C(5B)	−0.2668 (6)	−0.4213 (11)	−0.0168 (5)	0.059
C(6B)	−0.2623 (6)	−0.5106 (11)	−0.1041 (5)	0.060
C(7B)	−0.3324 (6)	−0.4670 (11)	−0.2057 (6)	0.058
C(8B)	−0.4058 (7)	−0.3294 (12)	−0.2216 (6)	0.070
C(9B)	−0.4088 (6)	−0.2404 (11)	−0.1353 (5)	0.062
C(10B)	−0.3372 (6)	−0.5633 (11)	−0.3051 (5)	0.066
C(11B)	−0.4390 (7)	−0.6831 (12)	−0.3517 (6)	0.074
C(12B)	−0.4338 (10)	−0.8180 (15)	−0.2766 (8)	0.122
C(13B)	−0.4477 (8)	−0.7513 (13)	−0.4568 (6)	0.107

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

O(1A)—C(1A)	1.329 (13)	O(2A)—C(1A)	1.211 (10)
C(1A)—C(2A)	1.466 (13)	C(2A)—C(3A)	1.533 (13)
C(2A)—C(4A)	1.549 (12)	C(4A)—C(5A)	1.376 (13)
C(4A)—C(9A)	1.348 (11)	C(5A)—C(6A)	1.347 (12)
C(6A)—C(7A)	1.374 (12)	C(7A)—C(8A)	1.390 (14)
C(7A)—C(10A)	1.552 (12)	C(8A)—C(9A)	1.398 (12)
C(10A)—C(11A)	1.505 (14)	C(11A)—C(12A)	1.476 (11)
C(11A)—C(13A)	1.491 (13)	O(1B)—C(1B)	1.306 (11)
O(2B)—C(1B)	1.202 (10)	C(1B)—C(2B)	1.520 (12)
C(2B)—C(3B)	1.512 (12)	C(2B)—C(4B)	1.548 (10)
C(4B)—C(5B)	1.370 (12)	C(4B)—C(9B)	1.374 (10)
C(5B)—C(6B)	1.402 (10)	C(6B)—C(7B)	1.358 (10)
C(7B)—C(8B)	1.397 (12)	C(7B)—C(10B)	1.533 (11)
C(8B)—C(9B)	1.382 (11)	C(10B)—C(11B)	1.521 (12)
C(11B)—C(12B)	1.470 (15)	C(11B)—C(13B)	1.489 (11)
O(1A)—C(1A)—O(2A)	119.5 (8)	O(1A)—C(1A)—C(2A)	115.7 (8)
O(2A)—C(1A)—C(2A)	124.6 (9)	C(1A)—C(2A)—C(3A)	111.6 (7)
C(1A)—C(2A)—C(4A)	108.4 (7)	C(3A)—C(2A)—C(4A)	114.4 (8)
C(2A)—C(4A)—C(5A)	121.6 (7)	C(2A)—C(4A)—C(9A)	119.7 (8)
C(5A)—C(4A)—C(9A)	118.6 (8)	C(4A)—C(5A)—C(6A)	122.2 (8)
C(5A)—C(6A)—C(7A)	120.9 (9)	C(6A)—C(7A)—C(8A)	117.3 (8)
C(6A)—C(7A)—C(10A)	123.7 (9)	C(8A)—C(7A)—C(10A)	119.0 (8)
C(7A)—C(8A)—C(9A)	121.0 (8)	C(4A)—C(9A)—C(8A)	120.0 (9)
C(7A)—C(10A)—C(11A)	114.3 (7)	C(10A)—C(11A)—C(12A)	112.8 (7)
C(10A)—C(11A)—C(13A)	112.3 (7)	C(12A)—C(11A)—C(13A)	109.4 (9)
O(1B)—C(1B)—O(2B)	122.6 (8)	O(1B)—C(1B)—C(2B)	115.7 (7)
O(2B)—C(1B)—C(2B)	121.7 (8)	C(1B)—C(2B)—C(3B)	110.8 (8)
C(1B)—C(2B)—C(4B)	106.9 (6)	C(3B)—C(2B)—C(4B)	114.6 (6)
C(2B)—C(4B)—C(5B)	118.0 (6)	C(2B)—C(4B)—C(9B)	122.7 (8)
C(5B)—C(4B)—C(9B)	119.3 (7)	C(4B)—C(5B)—C(6B)	120.8 (7)
C(5B)—C(6B)—C(7B)	120.1 (8)	C(6B)—C(7B)—C(8B)	119.0 (7)
C(6B)—C(7B)—C(10B)	123.3 (8)	C(8B)—C(7B)—C(10B)	117.7 (7)
C(7B)—C(8B)—C(9B)	120.7 (7)	C(4B)—C(9B)—C(8B)	120.1 (8)
C(7B)—C(10B)—C(11B)	115.2 (6)	C(10B)—C(11B)—C(12B)	112.0 (7)
C(10B)—C(11B)—C(13B)	111.6 (7)	C(12B)—C(11B)—C(13B)	110.9 (9)

