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Key indicators

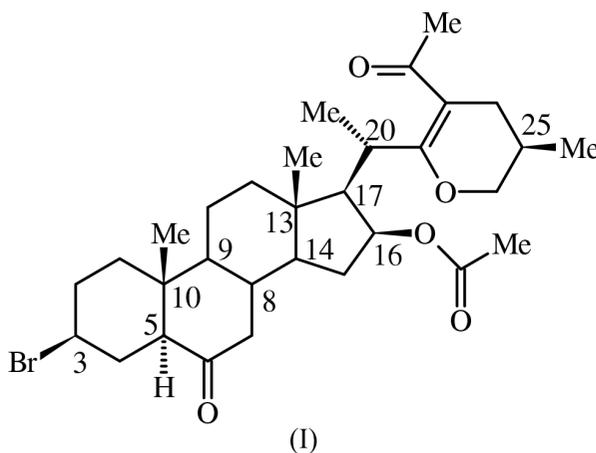
Single-crystal X-ray study
T = 300 K
Mean $\sigma(\text{C}-\text{C}) = 0.007 \text{ \AA}$
Disorder in main residue
R factor = 0.056
wR factor = 0.139
Data-to-parameter ratio = 17.2For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.A derivative of diosgenin: (25*R*)-23-acetyl-3 β -bromo-16 β -acetoxy-22,26-epoxy-5 α -cholest-22-en-6-one

The crystal structure of the title compound, $\text{C}_{31}\text{H}_{45}\text{BrO}_5$, has been determined at 0.80 Å resolution. This study demonstrates that the Marker transformation applied to a diosgenin derivative does not affect the *A*–*D* ring structure of the steroid. The configurations of the stereogenic centres C20 and C25 also remain unchanged during the reaction.

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Comment

Diosgenin is an important member of the sapogenin family, especially due to the possibility of using this compound as a starting material for large-scale production of progesterone (Marker *et al.*, 1940). Our group is currently working on the side-chain modification of diosgenin and related spirostane compounds, using Lewis acids (Sandoval-Ramírez *et al.*, 1999). During the course of this work, we prepared the title compound, (I), starting from a bromo derivative of a modified diosgenin previously reported (Coll-Manchado *et al.*, 1998). Compound (I) can also be considered as a precursor for a new brassinosteroid class (Mitchell *et al.*, 1970; Grove *et al.*, 1979) and related steroids of biological interest.



As expected, the Marker transformation (see *Experimental*) afforded (I) with an unmodified *A*–*D* steroidal nucleus, including *trans* *A/B* junction, and opened the *E* ring, providing the modified side chains (Fig. 1, and Tables 1 and 2). Position 16 of the *D* ring in (I) is substituted with an OAc group, while position 17 is substituted with a pyran ring containing an α,β -unsaturated carbonyl group. The C22 atom of the spiroketal group, characteristic of the *E*–*F* moiety in diosgenin, has changed its formal hybridization state from sp^3 to sp^2 and is clearly involved in the double bond $\text{C}22=\text{C}23$, with a distance of 1.345 (6) Å. The position of the O atom in the pyran ring is clearly demonstrated by bond lengths $\text{C}22-\text{O}26$ and $\text{C}26-$

O26, of 1.365 (5) and 1.441 (5) Å, respectively. This O atom is oriented towards the α face of the *A*–*D* ring system.

The pyran ring adopts a twisted conformation, very similar to that observed for the two crystallographically characterized sapogenins with the same substitution at C16 and C17 (Sandoval-Ramírez *et al.*, 1999). In the case of (25*R*)-23-acetyl-3 β ,16 β -diacetoxy-22,26-epoxy-cholesta-5,22-diene benzene solvate, a fit between the six-membered pyran ring of this compound and the pyran ring of (I) gives an r.m.s. deviation of 0.026 Å (in order to properly compute this fit, the structure of the first molecule should be inverted, since the refinement was unfortunately carried out with the wrong absolute configuration). In the case of (25*R*)-23-acetyl-3 β ,16 β -diacetoxy-22,26-epoxy-5 α -cholest-22-en-12-one diethyl ether solvate, reported in the same paper, the calculated r.m.s. deviation for the pyran rings is 0.023 Å. A comparison with compounds containing fused pyran rings also shows that the conformation is similar to that observed in (I). For instance, a fit with the pyran moiety of rhinacanthone (Kuwahara *et al.*, 1995) affords an r.m.s. deviation of only 0.030 Å.

