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Structure of *N*-Cyano-*N'*,*N''*-dimethyl-*N'*-nitrosoguanidine, $C_4H_7N_5O$

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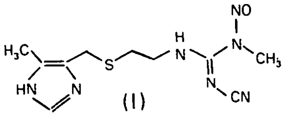
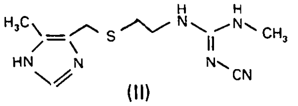
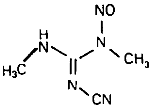
Abstract. $M_r = 141{\cdot}13$, *Pnma*, $a = 12{\cdot}152\ (4)$, $b = 6{\cdot}632\ (2)$, $c = 8{\cdot}346\ (3)$ Å, $V = 672{\cdot}6\ (4)$ Å^3, $Z = 4$, $D_m = 1{\cdot}38\ (1)$, $D_x = 1{\cdot}394$ g cm^{-3}, Cu $K\alpha$ ($K\alpha_1$, $\lambda = 1{\cdot}54050$ Å; $K\alpha_2$, $\lambda = 1{\cdot}54434$ Å), $\mu = 9{\cdot}1$ cm^{-1}, $T = 297$ K, $R = 0{\cdot}055$ for 466 reflections. The structure was determined by direct methods. The molecule lies on a mirror plane.

Introduction. Mutagens have been isolated from surgical samples of human stomach mucosal tissue (Stemmerman, Mower, Ichinotsubo, Tomiyasu, Mandel & Nomura, 1980). Some of these mutagens appear to be metabolites of the very drugs commonly used in preoperative treatment (Rice, Ichinotsubo, Stemmerman, Hayashi, Palumbo, Sylvester, Nomura & Mower, 1981). One of these mutagens is a nitrosated derivative (I) of the antiulcer drug cimetidine (II) and has a gross structure similar to that reported by Foster, Jarman & Mason (1980) and reconfirmed crystallographically (Prout, 1982) for synthetic mononitrosocimetidine nitrate salt. However, the mutagenic activity of the human metabolite is considerably greater (Ichinotsubo, MacKinnon, Liu, Rice & Mower, 1981) than that of the synthetic salt. When crystals of an analogue (III) of the human metabolite became available, this structure was determined.


(I)


(II)


(III)

Experimental. Crystals provided by Scott Rice and Howard F. Mower, Department of Biochemistry and Biophysics, University of Hawaii 96822. D_m from flotation in hexane/CCl_4 mixture. Clear yellow crystal $0{\cdot}22 \times 0{\cdot}14 \times 0{\cdot}12$ mm mounted along longest dimension in thin-walled capillary. Four-circle Syntex automated diffractometer with graphite monochromator. Lattice parameters by least-squares refinement of 15 reflections, widely placed in reciprocal space, with $2\theta < 19°$. Conditions for reflection: $0kl$, $k + l = 2n$; $hk0$, $h = 2n$. Absorption correction omitted. Diffraction intensities: all with $2\theta < 110°$, $h \geq 0$, $k \geq 0$, $l \geq 0$. Three standard reflections remeasured every 100 reflections varied < 3%; corrections for this and Lp (monochromator 50% mosaic) were made. All 466 reflections measured were used in refinement on F ($wR = 0{\cdot}065$). [For those 413 with $I > 2\sigma(I)$, $R = 0{\cdot}051$ and $wR = 0{\cdot}065$.] Solved by direct methods. H atoms located on difference Fourier and refined isotropically. $S = 4{\cdot}6$ with 78 parameters. Reflections weighted as $\sigma^{-2}(F_o)$; $\sigma(I) = [(\mathrm{CT} + B_1 + B_2)\omega^2 + (pI)^2]^{1/2}$, CT = total integrated count, B_1 and B_2 are background counts, total background/scan time ratio = 1·0, $I = \omega(\mathrm{CT} - B_1 - B_2)$, ω = scan rate = 0·5° (2θ) min^{-1}, $p = 0{\cdot}02$. In final full-matrix refinement cycle, each non-hydrogen shift < 0·1% of e.s.d., hydrogen shifts < 3·0%. Final difference Fourier, e.s.d. = 0·05 e Å^{-3}, $-0{\cdot}24 \leq$ peak height $\leq 0{\cdot}18$ e Å^{-3}, $F(000) = 296$. Scattering factors from *International Tables for X-ray Crystallography* (1974) for C(val), N^0, O^0 (p. 73), H (bonded) (p. 71); anomalous dispersion (p. 149). Computer programs: *LP*-76 (Ottersen, 1976); *MULTAN*80 (Main, Fiske, Hull, Lessinger, Germain, Declercq & Woolfson, 1980); *FMLS* (Gantzel, Sparks & Trueblood, 1964); *ALFF* (fast Fourier) (Hubbard, Quicksall & Jacobson, 1971); *ORTEP*II (Johnson, 1971); *ALDIST* (Trueblood, 1962); *MOLGE* (Wood, 1964).

