

Structure of the New Electrophilic Fluorinating Agent 1-Chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane Bis(tetrafluoroborate) and Two of its Monoquaternary Analogues

BY R. E. BANKS, I. SHARIF AND R. G. PRITCHARD*

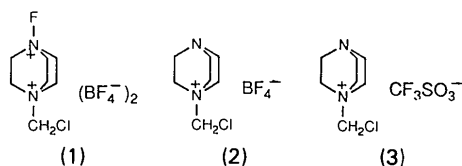
Department of Chemistry, University of Manchester Institute of Science and Technology, PO Box 88, Manchester M60 1QD, England

(Received 30 April 1992; accepted 10 August 1992)

Abstract. 1-Chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis(tetrafluoroborate) (1), $C_7H_{14}ClFN_2^+ \cdot 2BF_4^-$, $M_r = 354.26$, orthorhombic, $Pnma$, $a = 12.599$ (6), $b = 7.653$ (3), $c = 14.094$ (7) Å, $V = 1359$ (2) Å³, $Z = 4$, $D_x = 1.731$ Mg m⁻³, $\lambda(\text{Mo } K\alpha) = 0.71069$ Å, $\mu = 0.373$ mm⁻¹, $F(000) = 712$, $T = 293$ K, $R = 0.091$ (disordered tetrafluoroborate anions) for 500 unique reflexions [$I \geq 2\sigma(I)$] and 106 variables. 1-Chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane tetrafluoroborate (2), $C_7H_{14}ClN_2^+ \cdot BF_4^-$, $M_r = 248.46$, orthorhombic, $P2_12_12_1$, $a = 8.106$ (3), $b = 18.786$ (4), $c = 7.076$ (3) Å, $V = 1077.5$ (6) Å³, $Z = 4$, $D_x = 1.531$ Mg m⁻³, $\lambda(\text{Mo } K\alpha) = 0.71069$ Å, $\mu = 0.375$ mm⁻¹, $F(000) = 512$, $T = 293$ K, $R = 0.046$ for 813 unique reflexions [$I \geq 2\sigma(I)$] and 192 variables. 1-Chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane trifluoromethanesulfonate (3), $C_7H_{14}ClN_2^+ \cdot CF_3SO_3^-$, $M_r = 310.72$, orthorhombic, $Pnma$, $a = 19.877$ (7), $b = 8.769$ (3), $c = 7.138$ (2) Å, $V = 1244$ (1) Å³, $Z = 4$, $D_x = 1.659$ Mg m⁻³, $\lambda(\text{Mo } K\alpha) = 0.71069$ Å, $\mu = 0.50$ mm⁻¹, $F(000) = 640$, $T = 293$ K, $R = 0.064$ for 657 unique reflexions [$I \geq 2\sigma(I)$] and 97 variables. Monoquaternization of 1,4-diazabicyclo[2.2.2]octane expands the ring C—N bonds of the donor N atom (⁺NCH₂Cl) to 1.485 (8)–1.52 (1) Å compared to 1.445 (9)–1.454 (9) Å for the other bridgehead N atom. Subsequent fluorination of the latter N atom removes this asymmetry and contracts the bridgehead N...N distance from 2.56 (1), to 2.48 (2) Å. The ⁺N—F bond length of 1.37 (2) Å is significantly longer than found in $NF_4^+ \cdot BF_4^-$ [1.265 (9)–1.321 (10) Å; Christie, Lind, Thorup, Russell, Fawcett & Bau (1988). *Inorg. Chem.* **27**, 2450–2454].

