Table 1. *Fractional atomic coordinates and equivalent isotropic thermal parameters* (Å^2)

$$B_{eq} = (8\pi^2/3)\Sigma_i\Sigma_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	B_{eq}
Br	0.21430 (3)	0.15853 (3)	0.14066 (1)	4.439 (4)
O1	0.5295 (2)	0.5852 (2)	0.7836 (1)	5.57 (4)
O2	0.2713 (2)	0.1949 (3)	0.6261 (1)	5.92 (4)
N1	0.1151 (2)	0.2386 (2)	0.8197 (1)	3.68 (3)
C1	0.4452 (3)	0.5437 (3)	0.8756 (2)	5.11 (5)
C2	0.3749 (3)	0.3656 (3)	0.8764 (2)	4.65 (5)
C3	0.2287 (3)	0.3905 (3)	0.8082 (1)	3.86 (4)
C4	−0.0077 (3)	0.2602 (3)	0.7412 (1)	3.86 (4)
C5	0.0970 (3)	0.2322 (3)	0.6416 (1)	4.09 (4)
C6	−0.0242 (3)	0.2502 (3)	0.5646 (1)	3.84 (4)
C7	0.0660 (3)	0.2366 (3)	0.4718 (2)	4.71 (5)
C8	−0.0401 (4)	0.2493 (3)	0.3985 (2)	5.65 (6)
C9	−0.2343 (4)	0.2734 (3)	0.4153 (2)	5.58 (6)
C10	−0.3262 (4)	0.2851 (4)	0.5066 (2)	5.71 (6)
C11	−0.2209 (3)	0.2753 (4)	0.5807 (2)	5.04 (5)
C12	0.2446 (3)	0.0412 (3)	0.8240 (2)	5.22 (5)
C13	−0.0219 (3)	0.2672 (3)	0.9106 (2)	4.87 (5)

Table 2. *Geometric parameters* (Å, °)

O1—C1	1.410 (3)	C1—C2	1.505 (4)
O2—C5	1.213 (3)	C2—C3	1.511 (3)
N1—C3	1.521 (3)	C4—C5	1.514 (3)
N1—C4	1.505 (3)	C5—C6	1.484 (3)
C3—N1—C4	110.6 (1)	N1—C4—C5	116.7 (2)
O1—C1—C2	109.9 (2)	O2—C5—C4	121.5 (2)
C1—C2—C3	110.3 (2)	O2—C5—C6	122.0 (2)
N1—C3—C2	114.4 (2)	C4—C5—C6	116.6 (2)
H1OH—O1—C1—C2	−160 (2)	C1—C2—C3—N1	−166.6 (2)
C4—N1—C3—C2	−172.7 (2)	N1—C4—C5—O2	−0.2 (3)
C3—N1—C4—C5	63.5 (2)	O2—C5—C6—C7	−4.6 (3)
O1—C1—C2—C3	−59.2 (2)		

The crystal was sealed in a capillary. The space group was determined by successful refinement of a centrosymmetric model. Programs used include *MolEN* (Fair, 1990) and *ORTEP*II (Johnson, 1976).

Lists of structure factors, anisotropic thermal parameters, H-atom coordinates complete geometry and least-squares-planes data have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71247 (31 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: ST1053]

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Structure of 6-Fluoro-1,2,3,4,7,12-hexahydro-7-methyl-12-methylene-benz[*a*]anthracene

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Abstract

The X-ray analysis confirms the structure of the 12-methylene tautomer formed by the acid catalysis of 6-fluoro-1,2,3,4-tetrahydro-7,12-dimethylbenz-[*a*]anthracene. The central *C* ring is in a boat conformation, with the result that the molecule is bent about a line through atoms C(7) and C(12) with a dihedral angle of 32.5°. The cyclohexene *A* ring is in a half-chair conformation.