The structure was solved by direct methods with *MITHRIL* (Gilmore, 1984). Full-matrix least-squares refinement of coordinates and anisotropic thermal parameters was performed for all non-H atoms. All calculations were made on a MicroVAX 3600 using the Glasgow *GX* package (Mallinson & Muir, 1985).

(*S*)-(+)-Ibuprofen was kindly supplied by Boots Chemicals, Nottingham, England.

Lists of structure factors, anisotropic thermal parameters, H-atom coordinates, and bond distances and angles involving H atoms have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71015 (12 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: AL1030]

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Synthesis and Structure of New Families of Potential Antitumor or Antiviral Agents. I. 4b,6a,10b,10c-Tetrahydrobenzo[3,4]-cyclobuta[1,2-*a*]biphenylene-4b,6a-diyl Diacetate

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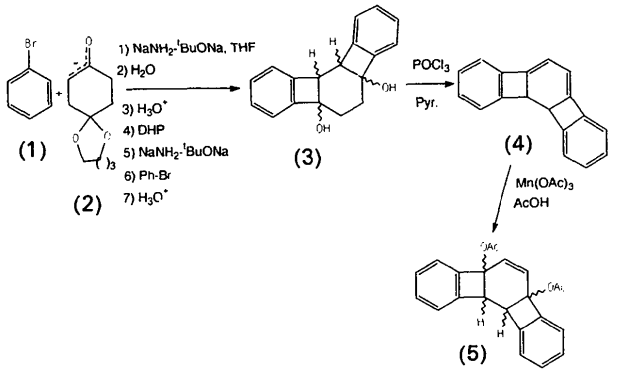
Abstract

The bent triphenylene derivative 4b,6a,10b,10c-tetrahydrobenzo[3,4]cyclobuta[1,2-*a*]biphenylene-4b,6a-diyl diacetate was prepared during the course of research into the synthesis of aromatic polycyclic derivatives showing antitumor or antiviral activity, and its structure determined by X-ray diffraction. The two benzocyclobutene groups are *anti* across the central cyclohexene ring; the acetoxy groups are *anti* to each other and *cis* to the benzocyclobutene groups. The geometry of the pentacyclic system is discussed and the factors determining the orientation of the acetoxy substituents are considered. The results of the refinements on F and F^2 are compared.

Comment

As a continuation of our program aimed at the synthesis of aromatic polycyclic derivatives with biological activ-

ity (Aatif *et al.*, 1990; Jamart-Grégoire, Caubère, Blanc, Gnassounou & Advenier, 1989), we undertook to design new families of potential antitumor or antiviral agents. At first, taking into account the known structure of intercalating agents (Atwell, Bos, Baguely & Dennmy, 1988; Atwell, Baguely & Dennmy, 1988), we thought that bent triphenylene derivatives would be good candidates. Following on from our previous work (Carré, Grégoire & Caubère, 1984; Grégoire, Carré & Caubère, 1986; Carré *et al.*, 1988), we developed a new route to such derivatives (Dierks & Vollhardt, 1986; Nambu & Siegel, 1988; Shepherd, 1988) which is shown in the scheme below (THF = tetrahydrofuran, DHP = dihydropyran). This gave compound (5) which was found to be active in interfering with DNA replication.



Interestingly, compound (4) was not dehydrogenated by treatment with manganese(III) (Ketcha, 1988) but unexpectedly transformed into compound (5), the structure of which was established by X-ray analysis and is reported here. This knowledge then allowed the structure of (3) to be deduced.