Introduction. It has been known for some time that fluorine substituents can exert a profound influence on the activity and selectivity of bio-organic molecules; in fact, site-selective fluorination has become

a standard strategy in the incessant search for improved drugs and agrochemicals (Welch & Eswarakrishnan, 1991). Electrophilic fluorinating agents of the N—F class now feature prominently in the search for new selective fluorinating agents (Furin, 1989); this paper records a structural study of a member of the latest class to be discovered, namely 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis(tetrafluoroborate) (1) (Banks, Mohialdin-Khaffaf, Lal, Sharif & Syvret, 1992).[†] Given the current importance of the ⁺N—F group, it is surprising that structural information is so sparse: tetrafluoroammonium tetrafluoroborate, $NF_4^+ \cdot BF_4^-$ (Christie, Lind, Thorup, Russell, Fawcett & Bau 1988) is the only compound comparable to (1) for which an X-ray structure has been reported. Because of this, and a need to understand better the nature of ⁺N—F bonding in relation to 'F⁺' transfer mechanisms, structural parameters for two monoquaternary analogues, (2) and (3), of the *N*-fluoro compound (1) have also been determined.



Experimental. A mixture of sodium tetrafluoroborate (1.97 g, 17.9 mmol) and 1-chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane chloride (3.53 g, 17.9 mmol) (Almarzoqi, George & Isaacs, 1986) in HPLC-grade acetonitrile (40 cm³; Aldrich) was stirred overnight (an excessive period) at 293 K under nitrogen. The product was filtered to remove sodium chloride, which was washed with acetonitrile (20 cm³). Evaporation (at 313 K and 14 mm Hg) of the filtrate plus washings, followed by recrystalli-

[†] A Selectfluor[™] reagent now available commercially (Air Products and Chemicals, Inc., 7201 Hamilton Boulevard, Allentown, PA 18195-1501, USA).

* To whom correspondence should be addressed.

Table 1. *Experimental details*

	(1)	(2)	(3)
Crystal dimensions (mm)	0.4 × 0.2 × 0.2	0.4 × 0.4 × 0.2	0.4 × 0.3 × 0.2
Unit-cell reflexions 2θ range (°)	15.8–24.4	20.0–25.7	14.2–27.3
ω-scan width (°)	1.2 + 0.3tanθ	1.05 + 0.3tanθ	0.8 + 0.35tanθ
θ range (°)	0–25	0–25	0–24
No. of measured reflexions	1305	1153	1188
No. of unique reflexions	1305	1153	1167
No. of observed reflexions [<i>I</i> ≥ 2σ(<i>I</i>)]	500	813	657
<i>R</i> _{int}	—	—	0.016
Intensity standards	141, 401, 240	151, 060, 151	026, 222, 131
Absorption correction (azimuthal scan method) minimum, maximum transmission	0.97, 1.00	0.90, 1.00	Not applied
Decline (%)	2.20	0.92	1.27
<i>R</i>	0.091	0.046	0.064
<i>wR</i>	0.081	0.050	0.049
Maximum fluctuations in final Δ <i>F</i> map (e Å ⁻³)	–0.43, 0.37	–0.18, 0.38	–0.46, 0.36
Maximum Δ <i>σ</i>	0.01	0.004	0.004
No. of variables	106	192	97
<i>S</i>	2.56	1.85	2.81

zation of the pale-yellow residue from ethanol-diethyl ether, provided white 1-chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane tetrafluoroborate (2) (3.75 g, 15.1 mmol, 84%; analysis found C 34.1, H 5.9, BF₄ 34.8, N 11.4%; C₇H₁₄BClF₄N₂ requires C 33.8, H 5.6, BF₄ 35.0, N 11.3%), a white non-hygroscopic solid, m.p. 405 K, δ_F (TFA; solution in MeCN) –74.3 p.p.m. (*s*, BF₄[–]), δ_H (Me₄Si; solution in D₂O) 3.29 (*m*), 3.5 (*m*), 5.11 (*s*, CH₂Cl) p.p.m. (relative intensities 3:3:1; residual H in D₂O, 4.75 p.p.m.).

1-Chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane chloride (4.81 g, 24.4 mmol) was treated with lithium triflate (3.81 g, 24.4 mmol) in acetonitrile (45 cm³) exactly as described for the reaction involving sodium tetrafluoroborate above. The same work-up procedure gave 1-chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane triflate (3) (6.68 g, 21.5 mmol, 88%; analysis found C 30.7, H 4.2, F 18.5, N 8.7%; C₈H₁₄ClF₃N₂SO₃ requires C 30.9, H 4.5, F 18.4, N 9.0%), a white solid, m.p. (dec.) 425 K, δ_F (TFA; solution in D₂O) 0.1 (*s*, CF₃SO₃[–]) p.p.m., δ_H (same solution) 3.29 (*m*), 3.57 (*m*), 5.12 (*s*, CH₂Cl) p.p.m. (relative intensities 3:3:1; residual H in D₂O, 4.75 p.p.m.).

