Structure of 4,5-Dihydro-1-oxo-1H-[1,2,4]oxadiazolo[4,3-a]quinoline

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Abstract. $C_{10}H_8N_2O_2$, triclinic, $P\bar{1}$, $a = 8.008$ (1), $b = 8.862$ (2), $c = 7.848$ (1) Å, $\alpha = 92.11$ (1), $\beta = 118.93$ (1), $\gamma = 63.52$ (1)°, $M_r = 188.19$, $Z = 2$, $D_m = 1.46$ (1) (by flotation in bromoform and 1-bromohexane mixture), $D_x = 1.471$ g cm^{-3}, $V = 424.8$ (1) Å^3. The structure was determined by direct methods and was refined by full-matrix least-squares procedures to a conventional R index of 0.033 for 987 reflections. In the final cycle of refinement, all shifts were less than 1.4% of their e.s.d.'s. The structure previously proposed on the basis of chemical analysis and IR, NMR and mass spectrometry is confirmed.

Introduction. The rearrangement of 2-nitro-1-tetralone oxime [2-nitro-3,4-dihydro-1(2H)-naphthalenone oxide] with polyphosphoric acid produced a mixture of a furoxane derivative of tetrahydronaphthalene and a 1,2-disubstituted tetrahydroquinoline (Kametani, Sugahara & Yagi, 1966). The complex course proposed for the formation of the latter compound is without analogy among similar reactants, 2-nitro-1-indanone oxime and α-nitroketones (Fischer & Weitz, 1980). The preparation and study of two additional derivatives of the new quinoline compound did not exclude an alternative structure. This work, which confirms the original assignment, was undertaken to resolve the dilemma.

A single crystal of 4,5-dihydro-1-oxo-1H-[1,2,4]-oxadiazolo[4,3-a]quinoline with extreme dimensions of $0.30 \times 0.12 \times 0.10$ mm was mounted approximately along its longest dimension on a glass rod. A Syntex four-circle computer-controlled diffractometer with graphite-monochromatized Cu $K\alpha$ radiation [$\lambda(K\alpha_1) = 1.54050$ Å; $\lambda(K\alpha_2) = 1.54434$ Å] was used for preliminary experiments and for the measurement of diffraction intensities. The cell constants and their standard deviations were determined by a least-squares treatment of the angular coordinates of 15 independent reflections with $2\theta < 26°$. The reflections were examined using the θ–2θ scan technique. Each reflection was scanned at a constant rate ω of $4.0°$ min^{-1} from $0.8°$ (in 2θ) below the calculated $K\alpha_1$ peak to $0.8°$ above the $K\alpha_2$ maximum. The background to scan time ratio was 1.0. Three check reflections, monitored after every one hundred reflections during the course of data collection, showed no significant fluctuations.

Standard deviations were assigned according to the formula $\sigma(I) = [(CT + B_1 + B_2)\omega^2 + (pI)^2]^{1/2}$ where CT is the total integrated count, B_1 and B_2 are the background counts, and the intensity is $I = \omega(CT - B_1 - B_2)$. A value of 0.02 was assigned to the empirical parameter p. The weights w used in least-squares refinement of the structural parameters were the reciprocal squares of $\sigma(F_o)$. Of the 1164 unique reflections measured, 1000 had intensities greater than twice their standard deviations. (13 of these, those whose scaled observed structure factors exceeded 15 e and whose $\sin\theta/\lambda$ values were less than 0.205 Å^{-1}, were later omitted from the final cycles of least-squares refinement because of apparent extinction.) The intensities were corrected for Lorentz and polarization effects (Ottersen, 1974). The monochromator crystal was assumed to be half-perfect and half-mosaic in character in the polarization correction. A correction for the effect of absorption ($\mu = 8.9$ cm^{-1}) was not made. The atomic scattering factors (*International Tables for X-ray Crystallography*, 1974, pp. 72–98) for C^0, N^0, O^0, and H (bonded) (*International Tables*, p. 71) were used; all but the last were modified to include the real part of the anomalous-dispersion correction (*International Tables*, pp. 149–150).