Comment

The study of the title compound (1) is part of an investigation of the carcinogenic activity of 1,2,3,4-tetrahydro-7,12-dimethylbenz[*a*]anthracene (THDMBA) (2) and its six aryl fluoro regioisomers (Witiak & Nair, 1990; Kumari, Milo & Witiak, 1990; Nair, Walker, Sharma, Witiak & DiGiovanni, 1992; Rinderle, Black, Sharma & Witiak, 1992). 6F-THDMBA (3) displays more mutagenic activity in human neonatal fibroblast (HNF) cells and more skin tumor initiating activity in mice than the parent compound (THDMBA) and its other aryl fluoro analogues. Acid-catalyzed isomerization of 6F-THDMBA results in formation of the 12- and 7-methylene tautomers, (1) and (4), respectively (Witiak, Abood, Goswami & Milo, 1986). Further work with the 12-methylene tautomer (1) indicated that it does not show any mouse skin tumor initiating activity (Nair, Walker, Sharma, Witiak & DiGiovanni, 1992). Although this tautomer was not studied in HNF cell transformation assays, a similar THDMBA analogue not having the planar anth-

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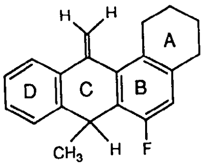
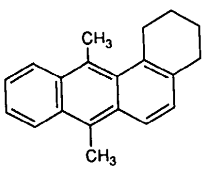
‡ Comprehensive Cancer Center.

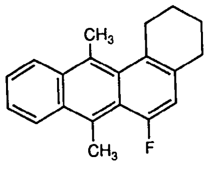
racene ring system (the 11F-7-*exo*-methylene compound) was inactive in HNF cell transformation assays (Kumari, Milo & Witiak, 1990). The structure of (1) was established by 270 MHz proton NOE (nuclear Overhausser effect) difference experiments; the X-ray structure analysis was undertaken to obtain detailed information about the conformation of the molecule, especially the central *C* ring. Synthesis of (1) was achieved by the previously reported method (Witiak, Abood, Goswami & Milo, 1986). Crystals were obtained by slow crystallization from absolute ethanol at 273 K.



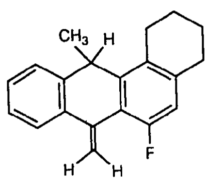
(1)



(2)



(3)



(4)

The structures of 6F-THDMBA and 5F-THDMBA have been reported previously (Black, Sharma, Gallucci, Blackburn, Downs, Rinderle & Witiak, 1992). The overall conformation of the three-ring fragment (*B*,*C*,*D*) in (1) differs markedly from its approximately planar conformation in 6F-THDMBA and 5F-THDMBA. The central six-membered ring in (1) (ring *C*) is in a boat conformation. Atoms C(7a), C(11a), C(6a) and C(12a) lie essentially in a plane with atoms C(7) and C(12) disposed on the same side of this plane and almost equidistant from it at 0.40 and 0.39 Å, respectively. The methyl and methylene groups, C(13) and C(14), also lie on the same side of this plane at distances of 1.91 and 1.12 Å. The boat conformation causes the three-ring fragment to be bent about a line through C(7) and C(12). The angle for this bending, as defined by the dihedral angle between the least-squares planes through C(7a), C(8), C(9), C(10), C(11), C(11a), C(7), C(12) and C(4a), C(5), C(6), C(6a), C(12a), C(12b), C(7), C(12), is 32.5°. The conformation of this three-ring fragment is similar to that observed for the analogous fragment in the 7,12-dimethylbenz[*a*]anthracene-7,12-*endo*-peroxide structure, where the peroxy group connecting C(7) and C(12) forces the central *C* ring into a boat conformation (Klein, Stevens, Zacharias & Glusker, 1987). The cyclohexene *A* ring exists in a half-chair conformation, similar to its form in 6F-THDMBA and 5F-THDMBA.

There is a large internal angle associated with the C atom bonded to fluorine: C(5)—C(6)—C(6a) = 123.7 (2)°. This has also been observed in 6F-THDMBA [125.9 (6)°] and 5F-THDMBA [125.0 (2)°]. The two external angles about C(6), C(6a)—C(6)—F and C(5)—C(6)—F, are significantly different in 6F-THDMBA [119.1 (5) and 114.9 (5)°] probably because of steric interactions between F and C(13) which result from the approximate planarity of that portion of the molecule. Steric interactions between F and C(13) are reduced in (1) because of the bending of the molecule and the sp^3 character of the C(7) atom, so that the two external angles about C(6) become essentially equal [118.1 (2) and 118.2 (2)°].

