We report here the crystal structure of this compound.



(I)

The title compound (Fig. 1 and Table 1) displays the expected *A*–*E* steroid nucleus, including a *trans A*/*B* junction. The *E*–*F* system is characteristic of diosgenin derivatives, including a spiroketal functional group at C22. Ring *F* adopts the expected chair conformation and five-membered rings *D* and *E* adopt approximate envelope conformations, a common feature observed for steroids based on the diosgenin framework (*e.g.* Yu & Tao, 2002). Rings *B* and *C* are very close to having chair forms [θ = 7.07 (34) and 6.03 (3)°, respectively], a feature also found in the vast majority of steroidal compounds, including diosgenin derivatives (*e.g.* Castro-Méndez *et al.*, 2002). Ring *A* is best described as having an envelope conformation (EC) with C5 as the flap atom [puckering angles: θ = 53.9 (5) and φ = 235.0 (6)°], representing a strong

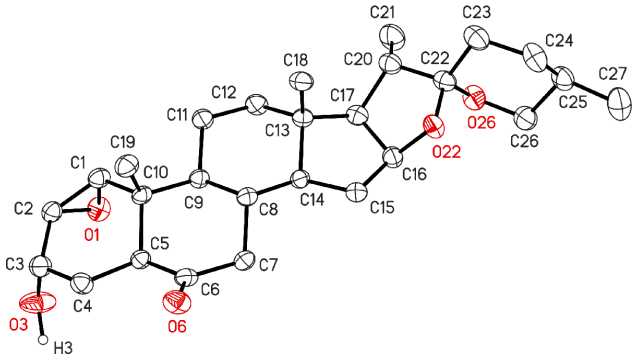


Figure 1
The structure of (I), with displacement ellipsoids drawn at the 30% probability level. H atoms have omitted for clarity, except H3 of the hydroxyl group.

conformational distortion compared to non-substituted A rings in the steroid series, which generally adopt a chair conformation (CC). The observed distortion clearly arises from the presence of the fused epoxy ring, inducing a strongly strained bicyclic system. Such a CC → EC distortion has been reported for 3α,4α-epoxy-5α-hydroxyandrostane-6-17-dione (Hanson *et al.*, 1999) and for a 2α,3α-epoxy-spirostane compound (Morales *et al.*, 2000). The oxirane ring in (I) does not deviate from the mean geometry observed in other oxirane-containing molecules (Table 1).

Experimental

(25*R*)-5α-Spirost-2-en-6-one was prepared as previously reported, using a three-step procedure starting from diosgenin (Castro-Méndez, 2003). An amount of this spirostene (1.35 g, 3.27 mmol) was dissolved in CH_2Cl_2 (5 ml) and an excess of a ^{t}BuOH/H_2O mixture (20:5) was added to this solution. A cetyltrimethylammonium permanganate solution in the same ^{t}BuOH/H_2O heterogeneous solvent system was then slowly added dropwise to the previous mixture, following the reaction by TLC. After completion, the mixture was filtered through silica gel, the solvent was removed and the resulting crude material was purified by flash chromatography, to give (25*R*)-2α,3α-dihydroxy-5α-spirostan-6-one (0.65 g, yield 45%) and (25*R*)-1α,2α-epoxy-3α-hydroxy-5α-spirostan-6-one, (I), as a minor product (0.073 g, yield 5%). The latter was crystallized from a CCl_4/$CHCl_3$ solution (3/2).

Crystal data

$C_{27}H_{40}O_5$
M_r = 444.59
Monoclinic, $P2_1$
a = 10.9714 (9) Å
b = 7.7711 (8) Å
c = 14.3786 (11) Å
β = 101.464 (4)°
V = 1201.46 (18) Å^3
Z = 2
D_x = 1.229 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 71 reflections
θ = 3.8–12.0°
μ = 0.08 mm^{-1}
T = 298 (1) K
Plate, colourless
0.60 × 0.18 × 0.08 mm

Data collection

Bruker *P*4 diffractometer
ω scans
Absorption correction: none
4919 measured reflections
2282 independent reflections
1591 reflections with $I > 2\sigma(I)$
R_{int} = 0.035
θ_{max} = 25.0°
$h = -13 \rightarrow 9$
$k = -9 \rightarrow 1$
$l = -16 \rightarrow 17$
2 standard reflections
every 48 reflections
intensity decay: 1.5%

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.042
$wR(F^2)$ = 0.114
S = 1.06
2282 reflections
293 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0538P)^2 + 0.0998P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.16 e Å^{-3}
$\Delta\rho_{min}$ = −0.17 e Å^{-3}
Extinction correction: *SHELXL*97
Extinction coefficient: 0.012 (2)

Table 1
Selected geometric parameters (Å, °).

C1—O1	1.443 (4)	C20—C21	1.517 (7)
C1—C2	1.468 (5)	C22—C20	1.540 (6)
C1—C10	1.503 (5)	C22—O26	1.427 (4)
C2—O1	1.459 (4)	C22—O22	1.427 (5)
C2—C3	1.502 (6)	C22—C23	1.510 (5)
C3—O3	1.422 (4)	C25—C27	1.523 (8)
C6—O6	1.215 (4)	O3—H3	0.99 (8)
O1—C1—C2	60.2 (2)	O26—C22—C23	110.7 (3)
O1—C1—C10	115.0 (3)	O22—C22—C23	108.1 (3)
C2—C1—C10	121.8 (3)	O26—C22—C20	106.8 (3)
O1—C2—C1	59.1 (2)	O22—C22—C20	105.1 (3)
O1—C2—C3	116.4 (3)	C23—C22—C20	115.9 (3)
C1—C2—C3	122.3 (4)	C1—O1—C2	60.8 (2)
O26—C22—O22	110.1 (3)	C3—O3—H3	108 (3)

H atoms bonded to C were placed at idealized positions, while the H atom of the O3 hydroxyl group was found in a difference map. All H atoms were constrained to ride on their parent atoms, with $U_{iso}(H) = xU_{eq}$(parent). Constrained distances and x parameters: methine CH: 0.98 Å, x = 1.2; methylene CH_2: 0.97 Å, x = 1.5; methyl CH_3: 0.96 Å, x = 1.5; hydroxyl OH: distance found from difference map and x = 1.5. In the absence of significant anomalous scattering, 336 measured Friedel pairs were merged and the absolute configuration was assumed from the synthesis.

Data collection: *XSCANS* (Siemens, 1996); cell refinement: *XSCANS*; data reduction: *XSCANS*; program(s) used to solve structure: *SHELXTL-Plus* (Sheldrick, 1998); program(s) used to refine structure: *SHELXTL-Plus*; molecular graphics: *SHELXTL-Plus*; software used to prepare material for publication: *SHELXTL-Plus*.

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