

2-[(Hydroxyimino)methyl]-1-methylpyridinium Chloride

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Abstract. $C_7H_9N_2O^+Cl^-$, triclinic, $P\bar{1}$, $Z = 2$, $a = 7.110$ (1), $b = 7.165$ (2), $c = 8.861$ (1) Å, $\alpha = 76.52$ (1), $\beta = 85.62$ (1), $\lambda = 65.81$ (1)°, $d_c = 1.432$ Mg m⁻³, $\mu(Mo K\alpha) = 4.205$ mm⁻¹; $R_w = 0.039$ for 2435 observed reflections. The structure was solved by heavy-atom techniques, showing the oxime moiety to have the (*E*) configuration. The existence of π -localization in the pyridinium ring is discussed.

Introduction. The antidotal activity of certain oxime derivatives of pyridine for nerve-gas poisoning and for organophosphate-pesticide poisoning induced us to study the crystal structures of 1-benzyl-2-[(hydroxyimino)methyl]pyridinium bromide and the corresponding methylsulphonate (Van Havere, Lenstra, Geise, Van den Berg & Benschop, 1982*a*), 1,1'-[oxybis(methylene)]bis{4-[(hydroxyimino)methyl]pyridinium} dichloride (obidoxime; Van Havere, Lenstra, Geise, Van den Berg & Benschop, 1982*b*) and 4'-carbamoyl-2-[(hydroxyimino)methyl]-1,1'-[oxybis(methylene)]dipyridinium dichloride (Van Havere, Lenstra, Geise, Van den Berg & Benschop, 1982*c*).

Indications were found that in the geometries of these compounds some localization of π -electrons occurs in the pyridinium rings, *i.e.* that resonance form (*b*) contributes significantly to the real structure (see Fig. 1). The same rationale was invoked by Carlström (1966) to explain certain features in 2-[(hydroxyimino)methyl]-1-methylpyridinium iodide (pralidoxime iodide). However, a firm decision about the significance of the π -localization could not be reached, partly because in some determinations the ratio parameters: independent reflections was not favourable, partly because the results for pralidoxime iodide were less reliable. Therefore we decided to investigate 2-[(hydroxyimino)methyl]-1-methylpyridinium chloride (pralidoxime chloride), which has a favourable ratio parameters: independent reflections. Colourless single crystals of pralidoxime chloride were obtained by slow evaporation at room temperature of a solution of the product in methanol/water (9/1, v/v).

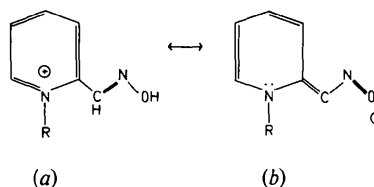


Fig. 1. Resonance forms in 2-[(hydroxyimino)methyl]pyridinium salts.

The structure was determined from data obtained at room temperature on an Enraf–Nonius CAD-4 diffractometer using a graphite monochromator and Mo radiation ($\lambda = 0.71073$ Å). All unique reflections with $\theta \leq 35^\circ$ were measured. Cell parameters were evaluated by a least-squares procedure using 25 reflections in the range $5^\circ < \theta \leq 20^\circ$. Other relevant experimental details are summarized in Table 1. No absorption correction was necessary.

The chloride ion was located from a Patterson map, while all other atoms, including H atoms, were located from subsequent difference Fourier calculations. The refinement was performed employing the Gauss–Seidel block method (Sparks, 1974) and the Enraf–Nonius SDP package described by Frenz (1978). Each reflection was given a weight based on counting statistics. Debye–Waller temperature factors of H atoms were fixed at 4.0 Å². After refinement of the isotropic extinction parameter (Zachariasen, 1963) to $r = 0.72 \times 10^{-6}$ mm, the R_w value converged to 0.039 with $R_w = [\sum w(|F_o| - |F_c|)^2 / \sum w|F_o|^2]^{1/2}$ for observed

Table 1. Experimental data

Crystal dimensions (mm)	0.1 × 0.1 × 0.1
Number of reflections	3521
Number of reflections in refinement with $I > 2\sigma(I)$	2435
Method of measurement	Pure ω scan
Scan angle (°)	1.2 + 1.0 tg θ
Aperture of detection unit (mm)	2.0 + 1.0 tg θ

