

Structure of a Tricyclic Iodoacetal, a Key Intermediate in the Ionic Cyclization of Enol-Ether Amine Alcohols

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Abstract. (+)-endo-2-Iodo-1-methoxy-4-(2-piperidyl)-7-oxabicyclo[2.2.1]heptane, $C_{12}H_{20}INO_2$, $M_r = 337.08$, triclinic, $P\bar{1}$, $a = 8.4185$ (16), $b = 9.1932$ (17), $c = 10.202$ (8) Å, $\alpha = 67.00$ (3), $\beta = 67.87$ (3), $\gamma = 88.497$ (19)°, $V = 666.41$ Å³, $Z = 2$, $D_x = 1.680$ Mg m⁻³, $\lambda(\text{Mo } K\alpha) = 0.70930$ Å, $\mu = 2.36$ mm⁻¹, $F(000) = 229.97$, room temperature, final $R = 0.037$ for 3262 observed reflections. The title compound is the first 1-methoxy-7-oxabicyclo[2.2.1]heptane derivative whose structure has been reported to date, and the relative stereochemistry of the C(2') and C(2) atoms was shown to be *RR* or *SS*, as expected from NMR studies. The methoxy group is oriented in such a manner as to respect the principle of the anomeric effect.

Introduction. The studied compound (1) is an intermediate isolated during the course of the cyclization of an enol-ether amine alcohol into a tricyclic amino-ketone (Bouchard, Lessard & Côté, 1989) whose skeleton is common to those of the securinine family (Snieckus, 1973). The structure was mainly determined by NMR experiments but the relative stereochemistry at the C(2') atom on the heterocycle was still uncertain. The X-ray diffraction study on a crystal of the racemic mixture of (1) has shown that the relative stereochemistry between C(2) and C(2') (Fig. 1) is *RR* or *SS*. This intermediate is expected to yield racemic allo-securinine whereas its diastereoisomer (2) would give racemic securinine.

Experimental. The synthesis of (1) will be described in another paper to be published later (Bouchard *et al.*, 1989). Crystals were obtained by cooling a saturated solution of (1) in 5 ml of hexane at room temperature to

258 K. A translucent colourless and prismatic crystal of $0.35 \times 0.30 \times 0.25$ mm was used for the X-ray analysis. Measurements were made on an Enraf-Nonius CAD-4 diffractometer using graphite-monochromatized Mo $K\alpha$ radiation. Cell parameters were obtained by least-squares procedure on 15 reflections in the range $20 \leq 2\theta \leq 40^\circ$. The $\omega/2\theta$ scan type was used for data collections at a constant scan speed of 4° min^{-1} . Absorption corrections were made, max. and min. transmission factors 0.97 and 0.68. 116 standard reflections, 0.05% intensity variation. A total of 5846 reflections was collected (5583 independent) in the range $4 \leq 2\theta \leq 44^\circ$ corresponding to $-10 \leq h \leq 10$, $0 \leq k \leq 11$, $-12 \leq l \leq 12$. 3262 reflections satisfying $I > 2.5\sigma(I)$ were considered as observed. The *NRCVAX* system (Gabe, Lee & Le Page, 1985) was used for all the calculations. The structure was solved by the application of direct methods and refined by full-matrix least squares on *F*. Anisotropic thermal parameters were refined for non-H atoms. The H atoms were located from a difference map, but their positions were not refined. The final

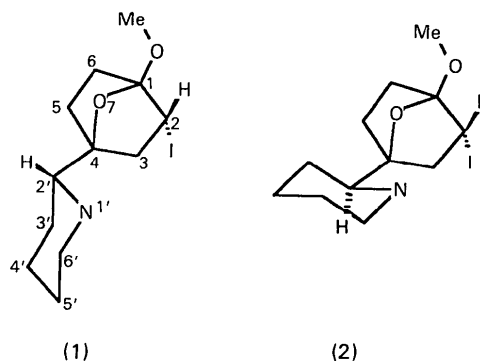


Fig. 1. Molecular scheme.

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Table 1. Final coordinates ($\times 10^4$) and equivalent B values (with *e.s.d.*'s in parentheses) of the title compound