The structure was solved by direct methods with *MULTAN*80 (Main, Fiske, Hull, Lessinger, Germain, Declercq & Woolfson, 1980). The statistical averages indicated the space group to be centrosymmetric and therefore $P\bar{1}$. All 14 non-hydrogen atoms were observed on the initial E function. The eight H positions were calculated assuming a C—H distance of 0.95 Å, and a difference function showed a peak very near each of these calculated positions. Several cycles of full-matrix least-squares refinement (Gantzel, Sparks & Trueblood, 1964) with anisotropic thermal parameters for non-hydrogen atoms and isotropic ones for H atoms yielded $R_1 = \sum (|F_o| - |F_c|)/\sum F_o = 0.033$ and $R_2 = [\sum w(F_o - |F_c|)^2/\sum wF_o^2]^{1/2} = 0.036$.* The 'goodness-of-fit', $[\sum w(F_o - |F_c|)^2/(m - s)]^{1/2}$, is 1.98, where m (987) is the number of observations used in least-

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Table 1. Positional (×10⁴, for H ×10³) and thermal parameters with e.s.d.'s

For non-hydrogen atoms the equivalent isotropic temperature factors, B_{eq}, have been calculated by $B_{eq} = \frac{4}{3}(\beta_{11}a^2 + \cdots + \beta_{23}bc\cos\alpha)$. $\sigma(B_{eq}) = [(8/9)a^4\sigma^2(\beta_{11}) + \cdots + (8/9)b^2c^2\cos^2\alpha \times \sigma^2(\beta_{23})]^{1/2}$. This expression differs from that obtained from the usual propagation-of-error expression by a factor of $1/\sqrt{2}$ (Schomaker & Marsh, 1981).

	x	y	z	B_{eq}/B (Å²)
O(1)	10599 (2)	1781 (2)	12844 (2)	5·12 (5)
C(2)	9347 (3)	1297 (3)	11770 (3)	3·98 (7)
O(3)	9581 (2)	−274 (2)	12254 (2)	5·11 (5)
N(4)	7836 (3)	−479 (2)	10635 (3)	5·02 (7)
C(5)	6683 (3)	946 (3)	9310 (3)	3·67 (7)
N(6)	7482 (2)	2076 (2)	9896 (2)	3·30 (5)
C(7)	6409 (3)	3779 (2)	8730 (2)	3·10 (6)
C(8)	7453 (3)	4751 (3)	9157 (3)	4·00 (7)
C(9)	6325 (3)	6406 (3)	8018 (3)	4·45 (8)
C(10)	4190 (3)	7072 (3)	6459 (3)	4·24 (7)
C(11)	3186 (3)	6075 (2)	6017 (3)	3·75 (7)
C(12)	4254 (3)	4412 (2)	7145 (2)	3·19 (6)
C(13)	3139 (3)	3335 (3)	6743 (3)	3·96 (7)
C(14)	4732 (3)	1399 (3)	7306 (3)	4·12 (7)
H(8)	890 (3)	427 (3)	1024 (3)	5·0 (5)
H(9)	702 (3)	709 (2)	834 (3)	4·4 (5)
H(10)	342 (3)	822 (3)	569 (3)	5·0 (5)
H(11)	171 (3)	651 (2)	492 (3)	3·9 (4)
H(13A)	237 (3)	359 (3)	754 (3)	5·7 (5)
H(13B)	202 (3)	363 (2)	534 (3)	4·4 (4)
H(14A)	408 (3)	71 (2)	729 (3)	4·6 (5)
H(14B)	519 (3)	110 (2)	634 (3)	4·7 (5)

Table 2. Molecular dimensions and e.s.d.'s

O(1)–C(2)	1·199 (2) Å	C(11)–C(12)	1·388 (3) Å
C(2)–O(3)	1·362 (2)	C(12)–C(13)	1·507 (3)
C(2)–N(6)	1·379 (2)	C(13)–C(14)	1·525 (3)
O(3)–N(4)	1·446 (2)		
N(4)–C(5)	1·287 (3)	C(8)–H(8)	0·94 (2)
C(5)–N(6)	1·370 (2)	C(9)–H(9)	0·95 (2)
C(5)–C(14)	1·479 (3)	C(10)–H(10)	0·95 (2)
N(6)–C(7)	1·428 (2)	C(11)–H(11)	0·96 (2)
C(7)–C(8)	1·380 (3)	C(13)–H(13A)	1·03 (2)
C(7)–C(12)	1·397 (2)	C(13)–H(13B)	0·97 (2)
C(8)–C(9)	1·379 (3)	C(14)–H(14A)	0·96 (2)
C(9)–C(10)	1·378 (3)	C(14)–H(14B)	0·98 (2)
C(10)–C(11)	1·374 (3)		