Table 2. Positional parameters in fractions of the cell edges

The e.s.d.'s given in parentheses refer to the last digit. Isotropic temperature parameters (\AA^2) are calculated from the anisotropic temperature parameters assuming equal volume of the 50% probability region according to Lipson & Cochran (1968); $B_{\text{iso}} = 8\pi^2(U_{11}^0 U_{22}^0 U_{33}^0)^{1/3}$. E.s.d.'s are about 0.2\AA^2 . All anisotropic thermal parameters were physically acceptable. H atom $H(j,x)$ ($j = 1,2,3$) is attached to atom x .

	x	y	z	B_{iso}
Cl	0.04351 (5)	0.27738 (5)	0.23507 (4)	3.34
O	0.5463 (1)	0.7602 (1)	0.6689 (1)	3.14
N(1)	0.1961 (1)	0.7489 (1)	0.2547 (1)	2.40
N(2)	0.5520 (2)	0.7481 (2)	0.5162 (1)	2.69
C(1)	0.1778 (2)	0.7436 (2)	0.1052 (2)	2.90
C(2)	0.3282 (2)	0.7462 (2)	0.0018 (2)	3.20
C(3)	0.5052 (2)	0.7491 (2)	0.0523 (2)	3.54
C(4)	0.5223 (2)	0.7549 (2)	0.2034 (2)	3.22
C(5)	0.3656 (2)	0.7573 (2)	0.3069 (1)	2.37
C(6)	0.0230 (2)	0.7468 (2)	0.3569 (2)	3.53
C(7)	0.3794 (2)	0.7663 (2)	0.4686 (1)	2.68
H(1,O)	0.678 (2)	0.742 (2)	0.692 (2)	4.00
H(1,C1)	0.058 (2)	0.731 (2)	0.075 (2)	4.00
H(1,C2)	0.300 (2)	0.746 (2)	-0.099 (2)	4.00
H(1,C3)	0.612 (2)	0.743 (2)	-0.013 (2)	4.00
H(1,C4)	0.635 (2)	0.760 (2)	0.238 (2)	4.00
H(1,C6)	-0.062 (2)	0.881 (2)	0.352 (2)	4.00
H(2,C6)	0.075 (2)	0.678 (2)	0.460 (2)	4.00
H(3,C6)	-0.029 (2)	0.652 (2)	0.333 (2)	4.00
H(1,C7)	0.259 (2)	0.789 (2)	0.537 (2)	4.00

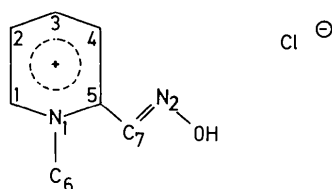


Fig. 2. Numbering of atoms in the title compound.

reflections. The maximum noise level in the final difference Fourier map was 0.15 e \AA^{-3} . Refined parameters are listed* in Table 2, the numbering of the atoms is given in Fig. 2.

Discussion. The (*E*) configuration is observed for the arrangement of substituents around the $\text{C}=\text{N}$ bond of the oxime moiety. It is of interest to note that the same configuration has been found by X-ray analysis in all other oximes (Van Havere *et al.*, 1982*a,b,c*; Carlström, 1966) with antidotal activity against intoxication with organophosphate anticholinesterases.

Bond distances, valence angles and selected torsion angles of the title compound are collected in Table 3, together with those of four other 2-

* Lists of structure factors and anisotropic thermal parameters have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 36880 (13 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

Table 3. Comparison of bond distances (\AA), valence angles ($^\circ$) and selected torsion angles ($^\circ$) in the title compound and in some other derivatives of 2-[(hydroxyimino)methyl]pyridinium salts