Finally, the presence of the heavy Br atom at the 3-position allowed the determination of the absolute configuration for the 11 chiral centres in (I). The refinement of the Flack (1983) parameter, $x = -0.008$ (12), determines unambiguously the following configurations: 3*S*, 5*R*, 8*R*, 9*S*, 10*R*, 13*S*, 14*S*, 16*S*, 17*R*, 20*S* and 25*R*. The Marker reduction thus does not induce an inversion of configuration for the stereogenic centres at C20 and C25.

Experimental

Compound (I) was obtained from a modified Marker degradation. To (25*R*)-3 β -bromo-5 α -spirostan-6-one (1.0 g, 2.026 mmol) was added 10 ml of acetic anhydride and 3 ml of BF₃·Et₂O. The mixture was stirred for 30 min and poured into cold water before extraction with ethyl acetate. The organic layer was washed with saturated aqueous NaHCO₃ and then water. After removal of the solvent, the crude product was flash chromatographed on silica gel to give (I), which was crystallized from ethyl acetate (82% yield).

Crystal data

C ₃₁ H ₄₅ BrO ₅	Mo <i>K</i> α radiation
$M_r = 577.58$	Cell parameters from 67 reflections
Orthorhombic, <i>P</i> 2 ₁ 2 ₁	$\theta = 4.7$ – 13.2°
$a = 8.5963$ (11) Å	$\mu = 1.42$ mm ⁻¹
$b = 12.4609$ (8) Å	$T = 300$ (2) K
$c = 27.7642$ (15) Å	Irregular block, colourless
$V = 2974.0$ (5) Å ³	0.70 × 0.44 × 0.40 mm
$Z = 4$	
$D_x = 1.290$ Mg m ⁻³	

Data collection

Bruker <i>P4</i> diffractometer	$R_{\text{int}} = 0.038$
2 θ/ω scans	$\theta_{\text{max}} = 26.3^\circ$
Absorption correction: ψ scan (<i>XSCANS</i> ; Fait, 1996)	$h = -10 \rightarrow 9$
$T_{\text{min}} = 0.528$, $T_{\text{max}} = 0.567$	$k = -15 \rightarrow 1$
7094 measured reflections	$l = -1 \rightarrow 34$
5918 independent reflections	3 standard reflections
3490 reflections with $I > 2\sigma(I)$	every 97 reflections
	intensity decay: 0.5%

Refinement

Refinement on F^2	$(\Delta/\sigma)_{\text{max}} = 0.002$
$R[F^2 > 2\sigma(F^2)] = 0.056$	$\Delta\rho_{\text{max}} = 0.62$ e Å ⁻³
$wR(F^2) = 0.139$	$\Delta\rho_{\text{min}} = -0.52$ e Å ⁻³
$S = 1.01$	Extinction correction: <i>SHELXL97</i>
5918 reflections	Extinction coefficient: 0.0014 (5)
345 parameters	Absolute structure: Flack (1983);
H-atom parameters constrained	2511 Friedel pairs
$w = 1/[\sigma^2(F_o^2) + (0.0489P)^2 + 2.0696P]$	Flack parameter = -0.008 (12)
where $P = (F_o^2 + 2F_c^2)/3$	

Table 1

Selected geometric parameters (Å, °).