O(1)–C(2)–O(3)	123·4 (2)°	C(7)–C(8)–H(8)	119 (1)°
O(1)–C(2)–N(6)	131·4 (2)	H(8)–C(8)–C(9)	122 (1)
O(3)–C(2)–N(6)	105·2 (1)	C(8)–C(9)–H(9)	119 (1)
C(2)–O(3)–N(4)	109·9 (1)	H(9)–C(9)–C(10)	120 (1)
O(3)–N(4)–C(5)	104·1 (2)	C(9)–C(10)–H(10)	120 (1)
N(4)–C(5)–N(6)	113·0 (2)	H(10)–C(10)–C(11)	120 (1)
N(4)–C(5)–C(14)	126·8 (2)	C(10)–C(11)–H(11)	121 (1)
N(6)–C(5)–C(14)	120·2 (2)	H(11)–C(11)–C(12)	118 (1)
C(2)–N(6)–C(5)	107·9 (1)	C(12)–C(13)–H(13A)	109 (1)
C(2)–N(6)–C(7)	128·8 (1)	C(12)–C(13)–H(13B)	111 (1)
C(5)–N(6)–C(7)	123·2 (1)	H(13A)–C(13)–C(14)	109 (1)
N(6)–C(7)–C(8)	121·4 (2)	H(13B)–C(13)–C(14)	107 (1)
N(6)–C(7)–C(12)	116·8 (1)	H(13A)–C(13)–H(13B)	107 (2)
C(8)–C(7)–C(12)	121·8 (2)	C(5)–C(14)–H(14A)	110 (1)
C(7)–C(8)–C(9)	119·2 (2)	C(5)–C(14)–H(14B)	109 (1)
C(8)–C(9)–C(10)	120·3 (2)	C(13)–C(14)–H(14A)	112 (1)
C(9)–C(10)–C(11)	120·0 (2)	C(13)–C(14)–H(14B)	110 (1)
C(10)–C(11)–C(12)	121·5 (2)	H(14A)–C(14)–H(14B)	106 (2)
C(7)–C(12)–C(11)	117·2 (2)		
C(7)–C(12)–C(13)	120·6 (2)		
C(11)–C(12)–C(13)	122·2 (2)		
C(12)–C(13)–C(14)	112·5 (2)		
C(5)–C(14)–C(13)	109·5 (2)		

squares refinement, and s (159) is the number of parameters. The overdetermination ratio (m/s) is 6·2.

The final positional coordinates, together with their standard deviations, are presented in Table 1. A final difference Fourier function (e.s.d. = 0·10 e Å⁻³) showed no peaks greater than 0·18 e Å⁻³ in magnitude.

Discussion. Fig. 1 shows our result, which confirms the structure reported for $C_{10}H_8N_2O_2$ by Kametani, Sugahara & Yagi (1966) by chemical analysis and IR, NMR and mass spectrometry. Bond distances and
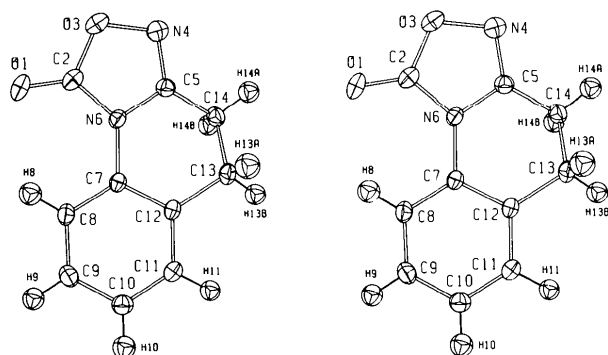

Fig. 1. An ORTEP (Johnson, 1965) stereoview of the title compound. Ellipsoids of 20% probability are used.