Treatment of a solution of 1-chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane tetrafluoroborate (2) (1.81 g, 7.28 mmol) and sodium tetrafluoroborate (0.80 g, 7.28 mmol) in dry acetonitrile (200 cm³) with neat fluorine [at *ca* 20 mm Hg in the apparatus described previously (Banks, Du Boisson, Morton & Tsiliopoulos, 1988)] until absorption of the halogen ceased (2 h), followed by evaporation of the filtered reaction mixture (to remove NaF), provided a white solid. This was washed with AnalaR acetone then dried *in vacuo*, to give 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis(tetrafluoroborate) (1) (2.15 g, 6.07 mmol, 83%; analysis found C 23.6, H 3.7, BF₄ 50.3, N 7.9%; C₇H₁₄B₂ClF₉N₂ requires C 23.7, H 3.95, BF₄ 49.1, N 7.9%), a white non-

Table 2. *Fractional coordinates and equivalent isotropic thermal parameters (Å²)*

$$B_{\text{eq}} = (8\pi^2/3) \sum_i \sum_j U_{ij} a_i^* a_j^* a_i a_j$$

Compound (1)	<i>x</i>	<i>y</i>	<i>z</i>	<i>B</i> _{eq}
Cl(1)	0.5095 (3)	↓	0.5273 (3)	5.8 (2)
F(1)	0.0703 (7)	↓	0.7362 (7)	8.5 (6)
N(1)	0.2977 (8)	↓	0.5539 (8)	3.4 (6)
N(2)	0.1501 (10)	↓	0.6700 (10)	5.2 (8)
C(1)	0.3847 (12)	↓	0.4787 (10)	5.1 (9)
C(2)	0.1928 (12)	↓	0.5038 (11)	4.5 (9)
C(3)	0.1034 (13)	↓	0.5740 (14)	8 (1)
C(4)	0.2143 (8)	0.4102 (14)	0.6830 (7)	5.2 (7)
C(5)	0.3054 (7)	0.4094 (14)	0.6158 (6)	4.4 (6)
B(11)	0.5397 (7)	0.2659 (25)	1.2379 (7)	5.7 (6)
F(11)	0.4974 (21)	0.3908 (33)	1.2952 (11)	4.5 (5)
F(12)	0.6471 (7)	0.2646 (65)	1.2479 (14)	7.7 (6)
F(13)	0.5144 (15)	0.3010 (28)	1.1461 (7)	5.7 (6)
F(14)	0.5000 (31)	0.1069 (26)	1.2625 (19)	11 (1)
B(12)	0.5416 (14)	0.2358 (34)	1.2328 (16)	5.7
F(15)	0.4553 (23)	0.1811 (55)	1.2825 (24)	6 (1)
F(16)	0.5524 (28)	0.1369 (60)	1.1532 (22)	6 (1)
F(17)	0.6300 (21)	0.2191 (68)	1.2874 (25)	6 (1)
F(18)	0.5289 (39)	0.4062 (37)	1.2079 (37)	11 (2)
B(21)	0.7965 (6)	0.2312 (19)	0.5792 (5)	5.5 (6)
F(21)	0.7503 (15)	0.3918 (21)	0.5814 (16)	9 (1)
F(22)	0.8698 (7)	0.2196 (33)	0.6498 (7)	6.4 (5)