E distribution indicated centrosymmetric space group. Later attempts to refine in $Pn2_1a$ showed (1) no atom significantly off mirror/molecular plane, (2) no overall decrease in β_{22} values, (3) no improvement in *R*'s, (4) poor convergence. $Pn2_1a$ was dismissed.

Discussion. Final parameters are in Table 1,* bond distances and angles in Table 2. Fig. 1 is a stereoview showing the numbering scheme. The dimensions of the molecule in the vicinity of the *N'*-nitroso group agree well with corresponding bond lengths and angles in other *N*-nitrosamines as shown in Table 3. The N—N bond distances lie between the single-bond [1·44 (4) Å]

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* Lists of structure factors and anisotropic thermal parameters have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 38437 (6 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Table 1. *Positional* (× 10^4, *for* H × 10^3) *and thermal parameters with e.s.d.'s*

For non-hydrogen atoms, the equivalent isotropic thermal parameters and their e.s.d.'s have been calculated (Cheng, Larson & Seff, 1982).

	x	y	z	B_{eq}/B (Å^2)
O(1)	3723 (2)	2500	3923 (4)	8·04 (8)
N(2)	2979 (3)	2500	4922 (4)	6·29 (8)
N(3)	1966 (2)	2500	4278 (4)	4·72 (6)
C(4)	1082 (3)	2500	5373 (4)	4·34 (8)
N(5)	116 (2)	2500	4696 (3)	4·82 (7)
C(6)	−822 (3)	2500	5463 (4)	4·60 (8)
N(7)	−1709 (3)	2500	5955 (5)	5·95 (8)
N(8)	1346 (3)	2500	6898 (4)	5·12 (7)
C(9)	572 (4)	2500	8224 (6)	6·58 (13)
C(10)	1793 (5)	2500	2540 (6)	6·26 (11)
H(8)	200 (4)	250	711 (5)	6 (1)
H(9*A*)	7 (3)	149 (6)	816 (4)	10 (1)
H(9*B*)	91 (5)	250	918 (8)	9 (2)
H(10*A*)	221 (3)	148 (6)	220 (5)	11 (1)
H(10*B*)	105 (6)	250	240 (8)	11 (2)

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

O(1)–N(2)	1·230 (4) Å	N(8)–H(8)	0·81 (5) Å
N(2)–N(3)	1·343 (4)	C(9)–H(9*A*)	0·91 (4)
N(3)–C(10)	1·465 (6)	C(9)–H(9*B*)	0·90 (7)
N(3)–C(4)	1·411 (4)	C(10)–H(10*A*)	0·89 (4)
C(4)–N(5)	1·302 (4)	C(10)–H(10*B*)	0·92 (7)
N(5)–C(6)	1·308 (5)		
C(6)–N(7)	1·153 (5)		
C(4)–N(8)	1·313 (5)		
N(8)–C(9)	1·452 (5)		
O(1)–N(2)–N(3)	113·7 (2)°	C(4)–N(8)–H(8)	117 (2)°
N(2)–N(3)–C(10)	121·9 (2)	C(9)–N(8)–H(8)	118 (2)
N(2)–N(3)–C(4)	116·0 (2)	N(8)–C(9)–H(9*A*)	113 (2)
C(10)–N(3)–C(4)	122·1 (2)	N(8)–C(9)–H(9*B*)	112 (2)
N(3)–C(4)–N(8)	116·2 (2)	H(9*A*)–C(9)–H(9*B*)	111 (4)
N(3)–C(4)–N(5)	113·9 (2)	H(9*A*)–C(9)–H(9*A*′)	95 (4)
N(8)–C(4)–N(5)	129·9 (2)	N(3)–C(10)–H(10*A*)	104 (3)
C(4)–N(8)–C(9)	125·5 (2)	N(3)–C(10)–H(10*B*)	106 (2)
C(4)–N(5)–C(6)	125·0 (2)	H(10*A*)–C(10)–H(10*B*)	121 (3)
N(5)–C(6)–N(7)	171·6 (4)	H(10*A*)–C(10)–H(10*A*′)	99 (5)