As shown in Fig. 1, the molecule consists of two phenylene groups joined in an *anti* orientation to a central cyclohexene ring with two acetoxy substituents at the junctions where the configurations are *cis*. The four C atoms at the junctions are chiral, all with the same *S* or *R* chirality, both enantiomers being present in the crystal. The central cyclohexene ring is nearly planar; the total puckering amplitude (Cremer & Pople, 1975) is only Q_T = 0.081 (1) Å.

The values for the bond distances and angles quoted in Table 2 show that there are no significant differences between the corresponding geometrical parameters of the *A* and *B* moieties (which are related by a local pseudo-twofold axis running along the midpoints of the C7*A*—C7*B* and C9*A*—C9*B* bonds), in spite of the e.s.d.'s being particularly low as a consequence of the good quality of the intensity data and the quite favorable ratio of observations to refined parameters.

The two benzocyclobutene moieties both show local *m* symmetry; the deformations of the benzene ring in them, caused by fusion with the strained cyclobutene ring, correspond quite well to those of the averaged structural data

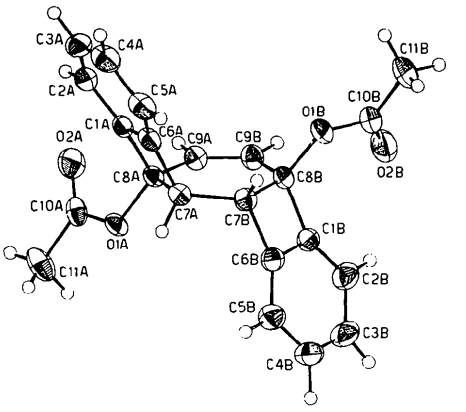


Fig. 1. *ORTEP* (Johnson, 1965) projection of the title compound with thermal ellipsoids drawn at the 50% level.

from the literature (Cambridge Structural Database; Allen *et al.*, 1979; Ianelli *et al.*, 1992) and the values obtained from *ab initio* molecular orbital calculations (Benassi, Ianelli, Nardelli & Taddei, 1991). There is good agreement not only in the angular deformations (which are the most relevant) but also in the systematic trends observed in the benzene bond lengths.

There is conformational freedom for the two acetoxy groups about the C8—O1 bonds, the only steric hindrance in the free molecule being between O2 and H7 or H9. Their orientation is determined by the packing environ-

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

$U_{eq} = \frac{1}{3}\sum_i\sum_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j.$

	x	*y*	*z*	U_{eq}
O1*A*	0.29585 (8)	0.55784 (5)	0.0914 (1)	0.0382 (3)
O2*A*	0.4796 (1)	0.58880 (7)	0.1225 (2)	0.0587 (4)
C1*A*	0.3214 (1)	0.62365 (7)	0.3673 (2)	0.0357 (4)
C2*A*	0.4015 (1)	0.67465 (7)	0.4199 (2)	0.0445 (4)
C3*A*	0.3663 (2)	0.72562 (8)	0.5236 (2)	0.0551 (6)
C4*A*	0.2591 (2)	0.72509 (8)	0.5702 (2)	0.0565 (6)
C5*A*	0.1792 (2)	0.67408 (8)	0.5159 (2)	0.0479 (5)
C6*A*	0.2146 (1)	0.62352 (7)	0.4129 (2)	0.0367 (4)
C7*A*	0.1759 (1)	0.55791 (6)	0.3139 (2)	0.0333 (4)
C8*A*	0.3006 (1)	0.55472 (6)	0.2731 (2)	0.0320 (4)
C9*A*	0.3714 (1)	0.49519 (7)	0.3474 (2)	0.0359 (4)
C10*A*	0.3913 (1)	0.57661 (7)	0.0321 (2)	0.0411 (5)
C11*A*	0.3710 (2)	0.5801 (1)	−0.1550 (2)	0.0614 (6)
O1*B*	0.21967 (9)	0.43300 (5)	0.6584 (1)	0.0458 (3)
O2*B*	0.2883 (1)	0.32433 (7)	0.6641 (2)	0.0665 (5)
C1*B*	0.1416 (1)	0.38709 (7)	0.3676 (2)	0.0393 (4)
C2*B*	0.1299 (2)	0.31839 (8)	0.3164 (2)	0.0512 (5)
C3*B*	0.0383 (2)	0.30500 (9)	0.1904 (2)	0.0591 (6)
C4*B*	−0.0355 (2)	0.3569 (1)	0.1208 (2)	0.0580 (6)
C5*B*	−0.0218 (1)	0.42596 (9)	0.1714 (2)	0.0505 (5)
C6*B*	0.0691 (1)	0.43881 (7)	0.2976 (2)	0.0390 (4)
C7*B*	0.1319 (1)	0.49642 (7)	0.4042 (2)	0.0349 (4)
C8*B*	0.2182 (1)	0.43814 (7)	0.4778 (2)	0.0356 (4)
C9*B*	0.3362 (1)	0.44502 (7)	0.4391 (2)	0.0390 (4)
C10*B*	0.2563 (2)	0.37336 (9)	0.7370 (2)	0.0509 (5)
C11*B*	0.2508 (2)	0.3770 (1)	0.9208 (2)	0.0695 (7)