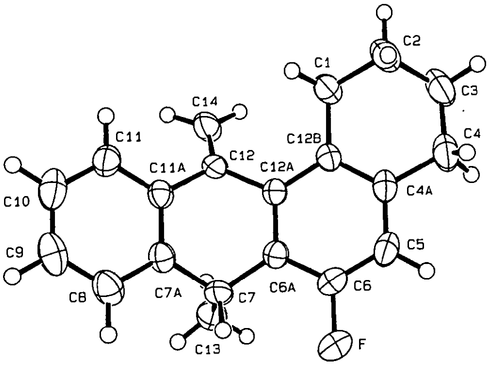


Fig. 1. *ORTEP* drawing (Johnson, 1976) of molecule (1). Thermal ellipsoids are drawn at the 50% probability level. H atoms are represented by spheres of arbitrary radii.

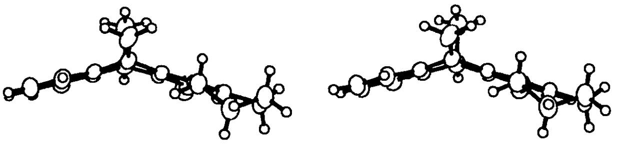


Fig. 2. Stereodrawing of a side-on view for (1).

Experimental

Crystal data

$C_{20}H_{19}F$
M_r = 278.37
Triclinic
$P\bar{1}$
a = 9.315 (1) Å
b = 11.162 (1) Å
c = 7.657 (1) Å
α = 108.42 (1)°
β = 93.98 (1)°
γ = 98.90 (1)°
V = 740.2 (2) Å^3
Z = 2

D_x = 1.25 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 25 reflections
θ = 12–15°
μ = 0.074 mm^{-1}
T = 296 K
Chunk
0.31 × 0.19 × 0.15 mm
Colorless

Data collection

Rigaku AFC-5*S* diffractometer
θ-2θ scans
Absorption correction: none
3592 measured reflections
3384 independent reflections
1749 observed reflections [$I \geq 3\sigma(I)$]
R_{int} = 0.019

θ_{max} = 27.5°
$h = 0 \rightarrow 12$
$k = -14 \rightarrow 14$
$l = -9 \rightarrow 9$
6 standard reflections monitored every 150 reflections intensity variation: average decrease of 1.1%

Refinement

Refinement on F
Final R = 0.041
wR = 0.046
S = 1.44
1749 reflections
199 parameters
$w = 1/\sigma^2(F_o)$
$(\Delta/\sigma)_{\text{max}}$ = 0.01
$\Delta\rho_{\text{max}}$ = 0.19 e Å^{-3}
$\Delta\rho_{\text{min}}$ = −0.19 e Å^{-3}

Secondary-extinction correction: Zachariasen (1963)
Extinction coefficient: 5.1 (5) × 10^{-6}
Atomic scattering factors from Cromer & Waber (1974) for C and F atoms, and Stewart, Davidson & Simpson (1965) for H atoms

Table 1. *Fractional atomic coordinates and equivalent isotropic thermal parameters* (Å^2)

$$B_{\text{eq}} = (8\pi^2/3)\Sigma_i\Sigma_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	B_{eq}
F	0.2936 (2)	0.4266 (1)	0.4855 (2)	4.97 (6)
C(1)	0.3927 (2)	0.2023 (2)	1.0374 (3)	3.78 (9)
C(2)	0.5464 (3)	0.1718 (2)	1.0440 (4)	4.5 (1)
C(3)	0.6579 (3)	0.2916 (3)	1.0719 (4)	4.9 (1)
C(4a)	0.4814 (2)	0.3288 (2)	0.8346 (3)	3.22 (8)
C(4)	0.6393 (3)	0.3373 (2)	0.9080 (4)	4.5 (1)
C(5)	0.4558 (3)	0.3815 (2)	0.6951 (4)	3.8 (1)
C(6a)	0.1943 (2)	0.3178 (2)	0.6811 (3)	2.78 (8)
C(6)	0.3155 (3)	0.3740 (2)	0.6230 (3)	3.37 (8)
C(7a)	−0.0628 (2)	0.1969 (2)	0.5950 (3)	2.97 (8)
C(7)	0.0410 (2)	0.3155 (2)	0.5975 (3)	3.10 (8)
C(8)	−0.1845 (3)	0.1432 (3)	0.4609 (3)	4.2 (1)
C(9)	−0.2832 (3)	0.0391 (3)	0.4650 (4)	4.8 (1)
C(10)	−0.2614 (3)	−0.0138 (2)	0.6030 (4)	4.7 (1)
C(11a)	−0.0418 (2)	0.1452 (2)	0.7362 (3)	2.85 (8)
C(11)	−0.1414 (3)	0.0382 (2)	0.7369 (4)	3.9 (1)
C(12a)	0.2183 (2)	0.2666 (2)	0.8229 (3)	2.62 (7)
C(12b)	0.3627 (2)	0.2692 (2)	0.8982 (3)	2.80 (7)
C(12)	0.0844 (2)	0.2080 (2)	0.8836 (3)	2.82 (8)
C(13)	−0.0141 (3)	0.4379 (2)	0.7028 (4)	4.3 (1)
C(14)	0.0704 (3)	0.2178 (3)	1.0587 (4)	4.0 (1)

