SYNTHESIS AND STEREOISOMERISM OF THE DECAHYDROQUINOLINE SERIES N-OXIDES

6.* X-RAY DIFFRACTION STUDY OF 1,2e-DIMETHYL-4a-ETHYNYL-4e-HYDROXY-trans-DECAHYDROQUINOLINE N-OXIDE HYDROBROMIDE

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The results of x-ray diffraction analysis on 1,2e-dimethyl-4a-ethynyl-4e-hydroxy-trans-decahydroquinoline N-oxide hydrobromide corroborated the orientation of the substituents at the nitrogen atom that was determined previously from PMR data.

In an earlier report in this series [2] we established the orientation of the substituents at the nitrogen atom of the epimeric N-oxides of the 1,2-dimethyl-4a-ethynyl(vinylethynyl, vinyl, acetyl)-4-hydroxy-trans-decahydroquinolines by means of the PMR method, making use of the fact that the chemical shifts of the 3-H_a and 3-H_e protons depend on the orientation of the N−O bond and the diamagnetic anisotropy of the ring C−C and C−H bonds.

In order to confirm that the orientation of the substituents at the nitrogen atom of the epimeric N-oxides was determined accurately, we have carried out an x-ray diffraction analysis of the hydrobromide crystals obtained from 1,2e-dimethyl-4a-ethynyl-4e-hydroxy-trans-decahydroquinoline N-oxide (I), whose N−O bond was previously assigned an axial orientation on the basis of PMR spectral data.†

The structure of N-oxide I ascertained from x-ray diffraction data is shown in Fig. 1, which also gives valence bond lengths. The standard deviation of the lengths was 0.008-0.009 Å for N−O, N−C, and O−C, and 0.01 Å for C−C. Valence angles are shown in Table 1 and torsion angles in Table 2.

The rings of the molecule were in a chair conformation, with the N−O bond having an axial and the N−CH_3 bond an equatorial orientation. The angle between the fused rings (i.e., the angle between the plane drawn by the least-square method through $C_{(2)}$, $C_{(3)}$, $C_{(10)}$, and $C_{(9)}$ (plane P_1) to an accuracy of at least 0.01 Å, and the plane formed by the atoms $C_{(6)}$, $C_{(7)}$, $C_{(9)}$, and $C_{(10)}$ (plane P_2), made to an accuracy of at least 0.03 Å) was 176.8°, i.e., close to the ideal value of 180°. The $C_{(4)}$ and $N_{(1)}$ atoms deviated from the plane P_1 by distances of 0.70 Å and −0.66 Å respectively. In this case the dihedral angles between the peri- and central planes were 50.8° for the first atom and 49.4° for the second atom. Atoms $C_{(5)}$ and $C_{(8)}$ deviated from plane P_2 by 0.66 Å and −0.68 Å respectively. The dihedral angles between the peri- and central planes were similar to those found in the adjacent ring, having values of 50.3° for atom $C_{(5)}$ and 49.6° for atom $C_{(8)}$.

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*For Communication 5, see [1].

†In the case of the $N_{(1)}$-epimeric N-oxide, no crystals suitable for x-ray diffraction analysis were obtained.

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TABLE 1. Valence Angles ω (deg.) in the N-Oxide I Molecule

Angle	ω	Angle	ω
$O_{(1)}-N_{(1)}-C_{(2)}$	105,7(5)	$O_{(1)}-N_{(1)}-C_{(9)}$	108,0(5)
$O_{(1)}-N_{(1)}-C_{(14)}$	108,8(5)	$C_{(2)}-N_{(1)}-C_{(9)}$	111,7(5)
$C_{(2)}-N_{(1)}-C_{(14)}$	111,2(6)	$C_{(9)}-N_{(1)}-C_{(14)}$	111,1(5)
$C_{(4)}-O_{(2)}-H_{(O2)}$	99,9(5)	$N_{(1)}-C_{(2)}-C_{(3)}$	110,3(6)
$N_{(1)}-C_{(2)}-C_{(13)}$	112,7(6)	$C_{(3)}-C_{(2)}-C_{(13)}$	112,4(7)
$C_{(2)}-C_{(3)}-C_{(4)}$	114,5(6)	$O_{(2)}-C_{(4)}-C_{(3)}$	110,2(6)
$O_{(2)}-C_{(4)}-C_{(10)}$	111,4(6)	$O_{(2)}-C_{(4)}-C_{(11)}$	105,5(6)
$C_{(3)}-C_{(4)}-C_{(10)}$	108,5(6)	$C_{(3)}-C_{(4)}-C_{(11)}$	110,3(6)
$C_{(10)}-C_{(4)}-C_{(11)}$	110,9(6)	$C_{(6)}-C_{(5)}-C_{(10)}$	112,2(7)
$C_{(5)}-C_{(6)}-C_{(7)}$	108,8(8)	$C_{(6)}-C_{(7)}-C_{(8)}$	111,9(8)
$C_{(7)}-C_{(8)}-C_{(9)}$	109,4(7)	$N_{(1)}-C_{(9)}-C_{(8)}$	110,7(6)
$N_{(1)}-C_{(9)}-C_{(10)}$	110,8(5)	$C_{(8)}-C_{(9)}-C_{(10)}$	113,1(6)
$C_{(4)}-C_{(10)}-C_{(5)}$	112,2(6)	$C_{(4)}-C_{(10)}-C_{(9)}$	110,5(6)
$C_{(5)}-C_{(10)}-C_{(9)}$	111,6(6)	$C_{(4)}-C_{(11)}-C_{(12)}$	178,9(8)