Table 2. *Comparison of bond distances* (Å) *and angles* (°) *with e.s.d.'s in parentheses*

				Average	Literature[a]	Calculated[b]
C1*A*—C2*A*	1.387 (2)	C1*B*—C2*B*	1.384 (2)	1.386 (1)	1.389 (1)	1.371
C5*A*—C6*A*	1.386 (2)	C5*B*—C6*B*	1.385 (2)	—	—	—
C1*A*—C6*A*	1.380 (2)	C1*B*—C6*B*	1.378 (2)	1.379 (1)	1.383 (3)	1.386
C2*A*—C3*A*	1.394 (2)	C2*B*—C3*B*	1.391 (2)	1.391 (1)	1.395 (2)	1.396
C4*A*—C5*A*	1.389 (2)	C4*B*—C5*B*	1.390 (3)	—	—	—
C3*A*—C4*A*	1.386 (3)	C3*B*—C4*B*	1.389 (3)	1.388 (2)	1.391 (3)	1.387
C1*A*—C8*A*	1.528 (2)	C1*B*—C8*B*	1.526 (2)	1.525 (1)		
C6*A*—C7*A*	1.524 (2)	C6*B*—C7*B*	1.523 (2)	—		
C7*A*—C8*A*	1.572 (2)	C7*B*—C8*B*	1.572 (2)	1.572 (1)	1.598 (4)	1.599
C8*A*—C9*A*	1.490 (2)	C8*B*—C9*B*	1.493 (2)	1.492 (2)		
C7*A*—C7*B*	1.524 (2)					
C9*A*—C9*B*	1.322 (2)					
O1*A*—C8*A*	1.456 (2)	O1*B*—C8*B*	1.455 (2)	1.456 (1)		
O1*A*—C10*A*	1.351 (2)	O1*B*—C10*B*	1.349 (2)	1.350 (1)		
O2*A*—C10*A*	1.203 (2)	O2*B*—C10*B*	1.204 (2)	1.204 (1)		
C10*A*—C11*A*	1.489 (2)	C10*B*—C11*B*	1.493 (3)	1.490 (2)		
C2*A*—C1*A*—C6*A*	122.6 (1)	C2*B*—C1*B*—C6*B*	122.7 (1)	122.6 (1)	122.5 (1)	122.2
C1*A*—C6*A*—C5*A*	122.6 (1)	C1*B*—C6*B*—C5*B*	122.5 (1)	—	—	—
C1*A*—C2*A*—C3*A*	115.0 (1)	C1*B*—C2*B*—C3*B*	115.1 (1)	115.1 (1)	115.3 (1)	116.2
C4*A*—C5*A*—C6*A*	115.2 (2)	C4*B*—C5*B*—C6*B*	115.3 (1)	—	—	—
C2*A*—C3*A*—C4*A*	122.3 (1)	C2*B*—C3*B*—C4*B*	122.3 (2)	122.3 (1)	122.1 (1)	121.5
C3*A*—C4*A*—C5*A*	122.4 (2)	C3*B*—C4*B*—C5*B*	122.0 (2)	—	—	—
C2*A*—C1*A*—C8*A*	144.6 (1)	C2*B*—C1*B*—C8*B*	144.1 (1)	144.4 (2)	143.4 (1)	—
C5*A*—C6*A*—C7*A*	142.9 (1)	C5*B*—C6*B*—C7*B*	143.2 (1)	143.0 (2)	—	—
C1*A*—C6*A*—C7*A*	94.4 (1)	C1*B*—C6*B*—C7*B*	94.3 (1)	94.4 (1)	94.1 (1)	94.0
C6*A*—C1*A*—C8*A*	92.6 (1)	C6*B*—C1*B*—C8*B*	93.0 (1)	92.8 (2)	—	—
C6*A*—C7*A*—C8*A*	85.7 (1)	C6*B*—C7*B*—C8*B*	85.8 (1)	85.8 (1)	85.8 (1)	86.0
C1*A*—C8*A*—C7*A*	87.0 (1)	C1*B*—C8*B*—C7*B*	86.8 (1)	86.9 (1)		
C6*A*—C7*A*—C7*B*	119.4 (1)	C6*B*—C7*B*—C7*A*	118.1 (1)	118.8 (6)		
C1*A*—C8*A*—C9*A*	115.4 (1)	C1*B*—C8*B*—C9*B*	115.6 (1)	115.5 (1)		
C8*A*—C7*A*—C7*B*	118.5 (1)	C8*B*—C7*B*—C7*A*	118.6 (1)	118.6 (1)		
C7*A*—C8*A*—C9*A*	116.1 (1)	C7*B*—C8*B*—C9*B*	116.1 (1)	116.1 (1)		
C8*A*—C9*A*—C9*B*	125.1 (1)	C9*A*—C9*B*—C8*B*	125.0 (1)	125.0 (1)		
C8*A*—O1*A*—C10*A*	117.7 (1)	C8*B*—O1*B*—C10*B*	118.6 (1)	118.2 (4)		
O1*A*—C8*A*—C1*A*	116.1 (1)	O1*B*—C8*B*—C1*B*	116.7 (1)	116.4 (3)		
O1*A*—C8*A*—C7*A*	108.7 (1)	O1*B*—C8*B*—C7*B*	109.2 (1)	109.0 (2)		
O1*A*—C8*A*—C9*A*	111.4 (1)	O1*B*—C8*B*—C9*B*	110.6 (1)	111.0 (4)		
O1*A*—C10*A*—O2*A*	122.8 (1)	O1*B*—C10*B*—O2*B*	122.8 (1)	122.8 (1)		
O1*A*—C10*A*—C11*A*	111.0 (1)	O1*B*—C10*B*—C11*B*	111.3 (1)	111.2 (1)		
O2*A*—C10*A*—C11*A*	126.2 (2)	O2*B*—C10*B*—C11*B*	126.0 (2)	126.1 (1)		