Br1–C3	1.966 (5)	C13–C18	1.533 (6)
O16–C30	1.311 (7)	C13–C17	1.552 (6)
O16–C16	1.463 (6)	C13–C14	1.563 (6)
O28–C28	1.206 (6)	C14–C15	1.520 (6)
C1–C2	1.533 (7)	C15–C16	1.519 (7)
C1–C10	1.547 (6)	C16–C17	1.553 (6)
C2–C3	1.500 (8)	C17–C20	1.528 (6)
C3–C4	1.516 (7)	C20–C22	1.515 (6)
C4–C5	1.529 (7)	C20–C21	1.542 (7)
C5–C6	1.500 (6)	C22–C23	1.345 (6)
C5–C10	1.543 (7)	C22–O26	1.365 (5)
C6–O6	1.215 (5)	C23–C28	1.479 (7)
C6–C7	1.491 (7)	C23–C24	1.513 (7)
C7–C8	1.531 (7)	C24–C25	1.510 (7)
C8–C14	1.509 (6)	C25–C26	1.483 (7)
C8–C9	1.557 (6)	C25–C27	1.505 (7)
C9–C11	1.538 (7)	C26–O26	1.441 (5)
C9–C10	1.541 (6)	C28–C29	1.514 (8)
C10–C19	1.536 (6)	C30–O30	1.21 (2)
C11–C12	1.541 (6)	C30–O30'	1.24 (2)
C12–C13	1.526 (6)	C30–C31	1.482 (9)
C30–O16–C16	117.0 (5)	C8–C14–C15	120.2 (4)
C2–C1–C10	114.0 (4)	C8–C14–C13	115.6 (4)
C3–C2–C1	111.5 (4)	C15–C14–C13	103.2 (4)
C2–C3–C4	111.1 (4)	C16–C15–C14	103.6 (4)
C2–C3–Br1	110.3 (3)	O16–C16–C15	111.4 (4)
C4–C3–Br1	111.1 (3)	O16–C16–C17	109.4 (3)
C3–C4–C5	107.9 (4)	C15–C16–C17	107.6 (4)
C6–C5–C4	113.7 (4)	C20–C17–C16	114.7 (4)
C6–C5–C10	110.6 (4)	C20–C17–C13	119.3 (3)
C4–C5–C10	114.9 (4)	C16–C17–C13	103.5 (3)
O6–C6–C7	122.8 (4)	C22–C20–C17	112.4 (4)
O6–C6–C5	122.5 (4)	C22–C20–C21	107.9 (4)
C7–C6–C5	114.7 (4)	C17–C20–C21	112.0 (4)
C6–C7–C8	114.2 (4)	C23–C22–O26	122.6 (4)
C14–C8–C7	111.3 (4)	C23–C22–C20	128.4 (4)
C14–C8–C9	107.9 (3)	O26–C22–C20	109.0 (4)
C7–C8–C9	111.1 (4)	C22–C23–C28	121.6 (5)
C11–C9–C10	115.5 (4)	C22–C23–C24	120.2 (4)
C11–C9–C8	108.7 (4)	C28–C23–C24	118.1 (5)
C10–C9–C8	113.5 (4)	C25–C24–C23	113.0 (4)
C19–C10–C9	111.9 (4)	C26–C25–C27	111.7 (4)
C19–C10–C5	110.5 (4)	C26–C25–C24	107.9 (4)
C9–C10–C5	107.6 (3)	C27–C25–C24	113.0 (4)
C19–C10–C1	110.6 (4)	O26–C26–C25	112.8 (4)
C9–C10–C1	108.9 (3)	C22–O26–C26	117.4 (4)
C5–C10–C1	107.3 (4)	O28–C28–C23	124.8 (5)
C9–C11–C12	113.1 (4)	O28–C28–C29	118.9 (5)
C13–C12–C11	112.2 (4)	C23–C28–C29	116.3 (5)
C12–C13–C18	110.3 (4)	O30–C30–O16	120.7 (15)
C12–C13–C17	117.1 (4)	O30'–C30–O16	119.5 (11)
C18–C13–C17	110.6 (4)	O30–C30–C31	122.4 (13)
C12–C13–C14	107.5 (4)	O30'–C30–C31	123.8 (11)
C18–C13–C14	111.8 (4)	O16–C30–C31	112.6 (7)
C17–C13–C14	99.0 (3)		

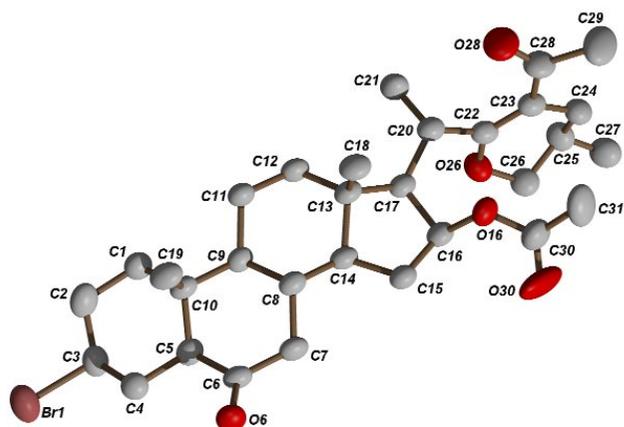


Figure 1
The structure of (I), with displacement ellipsoids at the 40% probability level. For clarity, H atoms and the minor disorder component have been omitted.

A minor disorder was detected for the carbonyl O atom of the OAc group on C16; this site was split into two components, O30 and O30', and refined with site-occupation factors of 0.54 (7) and 0.46 (7), respectively.

Data collection: *XSCANS* (Fait, 1996); cell refinement: *XSCANS*; data reduction: *XSCANS*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *RASTEP-three-dimensional* (Merritt & Bacon, 1997); software used to prepare material for publication: *SHELXL97*.

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