F(23)	0.8449 (11)	0.2072 (32)	0.4940 (7)	8.7 (7)
F(24)	0.7212 (11)	0.1061 (25)	0.5918 (11)	3.3 (4)
B(22)	0.8148 (18)	0.2240 (35)	0.5499 (17)	5.5
F(25)	0.7736 (26)	0.2911 (53)	0.4685 (20)	7 (1)
F(26)	0.8927 (25)	0.1075 (40)	0.5282 (27)	5 (1)
F(27)	0.7370 (33)	0.1419 (53)	0.5997 (31)	12 (2)
F(28)	0.8562 (30)	0.3554 (45)	0.6033 (29)	6 (1)
Compound (2)				
Cl(1)	0.4623 (2)	0.0283 (1)	0.0064 (3)	5.55 (8)
N(1)	0.5005 (5)	0.1095 (2)	0.3200 (7)	3.3 (2)
N(2)	0.6820 (6)	0.2001 (2)	0.4923 (8)	4.2 (2)
C(1)	0.3903 (8)	0.0559 (4)	0.2293 (11)	4.3 (3)
C(2)	0.4251 (9)	0.1286 (4)	0.5070 (12)	4.9 (3)
C(3)	0.5434 (10)	0.1806 (4)	0.6120 (11)	5.1 (4)
C(4)	0.6192 (13)	0.2293 (4)	0.3169 (13)	5.6 (4)
C(5)	0.5176 (10)	0.1767 (3)	0.2056 (10)	4.2 (3)
C(6)	0.6706 (8)	0.0798 (3)	0.3568 (11)	3.9 (3)
C(7)	0.7770 (9)	0.1363 (4)	0.4508 (11)	4.6 (4)
F(1)	0.5062 (5)	0.4394 (2)	–0.0932 (6)	5.9 (2)
F(2)	0.6038 (6)	0.3912 (2)	0.1737 (6)	7.6 (2)
F(3)	0.5851 (7)	0.3270 (2)	–0.0890 (7)	8.8 (3)
F(4)	0.3592 (6)	0.3576 (4)	0.0615 (7)	10.3 (4)
B(1)	0.5117 (9)	0.3785 (3)	0.0137 (12)	4.2 (3)
Compound (3)				
Cl(1)	0.2562 (2)	↓	0.5169 (4)	4.3 (2)
N(1)	0.1560 (4)	↓	0.2624 (10)	1.9 (4)
N(2)	0.1221 (4)	↓	–0.0856 (12)	3.4 (5)
C(1)	0.1708 (5)	↓	0.4657 (14)	3.0 (6)
C(2)	0.0798 (5)	↓	0.2402 (17)	4.0 (7)
C(3)	0.0629 (6)	↓	0.0324 (17)	5.5 (8)
C(4)	0.1614 (4)	0.1163 (10)	–0.0408 (10)	4.7 (5)
C(5)	0.1831 (3)	0.1119 (8)	0.1685 (9)	2.9 (4)
S(1)	0.3854 (1)	↓	0.0751 (4)	2.8 (1)
F(1)	0.4811 (2)	0.1300 (5)	–0.1277 (6)	6.0 (3)
F(2)	0.4091 (3)	↓	–0.2839 (9)	6.1 (5)
O(1)	0.3477 (2)	0.1145 (6)	0.0472 (7)	4.8 (3)
O(2)	0.4290 (4)	↓	0.2316 (11)	6.2 (5)
C(6)	0.4428 (5)	↓	–0.1271 (17)	3.2 (7)

hygroscopic solid, m.p. (dec.) 493–497 K, δ_F (TFA; solution in D₂O) 126.5 (*br.s*, FN⁺), –72.0 (*s*, BF₄[–]) p.p.m. (relative intensities 1:8), δ_H (Me₄Si; same solution) 4.53 (*m*), 4.97 (*m*), 5.50 (*s*, CH₂Cl) p.p.m. (relative intensities 3:3:1; residual H in D₂O, 4.70 p.p.m.).

Details of individual data collections and processing are presented in Table 1.