Notes: (*a*) averaged from 27 molecules in the literature (Ianelli *et al.*, 1992); (*b*) from *ab initio* calculations at the 3-21G level (Benassi *et al.*, 1991).

ment in the crystal. In fact, rotation of that group about the C8—O1 bond gives two wide minima in the nonbonded energy profiles for the free molecule (one corresponding to the orientation found experimentally, the other to a counter-clockwise rotation of *ca.* 135°); for the molecule packed in the crystal, there is only one well defined minimum corresponding to the conformation found experimentally in the crystal.

It is interesting to compare the U_{eq} values for the two moieties (Table 1); the values for moiety *B* are systematically a little larger than those for *A* [$U_{eq}(A)$ average 0.0420, minimum 0.320 (4), maximum 0.0614 (6); $U_{eq}(B)$ average 0.0459, minimum 0.0349 (4), maximum 0.0695 (7) Å^2]. An opposite trend is observed for the anisotropy ratios whose averaged values are 2.07 (minimum 1.32, maximum 3.19) and 1.99 (minimum 1.35, maximum 3.27) for moieties *A* and *B*, respectively. The relative values in the two moieties are approximately equal for both the U_{eq} values and the ratios. These findings must be related to the fact that the two moieties have different environments in the crystal and so experience different local force fields.

Packing is determined only by van der Waals contacts.

Experimental

Crystal data

$C_{22}H_{18}O_4$
M_r = 346.38
Monoclinic
$P2_1/c$
a = 11.915 (1) Å
b = 19.228 (3) Å
c = 8.050 (1) Å
β = 99.10 (1)°
V = 1821.1 (4) Å^3
Z = 4
D_x = 1.263 Mg m^{-3}
Cu $K\alpha_1$ radiation
λ = 1.540562 Å
Cell parameters from 30 reflections
θ = 25.3–43.4°
μ = 0.667 mm^{-1}
T = 293 (2) K
Tabular prisms
0.75 × 0.33 × 0.23 mm
Colorless