Table 3. N—N—O *geometry in N-nitrosamines*

Compound	N—O	N—N	N—N—O	References and notes
N-Cyano-*N*′,*N*″-dimethyl-*N*′-nitrosoguanidine	1·230 (4) Å	1·343 (4) Å	113·7 (2)°	This work
N-Nitrosocimetidinium nitrate	1·228 (4)	1·327 (5)	114·7 (3)	(1)
N-Nitrosodimethylamine	1·260 (6)	1·320 (6)	114·3 (3)	(2)
N-Nitrosodimethylamine	1·235 (2)	1·344 (2)	113·6 (2)	(3)
2-(*N*-Nitrosomethylamino)acetamide (*Z* form)	1·237 (4)	1·308 (3)	113·0 (3)	(4)
2-(*N*-Nitrosomethylamino)acetamide (*E* form)	1·223 (3)	1·328 (4)	113·0 (2)	(4)
1-(4-Chlorobenzyl)-1-nitroso-2-(4,5-dihydro-2-imidazolyl)hydrazine monohydrate	1·250 (14)	1·300 (14)	114·8 (11)	(5)
1-(2-Chloroethyl)-3-(*trans*-4-methylcyclohexyl)-1-nitrosourea	1·218 (4)	1·333 (4)	114·6 (3)	(6)
3-(*p*-Bromophenyl)-1-nitroso-2-pyrazoline	1·276 (15)	1·300 (16)	111·2 (12)	(7)
Dipotassium salt of methylenebis-(nitrosohydroxylamine)	1·323 (6)	1·297 (4)	110·2 (4)	(8)

References and notes: (1) Prout (1982). (2) Krebs & Mandt (1975) by single-crystal X-ray diffraction at 143 K. (3) Rademacher, Stølevik & Lüttke (1968) by gas-phase electron diffraction. (4) Templeton, Templeton & Zalkin (1973). The *Z* form has the nitroso O *trans* to the terminal methyl group, the *E* form *cis*. (5) Palenik (1965). (6) Smith, Camerman & Camerman (1978). (7) Sabesan & Venkatesan (1971). (8) Bryden (1959).

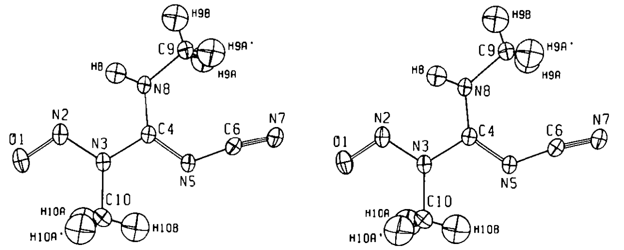

Fig. 1. A stereoview of the $C_4H_7N_5O$ molecule. Ellipsoids of 20% probability are shown (Johnson, 1971). All atoms except H(9*A*), H(9*A*′), H(10*A*), and H(10*A*′) are coplanar by symmetry. The formal (integral) order of each bond is shown.

and double-bond [1·24 (1) Å] values suggested for N—N (*International Tables*, 1968, p. 270), and are therefore of intermediate order.