A Rigaku AFC-6S diffractometer, with graphite-monochromated Mo *K*α radiation, was used for data

Table 3. Selected interatomic distances (Å), bond angles (°) and torsion angles (°)

	(1)	(2)	(3)
Cl(1)—C(1)	1.71 (2)	1.760 (8)	1.74 (1)
N(1)—C(1)	1.53 (2)	1.491 (7)	1.48 (1)
N(1)—C(2)	1.50 (2)	1.501 (9)	1.52 (1)
N(1)—C(5)	1.50 (1)	1.507 (7)	1.485 (8)
N(1)—C(6)	1.50 (1)	1.510 (7)	1.485 (8)
N(2)—C(3)	1.48 (2)	1.454 (9)	1.45 (1)
N(2)—C(4)	1.48 (1)	1.449 (9)	1.445 (9)
N(2)—C(7)	1.48 (1)	1.454 (8)	1.445 (9)
C(2)—C(3)	1.50 (2)	1.56 (1)	1.52 (1)
C(4)—C(5)	1.49 (1)	1.51 (1)	1.556 (9)
C(6)—C(7)	1.49 (1)	1.521 (9)	1.556 (9)
N(2)—F(1)	1.37 (2)	—	—
N(1)···N(2)	2.48 (2)	2.56 (1)	2.57 (1)
N(1)—C(1)—Cl(1)	112.5 (9)	112.7 (4)	113.6 (7)
C(1)—N(1)—C(2)	108 (1)	107.3 (5)	107.4 (8)
C(1)—N(1)—C(5)	110.9 (6)	113.0 (5)	111.7 (5)
C(1)—N(1)—C(6)	110.9 (6)	111.8 (4)	111.7 (5)
N(1)—C(2)—C(3)—N(2)	0	5.2 (8)	0
N(1)—C(5)—C(4)—N(2)	3 (1)	4 (1)	0.1 (9)
N(1)—C(6)—C(7)—N(2)	-3 (1)	4.7 (9)	-0.1 (9)

collection. Unit-cell dimensions were determined from setting angles of 20 accurately centred reflexions. Intensities were measured using ω - 2θ scans with ω -scan speed of 8° min^{-1} and up to two additional scans of weak reflexions [$I < 10\sigma(I)$]. Intensity standards were measured every 150 reflexions. Lp and decomposition corrections were applied. *MITHRIL* (Gilmore, 1984) was used to solve the phase problem. All non-H atoms were found in Fourier maps; H atoms were found from ΔF syntheses for (2), and placed in chemically reasonable positions for (1) and (3). Full-matrix least-squares refinements were based on F using *TEXSAN* crystallographic software (Molecular Structure Corporation, 1985), with weights $w = 1/[\sigma^2(F_o) + 0.03F_o^2]$, anisotropic thermal parameters for heavier atoms, and isotropic for H atoms. Disordered BF₄⁻ groups were represented by two partially populated tetrahedrally constrained BF₄⁻ groups in the fluorinated Dabco salt. Refinement with the opposite hand for (2) proved inconclusive. Scattering factors were taken from Cromer & Waber (1974). Computations were carried out on a Digital VAX station 3520. A literature survey was performed via the Cambridge Structural Database using the *Crystal Structure Search and Retrieval* interactive system (CSSR, 1984). Fractional atomic coordinates and vibrational parameters for the non-H atoms are represented in Table 2* and selected bond lengths and angles in Table 3. The cations of (1) and (2), including atomic labels, are displayed in Figs. 1 and 2.

* Lists of structure factors, bond distances and angles, H-atom coordinates and anisotropic vibrational parameters have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 55638 (35 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: AL1015]

Discussion. Of the three 1,4-diazabicyclo[2.2.2]octane derivatives studied, it is only in (2) that the molecules lie on general positions; in the other two compounds the barrel-shaped diazabicyclooctane moiety is bisected top-to-bottom by a crystallographic mirror plane. As a consequence, a twisting of the molecule seen in (2) is absent from the other two molecules; however, both situations are common, e.g. as in 1,4-dimethyl-1,4-diazoniabicyclo[2.2.2]octane salts (twist angle 5°) (Christoph & Goedken, 1973) and the parent diamine (twist angle 0°) (Weiss, Parkes, Nixon & Hughes 1964; Nimmo & Lucas, 1976; Sauvajol, 1980).