TABLE 2. Torsion Angles τ (deg) in the N-Oxide I Molecule

Angle	τ	Angle	τ
$O_{(1)}-N_{(1)}-C_{(2)}-C_{(13)}$	-62,1(7)	$O_{(1)}-N_{(1)}-C_{(2)}-C_{(3)}$	64,4(7)
$C_{(9)}-N_{(1)}-C_{(2)}-C_{(3)}$	-52,9(7)	$C_{(9)}-N_{(1)}-C_{(2)}-C_{(13)}$	-179,4(6)
$C_{(14)}-N_{(1)}-C_{(2)}-C_{(3)}$	-177,7(6)	$C_{(14)}-N_{(1)}-C_{(2)}-C_{(13)}$	55,8(8)
$O_{(1)}-N_{(1)}-C_{(9)}-C_{(8)}$	65,9(7)	$O_{(1)}-N_{(1)}-C_{(9)}-C_{(10)}$	-60,4(7)
$C_{(2)}-N_{(1)}-C_{(9)}-C_{(8)}$	-178,2(6)	$C_{(2)}-N_{(1)}-C_{(9)}-C_{(10)}$	55,5(7)
$C_{(14)}-N_{(1)}-C_{(9)}-C_{(8)}$	-53,4(8)	$C_{(14)}-N_{(1)}-C_{(9)}-C_{(10)}$	-179,7(6)
$H_{(O2)}-O_{(2)}-C_{(4)}-C_{(3)}$	62,1(7)	$H_{(O2)}-O_{(2)}-C_{(4)}-C_{(10)}$	-58,4(7)
$H_{(O2)}-O_{(2)}-C_{(4)}-C_{(11)}$	-178,8(5)	$C_{(2)}-C_{(3)}-C_{(4)}-C_{(11)}$	64,6(8)
$N_{(1)}-C_{(2)}-C_{(3)}-C_{(4)}$	55,2(8)	$C_{(13)}-C_{(2)}-C_{(3)}-C_{(4)}$	-178,2(7)
$C_{(2)}-C_{(3)}-C_{(4)}-O_{(2)}$	-179,3(6)	$C_{(2)}-C_{(3)}-C_{(4)}-C_{(10)}$	-57,0(8)
$O_{(2)}-C_{(4)}-C_{(10)}-C_{(5)}$	-56,2(8)	$O_{(2)}-C_{(4)}-C_{(10)}-C_{(9)}$	178,6(5)
$C_{(3)}-C_{(4)}-C_{(10)}-C_{(5)}$	-177,8(6)	$C_{(3)}-C_{(4)}-C_{(10)}-C_{(9)}$	57,0(7)
$C_{(11)}-C_{(4)}-C_{(10)}-C_{(5)}$	61,0(8)	$C_{(11)}-C_{(4)}-C_{(10)}-C_{(9)}$	-64,3(7)
$O_{(2)}-C_{(4)}-C_{(11)}-C_{(12)}$	89,0(9)	$C_{(3)}-C_{(4)}-C_{(11)}-C_{(12)}$	-152,0(9)
$C_{(10)}-C_{(5)}-C_{(6)}-C_{(7)}$	57,0(9)	$C_{(10)}-C_{(4)}-C_{(11)}-C_{(12)}$	-31,8(9)
$C_{(6)}-C_{(5)}-C_{(10)}-C_{(4)}$	-177,8(7)	$C_{(6)}-C_{(5)}-C_{(10)}-C_{(9)}$	-53,2(9)
$C_{(5)}-C_{(6)}-C_{(7)}-C_{(8)}$	-59,5(9)	$C_{(6)}-C_{(7)}-C_{(8)}-C_{(9)}$	58,0(9)
$C_{(7)}-C_{(8)}-C_{(9)}-N_{(1)}$	-178,1(6)	$C_{(7)}-C_{(8)}-C_{(9)}-C_{(10)}$	-53,1(8)
$N_{(1)}-C_{(9)}-C_{(10)}-C_{(4)}$	-57,6(7)	$N_{(1)}-C_{(9)}-C_{(10)}-C_{(5)}$	176,8(6)
$C_{(8)}-C_{(9)}-C_{(10)}-C_{(4)}$	177,4(6)	$C_{(8)}-C_{(9)}-C_{(10)}-C_{(5)}$	51,9(8)

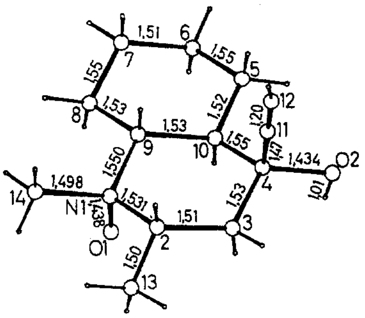

Fig. 1. Structure of N-oxide I molecule. Bond lengths in Å.