Data collection

Siemens-AED diffractometer
θ–2θ scans
Absorption correction: none
3717 measured reflections
3470 independent reflections
3106 observed reflections [$I > 2\sigma(I)$]
R_{int} = 0.0154
θ_{max} = 70.25°
$h = -14 \rightarrow 14$
$k = 0 \rightarrow 23$
$l = 0 \rightarrow 9$
1 standard reflection monitored every 50 reflections
intensity variation: within statistical fluctuation

Refinement

Final $R1 = 0.0459$ for $F_o > 4\sigma(F_o)$
$wR2 = 0.1288$ for F^2 data
$S = 1.058$ for all F^2 data
3456 reflections
241 parameters
Only H-atom U's refined
Calculated weights
$w = 1/[\sigma^2(F_o^2)+0.3073P+(0.0803P)^2]$
where $P = (F_o^2+2F_c^2)/3$
$(\Delta/\sigma)_{max} = -0.003$
$\Delta\rho_{max} = 0.300$ e Å^{-3}
$\Delta\rho_{min} = -0.197$ e Å^{-3}
Extinction correction:
$F_c^* = kF_c[1+(0.001\times F_c^2\lambda^3/\sin(2\theta)]^{-1/4}$
Extinction coefficient:
$k = 0.0321$ (15)
Atomic scattering factors from *International Tables for X-ray Crystallography* [1974, Vol. IV, Tables 2.2A, 2.3.1 (O, C) and 2.2C (H)]

Cell refinement: *LQPARM* (Nardelli & Mangia, 1984). Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1986). Program(s) used to refine structure: *SHELX*76 (Sheldrick, 1976) and *SHELXL*92 (Sheldrick, 1992). Molecular graphics: *ORTEP* (Johnson, 1965). Software used to prepare material for publication: *PARST* (Nardelli, 1983). The calculations were performed on the ENCORE91 and GOULD-POWERNODE 6040 computers of the Centro di Studio per la Strutturistica Diffrattometrica del CNR (Parma).

The integrated intensities were measured using a modified version (Belletti, Ugozzoli, Cantoni & Pasquinelli, 1979) of the Lehmann & Larsen (1974) peak-profile analysis procedure. A correction for Lorentz and polarization effects was applied.

The structure was determined by direct methods with *SHELXS*86 and refined by anisotropic full-matrix least squares on F using *SHELX*76 (H atoms refined isotropically) and on F^2 (to compare the results of the two analyses) using *SHELXL*92 (H atoms placed in calculated positions). The values of the conventional residual-error indices at the end of the F refinement ($R = 0.0522$, $wR = 0.0511$ for 3127 data and 307 refined parameters) compare well with the final $R1$ [$= \Sigma|F_o-F_c|/\Sigma(F_o)$] indices obtained in the F^2 refinement [$wR2$ $(= \{\Sigma[w(F_o^2-F_c^2)^2]/\Sigma[w(F_o^2)^2]\}^{1/2}) = 0.1288$ for 3456 independent data (14 reflections having $\Delta/\sigma > 4.5$ were omitted) and 241 parameters, $S = 1.058$, $wR2 = 0.1413$ for all 3470 data, $S = 1.160$, $R1 = 0.0459$ for 3106 reflections with $F_o > 4\sigma(F_o)$].

As expected, the e.s.d.'s from the F^2 analysis are lower than those from that on F as a result of the larger number of observations and the reduced number of parameters. A further comparison of the results of the two kinds of analysis is given by the half-normal probability plot (Abrahams & Keve, 1971) calculated using the program *ABRAHAMS* (Gilli, 1977) for all interatomic distances < 4.65 Å (excluding those involving H atoms) according to De Camp (1973). The parameters of the straight line through the points on this plot [intercept −0.067 (6), slope 0.933 (6), correlation coefficient $r = 0.9967$, $N = 171$] show that there are no systematic effects and that the e.s.d.'s have been estimated correctly. In agreement with this finding, no significant differences (*i.e.* $> 3\Delta/\sigma$) are observed in the structural parameters (distances, angles, torsions) derived from the two analyses.

In contrast, systematic effects are observed for the atomic displacement parameters; the U_{eq} values from the F^2 refinement are all greater than the corresponding values from the refinement on F [mean values $U_{eq}(F) = 0.0409$, $U_{eq}(F^2) = 0.0468$ Å^2], while the ratios between the maximum and minimum principal axes of the displacement ellipsoids (anisotropy ratios) show a tendency to be systematically larger for the refinement on F [mean values $r(F) = 2.28$, $r(F^2) = 2.03$]. These systematic effects appear in the half-normal probability plot calculated using the U_{eq} values from the two refinements. The parameters of the regression line through the distribution of points [intercept 0.48 (1), slope 0.25 (1), $r = 0.974$, $N = 26$] show that systematic effects are present and that the pooled e.s.d.'s are overestimated.