Table 2. *Geometric parameters* (Å, °)

F—C(6)	1.376 (3)	C(7a)—C(7)	1.507 (3)
C(1)—C(2)	1.523 (3)	C(7a)—C(8)	1.392 (3)
C(1)—C(12b)	1.516 (3)	C(7a)—C(11a)	1.393 (3)
C(2)—C(3)	1.507 (4)	C(7)—C(13)	1.536 (3)
C(3)—C(4)	1.506 (4)	C(8)—C(9)	1.377 (4)
C(4a)—C(4)	1.516 (3)	C(9)—C(10)	1.381 (4)
C(4a)—C(5)	1.396 (3)	C(10)—C(11)	1.379 (3)
C(4a)—C(12b)	1.398 (3)	C(11a)—C(11)	1.396 (3)
C(5)—C(6)	1.363 (3)	C(11a)—C(12)	1.486 (3)
C(6a)—C(6)	1.376 (3)	C(12a)—C(12b)	1.419 (3)
C(6a)—C(7)	1.516 (3)	C(12a)—C(12)	1.490 (3)
C(6a)—C(12a)	1.398 (3)	C(12)—C(14)	1.328 (3)
C(2)—C(1)—C(12b)	113.1 (2)	C(6a)—C(7)—C(13)	110.6 (2)
C(1)—C(2)—C(3)	109.8 (2)	C(7a)—C(7)—C(13)	111.0 (2)
C(2)—C(3)—C(4)	110.1 (2)	C(7a)—C(8)—C(9)	120.9 (2)
C(4)—C(4a)—C(5)	117.6 (2)	C(8)—C(9)—C(10)	119.9 (2)
C(4)—C(4a)—C(12b)	122.9 (2)	C(9)—C(10)—C(11)	120.0 (2)
C(5)—C(4a)—C(12b)	119.5 (2)	C(7a)—C(11a)—C(11)	119.1 (2)
C(3)—C(4)—C(4a)	114.4 (2)	C(7a)—C(11a)—C(12)	118.7 (2)
C(4a)—C(5)—C(6)	119.5 (2)	C(11)—C(11a)—C(12)	122.2 (2)
C(6)—C(6a)—C(7)	120.9 (2)	C(10)—C(11)—C(11a)	120.8 (2)
C(6)—C(6a)—C(12a)	117.4 (2)	C(6a)—C(12a)—C(12b)	120.7 (2)
C(7)—C(6a)—C(12a)	121.7 (2)	C(6a)—C(12a)—C(12)	115.8 (2)
F—C(6)—C(5)	118.2 (2)	C(12b)—C(12a)—C(12)	123.4 (2)
F—C(6)—C(6a)	118.1 (2)	C(1)—C(12b)—C(4a)	118.8 (2)
C(5)—C(6)—C(6a)	123.7 (2)	C(1)—C(12b)—C(12a)	122.0 (2)
C(7)—C(7a)—C(8)	121.1 (2)	C(4a)—C(12b)—C(12a)	119.1 (2)
C(7)—C(7a)—C(11a)	119.3 (2)	C(11a)—C(12)—C(12a)	115.6 (2)
C(8)—C(7a)—C(11a)	119.4 (2)	C(11a)—C(12)—C(14)	120.3 (2)
C(6a)—C(7)—C(7a)	111.0 (2)	C(12a)—C(12)—C(14)	123.9 (2)

Data reduction was by *TEXSAN* (Molecular Structure Corporation, 1989). The structure was solved by the direct-methods program *MITHRIL* (Gilmore, 1984) and expanded by standard Fourier methods. Full-matrix least-squares refinements used *TEXSAN*. All H atoms were located on a difference electron density map. The two H atoms bonded to C(14) were refined isotropically. All other H atoms were fixed at calculated positions based on C—H = 0.98 Å and B(H) = 1.2 × B_{eq} of the attached C atom.