$$B_{eq} = \frac{1}{3} \pi^2 \sum_i \sum_j U_{ij} a_i^* a_j^* a_i \cdot a_j$$

	<i>x</i>	<i>y</i>	<i>z</i>	$B_{eq}(\text{\AA}^2)$
I	0.64527 (4)	0.68387 (3)	0.33349 (4)	4.88
C(1)	0.7349 (5)	1.0455 (4)	0.1146 (4)	3.11
C(2)	0.8099 (5)	0.9112 (4)	0.2053 (4)	3.33
C(3)	0.8558 (6)	0.9809 (5)	0.3037 (5)	3.60
C(4)	0.8334 (5)	1.1572 (4)	0.2268 (4)	3.12
C(5)	0.6416 (5)	1.1743 (5)	0.2883 (5)	3.99
C(6)	0.5695 (5)	1.0845 (5)	0.2187 (5)	3.87
O(7)	0.8637 (3)	1.1767 (3)	0.0704 (3)	3.07
O(2)	0.7372 (4)	1.0242 (3)	-0.0120 (3)	3.87
C(7)	0.6972 (8)	1.1538 (6)	-0.1225 (6)	5.0
N(1')	1.1340 (4)	1.2633 (4)	0.1401 (4)	3.95
C(2')	0.9559 (5)	1.2810 (4)	0.2188 (4)	3.36
C(3')	0.9290 (6)	1.2653 (5)	0.3798 (5)	4.20
C(4')	1.0579 (7)	1.3869 (6)	0.3699 (6)	4.9
C(5')	1.2404 (7)	1.3791 (6)	0.2719 (6)	4.7
C(6')	1.2565 (6)	1.3911 (6)	0.1156 (6)	4.45

Table 2. Intramolecular bond lengths (\AA) and angles ($^\circ$) (with *e.s.d.*'s in parentheses) of the title compound

I—C(2)	2.156 (3)	C(4)—C(2')	1.514 (5)
C(1)—C(2)	1.512 (5)	C(5)—C(6)	1.537 (6)
C(1)—C(6)	1.534 (6)	O(2)—C(7)	1.421 (6)
C(1)—O(7)	1.452 (4)	N(1')—C(2')	1.450 (5)
C(1)—O(2)	1.373 (5)	N(1')—C(6')	1.465 (5)
C(2)—C(3)	1.541 (6)	C(2')—C(3')	1.518 (6)
C(3)—C(4)	1.543 (5)	C(3')—C(4')	1.526 (6)
C(4)—C(5)	1.525 (6)	C(4')—C(5')	1.503 (8)
C(4)—O(7)	1.454 (4)	C(5')—C(6')	1.508 (7)
C(2)—C(1)—C(6)	113.0 (3)	C(5)—C(4)—C(2')	116.0 (3)
C(2)—C(1)—O(7)	98.2 (3)	O(7)—C(4)—C(2')	109.5 (3)
C(2)—C(1)—O(2)	109.5 (3)	C(4)—C(5)—C(6)	101.8 (3)
C(6)—C(1)—O(7)	102.5 (3)	C(1)—C(6)—C(5)	102.1 (3)
C(6)—C(1)—O(2)	119.5 (3)	C(1)—O(7)—C(4)	96.9 (2)
O(7)—C(1)—O(2)	111.9 (3)	C(1)—O(2)—C(7)	116.1 (4)
I—C(2)—C(1)	114.8 (2)	C(2')—N(1')—C(6')	111.9 (3)
I—C(2)—C(3)	115.5 (3)	C(4)—C(2')—N(1')	110.1 (3)
C(1)—C(2)—C(3)	102.4 (3)	C(4)—C(2')—C(3')	111.4 (3)
C(2)—C(3)—C(4)	100.8 (3)	N(1')—C(2')—C(3')	108.6 (3)
C(3)—C(4)—C(5)	109.3 (3)	C(2')—C(3')—C(4')	110.7 (4)
C(3)—C(4)—O(7)	102.2 (3)	C(3')—C(4')—C(5')	111.2 (4)
C(3)—C(4)—C(2')	116.8 (3)	C(4')—C(5')—C(6')	111.4 (4)
C(5)—C(4)—O(7)	100.8 (3)	N(1')—C(6')—C(5')	108.5 (4)

residuals obtained at convergence were $R = 0.037$ and $wR = 0.038$. Counting statistics weights were used. The largest Δ/σ ratio was 0.009. The extreme fluctuations of the residual electron density in a final difference map were 1.15 and -0.75 e \AA^{-3} , mostly concentrated around the I atom. The scattering factors used were those of the *NRCVAX* system (Gabe *et al.*, 1985).

Discussion. Table 1 gives the final atomic parameters with their B_{eq} values.* Fig. 1 shows the numbering

* Lists of structure factors, anisotropic thermal parameters, H-atom parameters and torsion angles have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 51429 (26 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

scheme used and Fig. 2 shows a stereoscopic view of the molecule. Distances and angles are given in Table 2. In compound (1), the piperidine ring adopts a chair conformation and the bond between C(4) and C(2') is equatorial, as expected. The conformation is locked in such a manner that the N—C(2') and C(4)—C(5) bonds are antiperiplanar. The I atom is *endo* as expected from NMR experiments. The orientation of the methoxy group is such as, according to the anomeric effect (Lemieux & Koto, 1974), to have one of its lone pairs

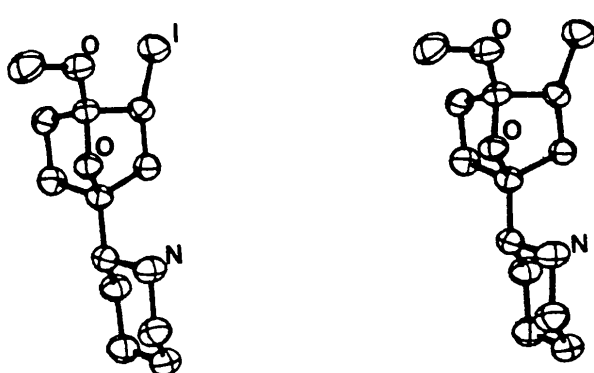


Fig. 2. ORTEP stereoscopic view (Johnson, 1976) of the molecule.