	E.s.d.'s are in parentheses.				
BPS:	1-benzyl-2-[(hydroxyimino)methyl]pyridinium	methane-sulphonate (Van Havere <i>et al.</i> , 1982 <i>a</i>).			
BPB:	1-benzyl-2-[(hydroxyimino)methyl]pyridinium	bromide (Van Havere <i>et al.</i> , 1982 <i>a</i>).			
MPI:	2-[(hydroxyimino)methyl]-1-methylpyridinium	iodide (Carlström, 1966).			
CPC:	4'-carbamoyl-2-[(hydroxyimino)methyl]-1,1'-[oxybis(methylene)]dipyridinium	dichloride monohydrate (Van Havere <i>et al.</i> , 1982 <i>c</i>).			
MPC:	title compound, this work.				
	MPC	BPS	BPB	CPC	MPI
N(1)-C(1)	1.352 (1)	1.351 (2)	1.341 (2)	1.327 (3)	1.34
C(1)-C(2)	1.357 (1)	1.345 (2)	1.353 (3)	1.364 (3)	1.36
C(2)-C(3)	1.377 (1)	1.370 (2)	1.361 (3)	1.378 (3)	1.40
C(3)-C(4)	1.365 (1)	1.370 (2)	1.351 (3)	1.340 (3)	1.41
C(4)-C(5)	1.386 (1)	1.361 (2)	1.392 (3)	1.385 (3)	1.38
C(5)-N(1)	1.352 (1)	1.365 (2)	1.349 (2)	1.388 (3)	1.36
N(1)-C(6)	1.474 (1)	1.492 (2)	1.484 (2)	1.491 (3)	1.50
C(5)-C(7)	1.460 (1)	1.472 (2)	1.454 (3)	1.434 (3)	1.47
C(7)-N(2)	1.274 (1)	1.271 (2)	1.279 (2)	1.286 (3)	1.33
N(2)-O	1.372 (1)	1.380 (1)	1.373 (2)	1.390 (2)	1.39
$\langle \text{Csp}^2\text{-H} \rangle$	0.94 (4)				
$\langle \text{Csp}^3\text{-H} \rangle$	0.94 (4)				
OH	0.924 (9)				
C(4)-C(5)-C(7)	122.30 (7)	122.3 (1)	122.2 (2)	124.8 (2)	122
C(5)-N(1)-C(1)	121.06 (6)	119.8 (1)	120.7 (2)	121.6 (2)	124
N(1)-C(1)-C(2)	121.53 (7)	121.5 (1)	120.7 (2)	122.8 (2)	120
C(1)-C(2)-C(3)	118.83 (7)	119.9 (2)	120.7 (2)	116.8 (2)	121
C(2)-C(3)-C(4)	119.28 (8)	118.2 (2)	118.3 (2)	120.6 (2)	118
C(3)-C(4)-C(5)	121.36 (7)	121.7 (2)	121.4 (2)	122.9 (2)	121
C(4)-C(5)-N(1)	117.90 (6)	118.7 (1)	118.2 (2)	115.2 (2)	118
N(1)-C(5)-C(7)	119.79 (6)	118.9 (1)	119.7 (2)	120.0 (2)	120
C(5)-C(7)-N(2)	116.96 (7)	116.1 (1)	116.8 (2)	116.5 (2)	115
C(7)-N(2)-O	111.77 (6)	110.7 (1)	112.5 (2)	112.3 (2)	109
C(1)-N(1)-C(6)	117.06 (6)	118.8 (1)	118.1 (2)	118.5 (2)	116
C(5)-N(1)-C(6)	121.88 (6)	121.3 (1)	121.2 (2)	120.0	120
N(2)=C(7)-C(5)-C(4)	-7.6 (1)	32.5 (4)	3.9 (5)	8.9 (5)	0
N(1)-C(1)-C(2)-C(3)	1.61 (1)	-2.34 (25)	1.0 (5)	2.6 (5)	0
C(1)-C(2)-C(3)-C(4)	-1.73 (1)	0.98 (30)	-0.6 (5)	-0.8 (5)	0
C(2)-C(3)-C(4)-C(5)	0.18 (1)	0.98 (42)	-0.4 (5)	-0.6 (5)	0
C(3)-C(4)-C(5)-N(1)	1.51 (1)	-1.67 (42)	1.1 (5)	0.4 (5)	0
C(4)-C(5)-N(1)-C(1)	-1.66 (1)	0.34 (42)	-0.7 (5)	1.4 (5)	0
C(5)-N(1)-C(1)-C(2)	0.12 (1)	1.63 (42)	-0.3 (5)	-3.0 (5)	0
C(1)-N(1)-C(6)-H(1,C6)	-91.3 (5)				
C(7)-N(2)-O-H(1,O)	178.5 (5)				

[(hydroxyimino)methyl]pyridinium derivatives for which data are available (see Table 3 for the abbreviations used in the further discussion).