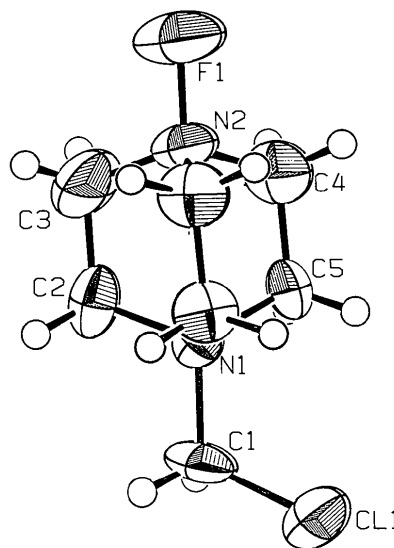


Fig. 1. 1-Chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane dication (1) drawn using ORTEPII (Johnson, 1976).

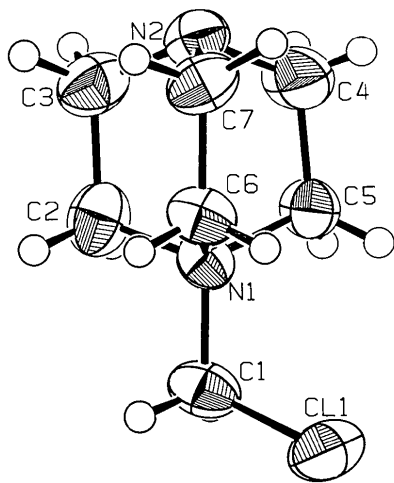
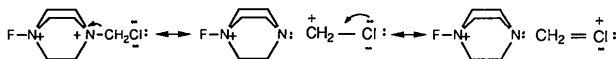


Fig. 2. 1-Chloromethyl-4-aza-1-azoniabicyclo[2.2.2]octane cation in the tetrafluoroborate salt (2). The atomic numbering in (3) follows a similar scheme.

Comparison of cations derived from monoquaternization of mono-substituted 1,4-diazabicyclo[2.2.2]octane with the diamine, itself in hydrogen-bonded complexes (Takama, Yasui, Harada, Kasai, Tanaka & Toda, 1988; Yasui, Yabuki, Takama, Harada, Kasai, Tanaka & Toda, 1989), shows that while the non-quaternized N-atom environment remains similar to that in the parent diamine, the bonds around the tetrahedrally coordinated N atom have lengthened significantly [1.485 (8)–1.52 (1) Å *cf.* 1.445 (9)–1.454 (9) Å at the amine N atom]. This change is accompanied by a contraction of some of the ring C—C bonds, so that the bridgehead N···N distances of 2.56 (1) and 2.57 (1) Å remain identical to that in 1,4-diazabicyclo[2.2.2]octane. On fluorination all N—C bonds become indistinguishable and the ring C—C distances are uniformly contracted; hence the bridgehead distance shortens to 2.48 (2) Å. The bond contraction that takes place when the amine becomes a dispositive cation is typical, although the bridgehead N···N distance shows some variation, with the value of 2.548 Å for the 1,4-dimethyl-1,4-diazoniabicyclo[2.2.2]octane dication matching that in the neutral non-quaternized amine, and the diprotonated species, like the *N*-fluoro salt (1), possessing a contracted N···N distance [to 2.475 (4) Å].

A further consequence of fluorination is a weakening of the $^+N-CH_2Cl$ bond [1.53 (2) Å *cf.* 1.491 (7) and 1.48 (1) Å], coupled with a shortening of the C—Cl bond [1.71 (2) Å *cf.* 1.760 (8) and 1.74 (1) Å], implying that partial donation of a Cl-atom lone pair is involved, as indicated by the resonance formulation below.



A decrease in electron density at the C atom of the CH_2Cl group once *N*-fluorination has occurred is

revealed by the 1H NMR spectral data: the protons of the CH_2Cl group in the *N*-fluoro compound (1) resonate *ca* 0.5 p.p.m. to lower field than those in the monoquaternary salt (2) (Banks, Fields, Khaffaf & Sharif, 1993).

