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(1*S*,3*S*)-1-*tert*-Butyldiphenylsiloxy-3-hydroxy-3-isopropenyl-1,2,3,4-tetrahydronaphthalene

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Key indicators

Single-crystal X-ray study
T = 193 K
Mean σ(C–C) = 0.003 Å
R factor = 0.038
wR factor = 0.095
Data-to-parameter ratio = 17.5

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

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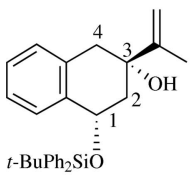
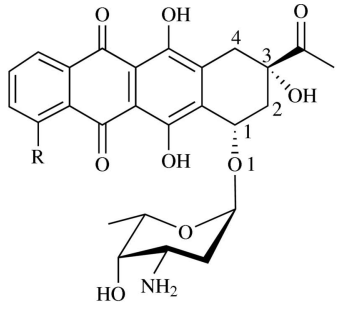
In the title compound, $C_{29}H_{34}O_2Si$, the isopropenyl group is oriented *trans* and the OH group is *cis* to the *tert*-butyldiphenylsiloxy (OTBDPS) group. The cyclohexane ring of the tetrahydronaphthalene system adopts a half-chair conformation in which the stereogenic centre at the ring C3 atom is projected above the plane of the ring ($^3H_2$), minimizing steric congestion between the substituents on the ring C3 atom and the bulky OTBDPS group.

Comment

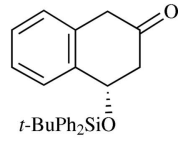
The title compound, (I), is an intermediate in the enantioselective synthesis of an anthracycline-like product. Compound (I) possesses obvious similarities to both idarubicin (II) and daunorubicin (III), and the stereochemistry of the stereogenic centers at C3 and C1 are exactly identical to that of the anthracycline antibiotics (Chen & Liu, 1994; Champoux, 2001; Achmatowicz & Szechner, 2002). The product was obtained in reasonable yield and diastereoselectivity (80% yield, 74% d.e.) through a two-step sequence in which (IV) was treated first with cerium(III) chloride, followed by isopropenyl magnesium bromide (Imamoto *et al.*, 1988; Dimitrov *et al.*, 1994). NMR analysis for the two diastereomers could not resolve the configuration of the newly formed stereogenic centre at C3. Fortunately, the two isomers were separable by chromatography, and a single-crystal X-ray diffraction study was carried out on the major isomer. The structure obtained confirmed the absolute configuration at C3, as shown in Fig. 1.



(I)



(II) R = H, Idarubicin
(III) R = OMe, Daunorubicin



(IV)

Previous X-ray crystallographic data from (II) and (III) (Neidle & Taylor, 1977; Courseille *et al.*, 1979) showed that C3 is positioned below the plane of the ring, placing the OH group pseudo-axial; hydrogen bonding is observed between this OH group and the glycosidic oxygen. Interestingly, the same conformation is not observed in the crystal structure of

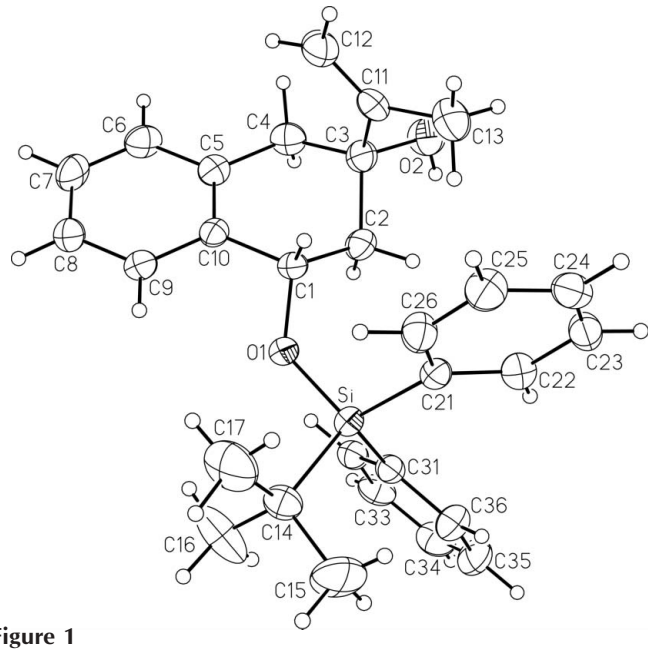


Figure 1
Perspective view of (I), showing the atom labelling scheme, with displacement ellipsoids drawn at the 50% probability level. H atoms are shown with arbitrarily small radii.