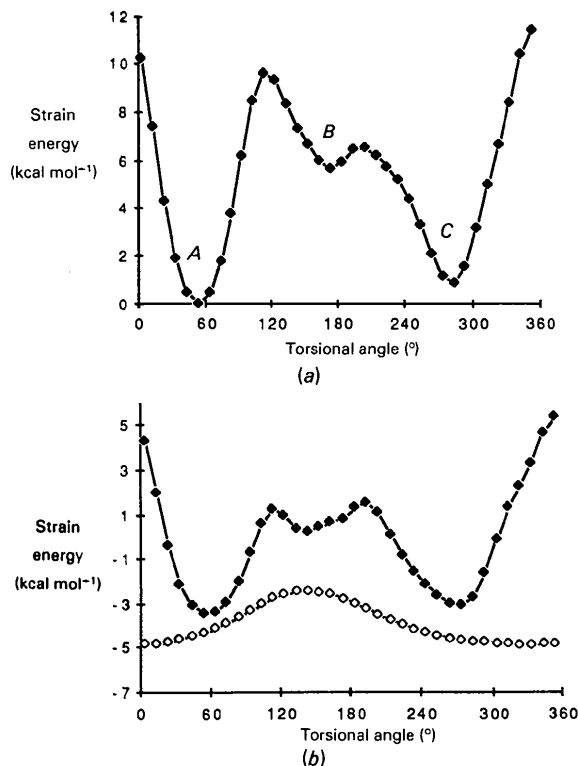


Fig. 3. (a) Total strain energy of (1) as a function of the torsional angle χ . (b) Electrostatic (lower curve) and van der Waals components of the total strain energy of (1) as a function of the torsional angle χ .

antiperiplanar to the C—O bond between C(1) and O(7), as the stereoelectronic principle (Deslongchamps, 1983) states in order to minimize the energy.

In order to investigate the rotational possibilities of the piperidine ring, conformational energy calculation of (1) using the *MM2* program (Burkert & Allinger, 1982) was made. The electrostatic component was computed, using atomic partial charges calculated by the empirical method (Gasteiger & Marsili, 1980). The piperidine ring was rotated around the C(4)—C(2') axis and the total strain energy calculated for each 10° rotation. The torsional angle χ was defined by the atoms C(3), C(4), C(2'), and N(1') (0° corresponding to the eclipsed rotamer). Fig. 3(a) shows the results obtained from this procedure: the total strain energy is given as a function of the χ rotation. The global minimum was found for a χ value of 54° (rotamer *A*) which corresponds to the crystallographic conformation: 56.1 (2)°. Two local minima were also found for $\chi = 174^\circ$ (rotamer *B*) and $\chi = -70^\circ$ (rotamer *C*), 5.6 and 0.5 kcal mol⁻¹ less stable than rotamer *A* respectively (1 kcal mol⁻¹ = 4.2 kJ mol⁻¹). Fig. 3(b) presents the long range van der Waals interactions (1–5 and longer) and the electrostatic contribution to the total strain energy. It appears from this diagram that both components contribute to a destabilization of rotamer *B*. Therefore, the stabilization of rotamers *A* and *C* can be attributed to the effects of van der Waals (1–5 and

longer) interactions and electrostatic attractions induced by the I atom.

No abnormally short intermolecular contacts were noted in the crystal packing.

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Structure of 1,3-Xylyl-18-crown-5*

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Abstract. C₁₆H₂₄O₅, *M_r* = 296.36, triclinic, *P* $\bar{1}$, *a* = 8.892 (1), *b* = 9.244 (2), *c* = 11.198 (1) Å, α = 68.85 (1), β = 67.82 (1), γ = 86.83 (1)°, *V* = 791.4 (2) Å³, *Z* = 2, *D_x* = 1.244 g cm⁻³, Cu *K*α, λ = 1.54184 Å, μ = 7.1 cm⁻¹, *F*(000) = 320, *T* = 294 K, *R* = 0.0493 for 2631 observed reflections with *I* > 2.5σ(*I*). The ring conformation of the uncomplexed

1,3-xylyl-18-crown-5 ether differs in five of the eighteen endocyclic torsion angles from the ring conformation in complexes with diphenylmagnesium or with *tert*-butylammonium perchlorate and dichloromethane.

Introduction. The crystal structure of 1,3-xylyl-18-crown-5 (I) was determined to compare the crown-ring conformation of the free molecule with the ring conformation in the recently studied rotaxane structure of 1,3-xylyl-18-crown-5 with diphenylmagnesium (Markies, Nomoto, Akkerman, Bickelhaupt, Smeets &

* IUPAC name: 4*H*,18*H*-6,7,9,10,12,13,15,16-octahydro-5,8,11,14,17-pentaoxabenzo[*ab*]cyclooctadecin.

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