The C—N bonds of the central guanidine moiety show two significantly different lengths. The C(4)—N(8) = 1·313 (5) and C(4)—N(5) = 1·302 (4) Å distances are about the same, both somewhat shorter than the C—N bond lengths of 1·34—1·35 Å in nitroguanidine (Bryden, Burkardt, Hughes & Donohue, 1956) and 1·32—1·33 Å in guanidinium chloride (Haas, Harris & Mills, 1965). The C(4)—N(3) = 1·411 (4) Å distance is much closer to the C—N single-bond value of 1·472 (5) Å (*International Tables*, 1968, p. 276). These distances are indicative of resonance, as has been discussed for nitroguanidine.

A comparison of the corresponding bond lengths in this molecule, $C_4H_7N_5O$, with those in *N*′-nitrosocimetidine (Prout, 1982) indicates a somewhat greater degree of aromaticity in $C_4H_7N_5O$. This can be seen in all bonds not involving H, the terminal methyl C atoms, and O(1), and most clearly in N(3)—C(4) and N(5)—C(6), relatively long bonds which are both longer yet by almost 0·02 Å in *N*′-nitrosocimetidine. This enhanced aromaticity may be present in human-derived nitrosated cimetidine and may be responsible, perhaps by increasing its ability to intercalate into DNA, for its greater mutagenic activity.

The planarity of $C_4H_7N_5O$ is typical of *N*-nitrosamines, and, together with the several bonds whose lengths indicate bond orders between one and two, shows appreciable aromaticity. The *N*-nitroso groups of the molecules presented in Table 3 all lie in the planes of at least their nearest neighboring atoms.

An in-plane intermolecular hydrogen bond is seen {N(7)–N(8) = 2·97 Å; N(8)–H(8)–N(7) = 147 (3)°; N(8)–H(8) = 0·81 (5) Å; H(8)–N(7) = 2·25 (4) Å [N(7) coordinates are related to those in Table 2 by $\frac{1}{2}+x,y,\frac{3}{2}-z$]}. A 2·18 Å intramolecular interaction occurs between H(8) and N(2). The O(1) through N(7) aromatic 'backbones' of the molecules stack along **b** with an interplanar spacing of $b/2 = 3{\cdot}316$ (1) Å, a distance indicative of a substantial charge-transfer interaction (see Fig. 2).

We are indebted to Scott Rice and Howard F. Mower for suggesting the problem and for valuable discussions, to Richard E. Marsh for discussions regarding the choice of space group, and to the University of Hawaii Computing Center.

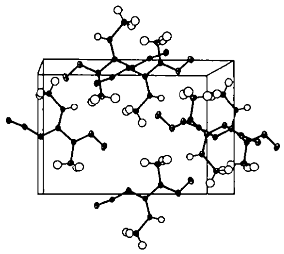
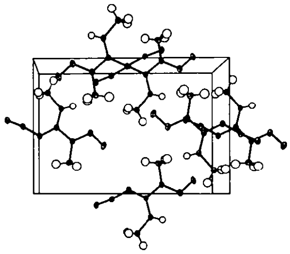

Fig. 2. A stereoview illustrating intermolecular interactions in the unit cell. Ellipsoids of 10% probability are shown (Johnson, 1971). The view is along the +**b** direction with +**a** horizontal to the right and +**c** vertical in the plane of the page.

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SHORT COMMUNICATION

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Acta Cryst. (1983). C**39**, 920

The low-temperature X-ray diffraction studies of the heptahydridobis(tertiaryphosphine)rhenium complexes, $[ReH_7\{P(C_3H_7)_2(C_6H_5)\}_2]$ and $[ReH_7\{P(C_6H_5)_3\}_2]$: erratum.

By Judith A. K. Howard, Kevin A. Mead and John L. Spencer, *Department of Inorganic Chemistry, University of Bristol, Bristol BS*8 1*TS, England*

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Abstract

A printer's error is corrected. In the *Abstract* of the paper by Howard, Mead & Spencer [*Acta Cryst.* (1983). C**39**, 555–559] the measurement temperature for crystal (II) is incorrect. The correct value is 200 K.

The *Abstract* contains all relevant information.

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