compound (I). The difference in the orientation of (I) *versus* that of (II) and (III) is presumably the result of steric effects. In the case of (I), one of the phenyl rings of the OTBDPS group prevents C3 and the attached substituents from adopting a conformation similar to that of the anthracyclines. Compound (I), therefore, must adopt the $^3H_2$ half-chair conformation, leading to the isopropenyl group being positioned pseudo-axially, and the OH group pseudo-equatorially. In this conformation, the distance between the OH group and the glycosidic oxygen is increased and hydrogen bonding to O1 is not observed. Instead, the OH group is directed towards the aromatic ring of the tetrahydronaphthalene group of a neighbouring molecule (located at $1-x, -\frac{1}{2}+y, 1-z$), and an O—H$\cdots\pi$ interaction is observed (H$\cdots$centroid of ring, 2.64 Å).

Experimental

Cerium chloride ($CeCl_3\cdot 7H_2O$) (4.53 g, 18.4 mmol) and a magnetic stir bar were placed in a flask and heated to 413–415 K *in vacuo* (0.1 Torr) for 24 h. The flask was allowed to cool, and (*S*)-1-*tert*-butyldiphenylsiloxy-1,2,3,4-tetrahydronaphthal-3-one [(IV), 2.10 g, 5.25 mmol) and THF (20 ml) were added. The reaction mixture was vigorously stirred for 1.5 h after which the mixture had become an orange paste. Isopropenylmagnesium bromide 0.5 *M* in THF (18.9 ml, 9.45 mmol) was added over 10 min at 273 K and the solution was stirred for 24 h. The mixture was then treated with a saturated solution of NH_4Cl (50 ml), and EtOAc (50 ml) was added. The mixture was filtered through a pad of Celite and the aqueous layer was extracted with EtOAc (2 × 40 ml). The combined organic layers were dried over Na_2SO_4 and purified by chromatography (15:1, hexanes–EtOAc) to yield (I) (1.86 g, 80%) as a white solid. The solid was recrystallized from hexane/Et_2O (1:1) (m.p. 368–371 K). R_F 0.65 (5:1, hexanes–EtOAc); $[\alpha]_D$ −10.5 (*c* 0.7, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 6.92–7.82 (*m*, 14 H, Ar—H), 5.08 (*s*, 1, alkene), 4.94 (*appt*, 1H, $J_{1,2}$ = 3.8 Hz, H1), 4.87 (*br s*, 1H, alkene), 4.59 (*s*, 1H, OH), 3.08 (*d*, 1H, $J_{4,4'}$ = 16.8 Hz, H4), 3.03 (*d*, 1H, $J_{4,4'}$ = 16.8 Hz, H4') 2.30 (*ddd*, 1H, $J_{2,2'}$ = 14.0 Hz, $J_{1,2}$ = 3.8 Hz, $J_{2,4}$ = 1.3 Hz, H2), 2.00 (*dd*, 1H, $J_{2,2'}$ = 14.0 Hz, $J_{1,2'}$ = 3.8 Hz, H2'), 1.82 (*s*, 3H, CH_3), 1.03 (*s*, 9H, $C(CH_3)_3$); ^{13}C NMR (125 MHz, $CDCl_3$): δ 149.9 (Ar—C), 136.2 (Ar—C), 135.8 (Ar—C), 135.2 (Ar—C), 134.8 (Ar—C), 134.6 (Ar—C), 133.0 (Ar—C), 132.9 (Ar—C), 130.1 (Ar—C), 129.8 (Ar—C), 129.6 (Ar—C), 129.5 (Ar—C), 128.1 (Ar—C), 127.9 (Ar—C), 127.7 (Ar—C), 127.6 (Ar—C), 125.8 (Ar—C), 110.0 (=CH_2), 73.1 (C3), 70.6 (C1), 41.6 (C4), 40.5 (C2), 26.9 (CH_3), 19.3 (C), 18.7 (CH_3). HRMS (ESI) calculated for (*M* + Na) $C_{29}H_{34}O_2SiNa$: 465.2220, found 465.2221. Analysis calculated for $C_{29}H_{34}O_2Si$: C 78.68, H 7.74, O 7.23%; found: C 78.35, H 7.68, O, 7.64%.