All the structural parameters discussed in the *Comment* are from the F^2 refinements.

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Lists of structure factors, anisotropic thermal parameters, H-atom coordinates and complete geometry have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 55981 (49 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: HA1033]

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Synthesis and Structure of New Families of Potential Antitumor or Antiviral Agents. II. 1-(*p*-Toluenesulfonyloxy)-3,4:7,8-dibenzotricyclo[3.3.2.0^{2,6}]decane

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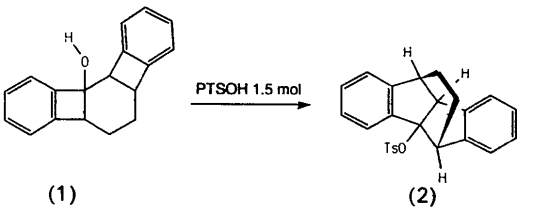
Abstract

The title compound, 3,4:7,8-dibenzotricyclo[3.3.2.0^{2,6}]-dec-1-yl *p*-toluenesulfonate was prepared by the reaction of 4b,5,6,6a,10b,10c-hexahydrobenzo[3,4]cyclobuta[1,2-*a*]biphenylen-4b-ol with an excess of *p*-toluenesulfonic acid and its structure determined by X-ray diffraction. The space group, *Cc*, is non-centrosymmetric and four chiral centres are present in the molecule (asymmetry in the environment of S also makes this atom chiral) but both enantiomers are present in the crystal as a result of the presence of the *c* glide. The conformation of the molecule is illustrated and the orientation of the *p*-toluenesulfonic substituent discussed. A systematic asymmetry of the O=S—O angles (which makes sulfur chiral) is observed.

Comment

As part of our continuing work on new families of antitumor or antiviral agents (Ianelli *et al.*, 1993), we studied the chemical behavior of 4b,5,6,6a,10b,10c-hexahydrobenzo[3,4]cyclobuta[1,2-*a*]biphenylen-4b-ol (1) in the presence of *p*-toluenesulfonic acid (PTSOH) and observed the reaction shown below.



(1) (2)

Compound (1) remained unchanged in the presence of catalytic amounts of PTSOH, and its transformation took place only with an excess of sulfonic reagent. The structure of 1-(*p*-toluenesulfonyloxy)-3,4:7,8-dibenzotricyclo[3.3.2.0^{2,6}]decane (2), which could not be determined by classical spectroscopic methods, has been established using X-ray diffraction analysis.

A mechanism explaining the observed transformation has been proposed previously (Zouaoui *et al.*, 1991). The nucleophilic behavior of PTSOH must be emphasized; although it has been observed previously (Caubère & Mourad, 1974), such behavior is rather unusual.

It is important to note that the structure of (2), which contains a highly condensed polycyclic lipophilic part, should be of interest in obtaining potential new antivirus agents. A similar transformation is presently under investigation.

Fig. 1 shows that the molecule is built up from two fused benzocyclopentene moieties and a dimethylene bridge joining two α-C atoms of the cyclopentene rings so as to form a central cyclohexane ring fused with the benzocyclopentene cycles. The *p*-toluenesulfonyloxy substituent is inserted at an apex of the cyclohexane common to the cyclopentene rings.

The relative configurations at the C7*A*, C7*B* and C8*A* chiral centres are *R*, *S* and *R*, respectively; the enantiomer is also present in the crystal because *c* glides are present in the structure.

If the *p*-toluenesulfonyloxy substituent is not considered, there is an approximate local twofold axis running along the midpoints of bonds C8*A*—C8*B* and C9*A*—C9*B*. The most significant differences between the bonds are at C8*A* and C8*B* and therefore are probably caused by the presence of the *p*-toluenesulfonyloxy substituent. The difference (Δ/σ = 3.5) observed between the C3*A*—C4*A* and C3*B*—C4*B* benzene bonds is probably not real, but is caused instead by the high thermal motion (or disorder) affecting these atoms.

The fusion of the two benzocyclopentene systems, the presence of the dimethylene bridge and the *p*-