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Lists of structure factors, anisotropic thermal parameters, H-atom coordinates, least-squares-planes data and torsion angles have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71250 (32 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: GR1009]

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Acta Cryst. (1993). C**49**, 1871–1873

Delnuttaline, (6*β*,9*β*,13*β*)-13-Acetoxy-6,9-dihydroxyhetisan-2-one

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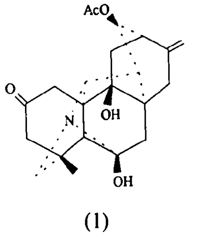
Abstract

The crystal structure of the C-20 diterpenoid alkaloid 6,9-dihydroxy-2-oxohetisan-13-yl acetate consists of two independent molecules in the asymmetric unit with average bond distances C(sp^3)—C(sp^3) 1.55 (1), C(sp^3)—C(sp^2) 1.52 (1), C=C 1.31 (1), N—C 1.51 (1), C(sp^3)—O 1.46 (1), C(sp^2)—O 1.35 (1) and C=O 1.22 (1) Å. The structure is stabilized through a network of hydrogen bonds involving nitrogen and hydroxy groups with O···O and O···N separations in the range 2.688 (7)–2.903 (8) Å.

Comment

Delnuttaline (1), a new C-20 diterpenoid alkaloid of the atisine type, was isolated from *Delphinium nuttallianum* Pritz. which is a cow-poisoning plant growing wild in the southern regions of British Columbia, Canada. Suitable crystals of (1) were grown from a mixture of ethanol and ethyl acetate in order to determine its structure and relative configuration by X-ray methods.



(1)

The crystal structure of (1) consists of two independent molecules in the asymmetric unit which differ from each other with respect to the orientation of the acetate groups and of the hydroxy groups at C(6).

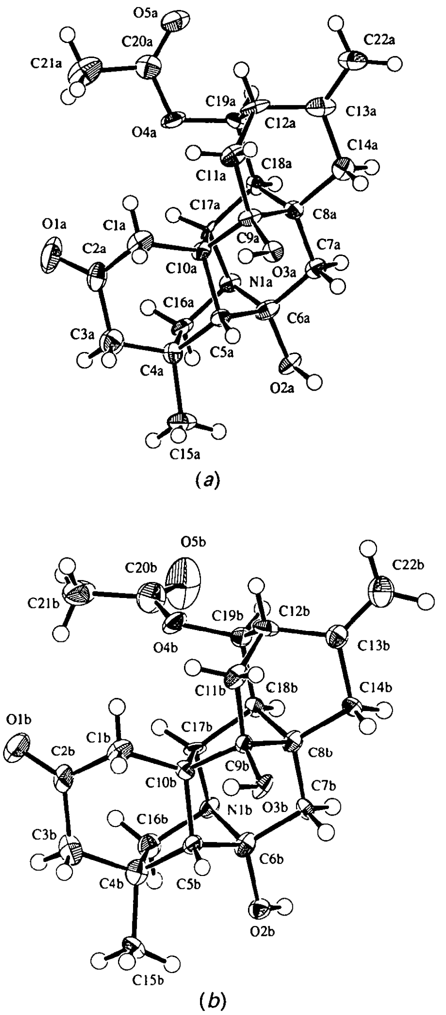


Fig. 1. Perspective views of the two independent molecules (*a*) and (*b*) of delnuttaline with crystallographic numbering scheme. Thermal ellipsoids are shown at 50% probability levels; H atoms are assigned an arbitrary radius.

Experimental

Crystal data

$C_{22}H_{27}NO_5$
$M_r = 385.46$
Monoclinic
$P2_1$
$a = 6.623\ (3)$ Å
$b = 18.411\ (4)$ Å
$c = 15.631\ (5)$ Å
$\beta = 96.75\ (2)°$

Mo $K\alpha$ radiation
$\lambda = 0.71069$ Å
Cell parameters from 19 reflections
$\theta = 9\text{–}15°$
$\mu = 0.095\ \text{mm}^{-1}$
$T = 150\ (1)$ K
Block

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