TABLE 3. Atomic Coordinates ($\times 10^4$) for N-Oxide I Hydrobromide

Atom	x/a	y/b	z/c	Atom	x/a	y/b	z/c
Br	2267(1)	5462(1)	5907(2)	$C_{(8)}$	-698(6)	9429(11)	1823(6)
$N_{(1)}$	-426(4)	6897(8)	3036(4)	$C_{(9)}$	-22(5)	8692(9)	2600(5)
$O_{(1)}$	-417(4)	5522(7)	2297(4)	$C_{(10)}$	1014(5)	8420(9)	2245(5)
$O_{(2)}$	2640(4)	7448(7)	2754(4)	$C_{(11)}$	1745(5)	9152(11)	3829(5)
$C_{(2)}$	223(5)	6161(11)	3838(5)	$C_{(12)}$	1805(6)	10318(12)	4434(6)
$C_{(3)}$	1247(6)	5993(9)	3488(6)	$C_{(13)}$	-149(7)	4409(12)	4264(7)
$C_{(4)}$	1671(5)	7756(10)	3077(5)	$C_{(14)}$	-1441(6)	7148(12)	3380(6)
$C_{(5)}$	1404(6)	10139(12)	1764(7)	$H_{(O2)}$	2517(0)	6511(0)	2240(0)
$C_{(6)}$	728(6)	10846(11)	958(10)	$H_{(Br)}$	1341(0)	4671(0)	5839(0)
$C_{(7)}$	-256(8)	11190(11)	1379(6)				

In summary, x-ray diffraction data corroborated the findings of our previous works regarding the orientation of the substituents at the nitrogen atom, the substituents at the $C_{(2)}$ and $C_{(4)}$ positions, and the fusion and conformation of the rings [2-4] for the axial N-oxide of 1,2e-dimethyl-4a-ethynyl-4e-hydroxy-trans-decahydroquinoline.

EXPERIMENTAL

The synthesis of N-oxide I is described in [5]. The hydrobromide obtained from it ($C_{13}H_{22}NO_2Br$) had a melting point of 187-188°C. Crystals of the hydrobromide were grown from ethyl alcohol solution.

Orthorhombic crystals, at 19°C a = 13.860(6) Å, b = 7.310(3) Å, c = 13.512(5) Å (Z = 4), sp. gr. $Pca2_1$.

Elementary nuclear parameters and the intensity of 1265 independent reflections, of which 1227 with $F > 2.5 \cdot \sigma_F$ were used to interpret and clarify the structure, were measured with a NICOLET R3m 4-circle diffractometer (USA), using the standard technique (MoKα-emission, graphite monochromator, $\theta/2\theta$ scanning, $2\theta_{max} = 64°$). An empirical correction was made for absorption.

The structure was resolved by direct method using a Shelx 84 program complex (Rev. 4.1). Coordinates for nonhydrogen atoms were refined using the least-square method in block-diagonal isotropic, then anisotropic approximation. The $H_{(02)}$ atom was identified by Fourier differential synthesis. It was not possible to determine unambiguously the coordinates of the $H_{(Br)}$ hydrogen at the bromine atom. In differential synthesis three peaks appeared at a distance of about 1.3 Å from the Br atom. The coordinates of one of these peaks were used in the calculations as the $H_{(Br)}$ coordinates. The position of the other hydrogen atoms was calculated geometrically. All the hydrogen atoms were used in the F_{calc} calculation with fixed coordinates and isotropic temperature factors. At the last refinement stage the standard R-factor value was 0.040. Atomic coordinates for N-oxide I hydrobromide are shown in Table 3 (hydrogen atoms whose coordinates were calculated are omitted; they were used in the calculation with B_{iso} values of 6 Å^2). All calculations were performed using a NOVA 3 minicomputer.

REFERENCES

1. A. A. Akhrem, L. I. Ukhova, M. F. Marchenko, and V. M. Gorul'ko, Khim. Geterotsikl. Soedin., No. 10, 1378 (1976).
2. A. A. Akhrem, V. M. Gorul'ko, L. I. Ukhova, M. F. Marchenko, and A. P. Marochkin, Khim. Geterotsikl. Soedin., No. 10, 1372 (1976).
3. V. G. Zaikin, N. S. Vulfson, V. I. Zaretskii, A. A. Bakaev, A. A. Akhrem, L. I. Ukhova, and N. F. Uskova, Org. Mass. Spectrom., **2**, 1257 (1969).
4. V. S. Bogdanov, L. I. Ukhova, N. F. Uskova, A. N. Sergeeva, A. P. Marochkin, A. M. Moiseenkov, and A. A. Akhrem, Khim. Geterotsikl. Soedin., No. 8, 1078 (1973).
5. A. A. Akhrem, L. I. Ukhova, and N. F. Sakovich, Izv. Akad. Nauk SSSR, Ser. Khim., No. 5, 838 (1963).