Crystal data

$C_{29}H_{34}O_2Si$
M_r = 442.65
Monoclinic, $P2_1$
a = 10.4483 (12) Å
b = 10.2152 (12) Å
c = 11.6877 (13) Å
β = 94.506 (2)°
V = 1243.6 (2) Å^3
Z = 2
D_x = 1.182 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 4566 reflections
θ = 2.5–26.2°
μ = 0.12 mm^{-1}
T = 193 (2) K
Plate, pale yellow
0.47 × 0.28 × 0.11 mm

Data collection

Bruker PLATFORM diffractometer/SMART 1000 CCD area-detector
ω scans
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2003)
T_{min} = 0.947, T_{max} = 0.987
9592 measured reflections
5064 independent reflections
4498 reflections with $I > 2\sigma(I)$
R_{int} = 0.031
θ_{max} = 26.4°
$h = -13 \rightarrow 13$
$k = -12 \rightarrow 12$
$l = -14 \rightarrow 14$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.038
$wR(F^2)$ = 0.095
S = 1.05
5064 reflections
290 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0494P)^2 + 0.0552P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.26 e Å^{-3}
$\Delta\rho_{min}$ = −0.18 e Å^{-3}
Absolute structure: Flack (1983), 2367 Friedel pairs
Flack parameter: 0.01 (10)

Table 1
Selected geometric parameters (Å, °).

Si—O1	1.6420 (13)	C5—C10	1.398 (3)
Si—C31	1.8720 (18)	C2—C3	1.533 (3)
Si—C21	1.879 (2)	C3—C4	1.521 (3)
Si—C14	1.890 (2)	C3—C11	1.523 (3)
O1—C1	1.429 (2)	C4—C5	1.512 (3)
O2—C3	1.441 (2)	C11—C12	1.313 (3)
C1—C10	1.512 (3)	C11—C13	1.496 (3)
C1—C2	1.517 (3)		
O1—Si—C31	108.26 (8)	O2—C3—C4	108.50 (16)
O1—Si—C21	110.44 (8)	O2—C3—C11	104.54 (17)
C31—Si—C21	111.14 (9)	C4—C3—C11	114.32 (17)
O1—Si—C14	104.78 (9)	O2—C3—C2	110.98 (16)
C31—Si—C14	108.35 (9)	C4—C3—C2	107.17 (17)
C21—Si—C14	113.57 (9)	C11—C3—C2	111.33 (17)
C1—O1—Si	130.40 (12)	C5—C4—C3	113.74 (16)
O1—C1—C10	108.16 (15)	C12—C11—C13	121.1 (2)
O1—C1—C2	112.45 (15)	C12—C11—C3	123.1 (2)
C10—C1—C2	111.86 (16)	C13—C11—C3	115.76 (19)
C1—C2—C3	110.15 (15)		

H atoms were placed in idealized positions, and then refined using a riding model, with fixed C—H and O—H distances (C—H = 0.95–1.00 Å and O—H = 0.84 Å) and with U_{iso}(H) = 1.2U_{eq}(C,O). The hydroxyl torsion angle (H—O—C—C) was allowed to refine to improve the position of the H atom.

Data collection: *SMART* (Bruker, 1997); cell refinement: *SAINT* (Bruker, 1997); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1990); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997*a*); molecular graphics: *SHELXTL* (Sheldrick, 1997*b*); software used to prepare material for publication: *SHELXTL*.

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References

Achmatowicz, O. & Szechner, B. (2002). *J. Org. Chem.* **68**, 2398–2404.
Bruker (1997). *SMART* (Version 5.0) and *SAINT* (Version 6.45A). Bruker AXS Inc., Madison, Wisconsin, USA.
Champoux, J. J. (2001). *Ann. Rev. Biochem.* **70**, 369–413.
Chen, A. Y. & Liu, L. F. (1994). *Ann. Rev. Pharmacol. Toxicol.* **34**, 191–218.
Courseille, C., Busetta, B., Geoffre, S. & Hospital, M. (1979). *Acta Cryst.* B**35**, 764–769.
Dimitrov. V., Bratovanov, S. S. & Kostova. L. (1994). *Tetrahedron Lett.* **35**, 6713–6716.
Flack, H. D. (1983). *Acta Cryst.* A**39**, 876–881.
Imamoto, T., Takiyama, N., Nakamura, K., Hatajima, T. & Kamiya, Y. (1988). *J. Am. Chem. Soc.* **111**, 4392–4398.
Neidle, S. & Taylor, G. (1977). *Biochim. Biophys. Acta*, **479**, 450–459.
Sheldrick, G. M. (1990). *Acta Cryst.* A**46**, 467–473.
Sheldrick, G. M. (1997*a*). *SHELXL97*. University of Göttingen, Germany.
Sheldrick, G. M. (1997*b*). *SHELXTL*. Version 5.1. Bruker AXS Inc., Madison, Wisconsin, USA.
Sheldrick, G. M. (2003). *SADABS*. Version 2.10. University of Göttingen, Germany.