Clearly, in the section C(1)-C(2)-C(3)-C(4)-C(5) a short-long-short-long pattern in bonded distances is visible, except in BPS and MPI. Such a pattern is consistent with π -localization as shown in Fig. 1.

The conclusion that π -localization can exist in these compounds is based on the high accuracy obtained with the title compound, on the internal consistency of the collected data and is corroborated by reasons for which BPS and MPI fail to display the effects of π -localization. The high accuracy shows itself in the high ratio reflections : parameters (18:1), the low R_w

value and the low e.s.d.'s. The latter values, however, may be underestimated. The presence of an iodide ion and the use of photographic data render the numerical results of MPI less reliable.

Internal consistency becomes apparent when comparing the bond lengths within the oxime moieties. Lack of reliable standard values for the section O–N(2)–C(7)–C(5) prevents the direct observation of the short–long–short pattern that should accompany the π -localization in the pyridinium ring. Indirectly, however, the pattern can be inferred because BPS, in which the localization is absent, has the longest O–N(2), the shortest N(2)–C(7) and the longest C(7)–C(5) bond. The absence of π -localization in the pyridinium ring of BPS is inferred from the torsion angle N(2)=C(7)–C(5)–C(4) (32.5°), which diminishes the possibility of resonance interaction between the pyridinium ring and the oxime moiety.

Some other geometrical features of the 2-pyridiniumcarbaldehyde oximes also attract attention. First, the valence angles C(7)–N(2)–O are small for angles at an sp^2 -hybridized centre. However, values in the range 110 – 113° are common in oximes. Secondly, the oxime moiety is planar, and N(1) with its direct environment shows no pyramidization. Thirdly, the pyridinium rings show a distortion from planarity as follows from the relevant torsion angles. The Cremer & Pople (1975) parameters (Table 4) reveal that this distortion is towards (twist-)boat (θ ca 90°) or sofa forms (θ ca 60°), rather than towards a chair form (θ ca 0°). A tendency to distort towards flexible forms was also noted in other perturbed aromatic rings, e.g. in 3,5-diacetyl-2,6-dimethylpyridine (Lenstra & Petit,

1980) and in 4-*tert*-butyl-3,5-dinitroanisole (Van Havere, Lenstra & Geise, 1982). It is understandable because the force constant to bend benzene into a boat form [$f(\text{boat}) = 0.4105$ aJ rad $^{-1}$] is smaller than the force constant [$f(\text{chair}) = 0.4894$ aJ rad $^{-1}$] to bend it to a chair form (Pulay, Fogarasi & Boggs, 1981).

The molecules of the title compound stack in almost perfect planes that are perpendicular to the y axis, with no apparent strong interactions between the planes. This explains the preferred cleavage of the crystals. Within the planes the molecules are linked through hydrogen bonds O–H...Cl $^-$ (Table 5). The crystal structure explains the high birefringence of the compound as was also indicated for MPI by Carlström (1966).

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Table 4. Cremer & Pople (1975) puckering parameters for the pyridinium rings

E.s.d.'s are calculated according to Norrestam (1981). For the designation of the compounds see Table 3.

	MPC	BPS	BPB	CPC	MPI
q_2 (Å)	0.020 (2)	0.020 (3)	0.011 (5)	0.019 (6)	0
q_3 (Å)	0.000 (2)	–0.003 (3)	0.000 (5)	0.009 (6)	0
Q (Å)	0.020 (2)	0.020 (3)	0.011 (5)	0.021 (6)	0
φ (°)	124.6 (5.2)	259.7 (8.0)	99.9 (23.4)	51.3 (17.5)	—
θ (°)	89.0 (5.3)	97.2 (8.1)	92.3 (24.0)	63.5 (15.2)	—

Table 5. Short OH...Cl interaction (A: acceptor, D: donor)

D–H	A	A at	D–H (Å)	A...H (Å)	D...A (Å)	D–H...A (°)
O–H(1,0)	Cl	1–x, 1–y, 1–z	0.92 (1)	2.07 (1)	2.989 (1)	172.6 (7)