Table 3. Deviations (×10³) of atoms from least-squares planes

Boldface deviations indicate the atoms used to define the least-squares plane. A negative deviation from a plane indicates that the atoms with coordinates in Table 1 lie between that plane and the origin. The direction cosines (A,B,C) are with respect to orthogonalized axes: y is along **b**, z is along **a** × **b**, and x is along **b** × (**a** × **b**). D is the distance (in Å) from the plane to the origin. E.s.d.'s of deviations are ca 0·002 Å.

	Plane 1	Plane 2	Plane 3
O(1)	−25		
C(2)	−5	358	
O(3)	2		
N(4)	1	321	
C(5)	−3	**60**	
N(6)	4	**75**	33
C(7)	82	**−106**	**6**
C(8)		**−349**	**−9**
C(9)			**1**
C(10)			**10**
C(11)		**−181**	**−9**
C(12)		**−22**	**1**
C(13)		**275**	49
C(14)	−59	**−281**	
A	−0·9043	−0·8040	−0·7610
B	0·1159	0·0401	0·2003
C	0·4108	0·5932	0·6170
D	2·0207	2·9679	3·9007

angles are given in Table 2, and some least-squares planes are presented in Table 3. The average bond length in the benzene ring, 1·383 Å, is normal. The five-membered oxadiazolo ring (atoms 2 through 6) is planar (Table 3). In the heterocyclic six-membered ring (atoms 5–7 and 12–14), C(13) and C(14) deviate most notably and approximately equally on opposite sides of the best plane. The C(2)–N(6)–C(7)–C(8) torsion angle is 16·8 (2)° and C(5)–C(14)–C(13)–C(12) is 46·7 (2)°.

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2-Acetoxy-6-methylbenzoic Acid*

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Abstract. $C_{10}H_{10}O_4$, monoclinic, $P2_1/n$, $a = 10\cdot164$ (2), $b = 7\cdot238$ (2), $c = 13\cdot186$ (3) Å, $\beta = 96\cdot74$ (2)° at 299 K, $Z = 4$, $d_c = 1\cdot340$ (1) Mg m^{-3}; $R = 0\cdot041$ for 1260 data having $F_o^2 > 3\sigma(F_o^2)$ measured by diffractometer. The crystal structure of 2-acetoxy-6-methylbenzoic acid (6-methylaspirin) has been determined. The molecule forms dimers with linear asymmetric hydrogen bonds of length 2·621 (2) Å. The carboxyl group is rotated 44·7 (2)° from the plane of the benzene ring. This rotation is significant when compared to aspirin, and is likely caused by steric interactions of the methyl group juxtaposed to the carboxyl.

Introduction. Considerable research has been devoted to understanding the efficiency of enzymatic catalysis. One school of thought ascribes a major part of this efficiency to the juxtaposition of functional groups (Kirby, 1980). In addition, the orientation of these groups is also important, but just how important is a subject of controversy (Koshland, 1972; Wang, 1970; Gandour, 1978, 1981). Thus, studies of structure and dynamics on chemical models of enzymatic catalysts have the potential of providing information about geometry and its relationship to catalytic efficiency.

Studies of the pH dependence of hydrolysis rates of methyl-substituted 2-acyloxybenzoic acids (Gandour, Mani, Blanco, Wiseman & Williams, 1980) reveal that a 6-methyl substituent retards the rate in the neutral region; however, in the acid region there is an acceleration in the rate. An X-ray crystallographic analysis of the structure of 2-acetoxy-6-methylbenzoic acid (6-methylaspirin) has been performed to assist in explaining this novel pH-dependent steric effect. The combination of this report with the recent structure report on 2-acetoxy-3-methylbenzoic acid (Chiari, Fronczek, Davis & Gandour, 1981) reveals the marked structural changes to the catalyst (carboxyl group) and substrate (acetoxy group) of the model system brought about by methyl substitution.

6-Methylaspirin was prepared as described previously (Eliel, Rivard & Burgstahler, 1953). Crystals,

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