References

- ALMARZOQI, B., GEORGE, A. V. & ISAACS, N. S. (1986). *Tetrahedron*, **42**, 601–607.
- BANKS, R. E., DU BOISSON, R. A., MORTON, W. D. & TSILIOPOULOS, E. (1988). *J. Chem. Soc. Perkin Trans. 1*, pp. 2805–2820.
- BANKS, R. E., FIELDS, R. E., KHAFFAF, S. N. & SHARIF, I. (1993). In preparation.
- BANKS, R. E., MOHIALDIN-KHAFFAF, S. N., LAL, G. S., SHARIF, I. & SYVRET, R. G. (1992). *J. Chem. Soc. Chem. Commun.* pp. 595–596.
- CHRISTIE, K. O., LIND, M. D., THORUP, N., RUSSELL, D. R., FAWCETT, J. & BAU, R. (1988). *Inorg. Chem.* **27**, 2450–2454.
- CHRISTOPH, G. G. & GOEDKEN, V. L. (1973). *J. Am. Chem. Soc.* **95**, 3869–3875.
- CROMER, D. T. & WABER, J. T. (1974). *International Tables for X-ray Crystallography*, Vol. IV, Table 2.2A. Birmingham: Kynoch Press. (Present distributor Kluwer Academic Publishers, Dordrecht.)
- CSSR (1984). *Crystal Structure Search and Retrieval Instruction Manual*. SERC Daresbury Laboratory, Warrington, England.
- FURIN, G. G. (1989). *New Fluorinating Agents in Organic Synthesis*, edited by L. GERMAN & S. ZEMSKOV, pp. 35–68. Berlin: Springer-Verlag.
- GILMORE, C. J. (1984). *J. Appl. Cryst.* **17**, 42–46.
- JOHNSON, C. K. (1976). *ORTEPII*. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.
- Molecular Structure Corporation (1985). *TEXSAN. TEXRAY Structure Analysis Package*. MSC, 3200A Research Forest Drive, The Woodlands, TX 77381, USA.
- NIMMO, J. K. & LUCAS, B. W. (1976). *Acta Cryst.* **B32**, 348–354.
- SAUVAJOL, J. L. (1980). *J. Phys. C*, **13**, L927–L934.
- TAKAMA, M., YASUI, M., HARADA, S., KASAI, N., TANAKA, K. & TODA, F. (1988). *Bull. Chem. Soc. Jpn.* **61**, 567–568.
- WEISS, G. S., PARKES, A. S., NIXON, E. R. & HUGHES, R. E. (1964). *J. Chem. Phys.* **41**, 3759–3767.
- WELCH, J. T. & ESWARAKRISHNAN, S. (1991). *Flourine in Bioorganic Chemistry*. New York: John Wiley.
- YASUI, M., YABUKI, T., TAKAMA, M., HARADA, S., KASAI, N., TANAKA, K. & TODA, F. (1989). *Bull. Chem. Soc. Jpn.* **62**, 1436–1445.

Acta Cryst. (1993). **C49**, 495–497

Structure of *N*-Acetyl-L-homocarnosine Monohydrate

BY JACQUELINE A. CAMPBELL, ANDREW A. FREER* AND DAVID J. ROBINS

Department of Chemistry, University of Glasgow, Glasgow G12 8QQ, Scotland

(Received 2 April 1992; accepted 26 August 1992)

Abstract. *N*-(4-Acetamido-1-oxobutyl)-L-histidine monohydrate, $C_{12}H_{18}N_4O_4 \cdot H_2O$, $M_r = 300.3$, ortho-

rhombic, $P2_12_1$, $a = 7.181$ (1), $b = 13.919$ (1), $c = 14.547$ (1) Å, $V = 1454.1$ Å³, $Z = 4$, $D_x = 1.37$ g cm⁻³, $\lambda(Cu K\alpha) = 1.5418$ Å, $\mu = 1.01$ cm⁻¹, $F(000) = 640$, $T = 291$ K, final $R = 0.038$ for 1486

* Author to whom correspondence should be addressed.