O(2)	−0.2099 (2)	0.6585 (1)	0.4961 (1)	4.52 (4)
N(3)	−0.1255 (2)	0.5132 (1)	0.3752 (1)	3.69 (3)
C(4)	−0.0230 (2)	0.4923 (2)	0.3019 (2)	3.68 (4)
O(4)	−0.0230 (2)	0.3836 (1)	0.2482 (1)	4.84 (4)
N(5)	0.0847 (2)	0.5710 (2)	0.2736 (1)	4.20 (4)
C(6)	0.0815 (2)	0.6769 (2)	0.3308 (2)	3.64 (4)
O(6)	0.1922 (2)	0.7574 (1)	0.3013 (1)	4.87 (4)
C(20)	−0.3366 (3)	0.5766 (3)	0.5114 (2)	4.96 (6)
C(40)	−0.1362 (3)	0.2932 (2)	0.2749 (3)	5.47 (7)
N(61)	0.1964 (2)	0.8680 (1)	0.3617 (2)	4.11 (4)
C(62)	0.1031 (2)	0.9674 (2)	0.3307 (2)	3.96 (4)
O(62)	0.0052 (2)	0.9650 (2)	0.2557 (1)	5.66 (5)
C(63)	0.1486 (2)	1.0710 (2)	0.4100 (2)	4.52 (5)
C(64)	0.2723 (3)	1.0190 (3)	0.4898 (2)	5.79 (7)
C(65)	0.2956 (2)	0.8853 (2)	0.4546 (2)	4.96 (5)
O(65)	0.3776 (2)	0.8060 (2)	0.4949 (2)	7.73 (7)

Table 2. *Selected geometric parameters* (Å, °)

C(2)—O(2)	1.314 (2)	C(6)—O(6)	1.373 (2)
C(4)—O(4)	1.326 (2)	C(6)—N(61)	1.383 (2)
C(2)—O(2)—C(20)	118.2 (2)	C(6)—O(6)—N(61)	113.2 (2)
C(4)—O(4)—C(40)	116.9 (2)		
N(1)—C(6)—O(6)—N(61)	2.4 (2)	N(3)—C(2)—O(2)—C(20)	−6.2 (2)
C(6)—O(6)—N(61)—C(62)	−83.9 (2)	N(3)—C(4)—O(4)—C(40)	−0.6 (3)

Structure solution and refinement were performed using the *SHELXTL* (Sheldrick, 1990) program package on a PS-2 computer.

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Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: VS1011). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Geneserine Hydrochloride

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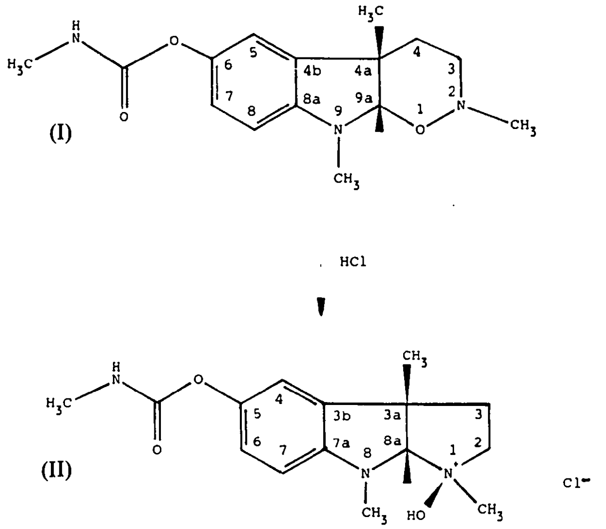
Abstract

An experimental procedure to obtain single crystals of geneserine hydrochlorode, 1,2,3,3a,8,8a-hexahydro-1,3a,8-trimethylpyrrolo[2,3-*b*]indol-5-ol methylcarbamate *N*-oxide hydrochloride (IUPAC system: 5-methylcarbamoyloxy-1,2,3,3a,8,8a-hexahydro-1-hydroxy-1,3a,8-trimethylpyrrolo[2,3-*b*]indol-1-ium chloride), is described. The structure of the compound has been determined by X-ray diffraction: it crystallizes in the triclinic space group $P1$ and the unit cell contains two independent $C_{15}H_{22}N_3O_3^+$ cations, two independent Cl^- anions and a single water molecule. The conformations of the two cations are described; a comparison of their geometries shows no significant differences. The crystal packing is characterized by a network of hydrogen bonds giving stacks of corrugated layers.

Comment

Geneserine {(−)-2,3,4,4a,9,9a-hexahydro-2,4aα,9α-trimethyl-1,2-oxazino[6,5-*b*]indol-6-ol methylcarbamate ester} (I) is an alkaloid which was first isolated from the basic extracts of Calabar bean seeds (Polonovsky, 1915) and later obtained from physostigmine by oxidation with H_2O_2 (Polonovsky, 1917). The structure for geneserine with a *cis*-fused tetrahydro-1,2-oxazine ring [instead of the *N*-oxide structure postulated by Polonovsky (1925)] was established unambiguously by Hootele′ (1969) and independently supported by ^{1}H NMR analysis using nuclear Overhauser effect measurements (Robinson & Moorcroft, 1970). Since the absolute configuration at the indoline C4 was already known (Hill & Newkome, 1969; Pauling & Petcher, 1973), the absolute stereochemistry of the alkaloid was determined to be 4a*S*,9a*S*. Total synthesis of the racemic form of (I) was reported by Shisido, Hiroya, Komatsu, Fukumoto & Kametani (1986, 1987) and Wright, Shulkind, Jones & Thompson (1987). Like other members of this class, geneserine inhibits acetylcholinesterase activity (Brufani, Marta & Pomponi, 1986; Brufani *et al.*, 1987; Marta *et al.*, 1988; De Sarno, Pomponi, Giacobini, Tang & Williams, 1989); the renewed therapeutic interest in these compounds arises from their potential use in the treatment of Alzheimer's disease. Although it is reported that geneserine 'does not form crystalline salts with mineral acids' (*The Merck Index*, 1989), we were able to convert geneserine quantitatively, prepared according to Polonovsky (1917) with minor modifications, into its hydrochloride salt. Evidence of the crystalline nature of the salt came initially from microscopic investigation and from a powder diffraction pattern, which shows very sharp peaks (Redenti, 1993, unpublished results). According to Yu, Yeh, Brossi & Flippen-Anderson (1989), who determined the structure of the HCl salt of geneseroline by X-ray analysis, the *cis*-fused ring of the salt of geneserine adopts the *N*-oxide five-membered-ring conformation (II) rather than the six-membered 1,2-oxazine form found for (I).


(I)

(II)

Single crystals of the title compound were grown from an ethyl acetate solution under a nitrogen atmosphere and their structure was determined by X-ray diffraction. The compound crystallizes in the triclinic $P1$ space group and the unit cell contains two independent cations (*A* and *B*) with the same absolute configuration at the asymmetric centres: C3(*S*), C4(*S*) and N1(*R*). Perspective views of the two cations are shown in Fig. 1; for the sake of clarity we have chosen to number the atoms progressively which is different to the IUPAC numbering shown in the scheme above.

In each cation the two *cis*-fused five-membered rings C3, C4, N2, C5, C6 and C1, C2, C3, C4, N1 of the pyrrolo[2,3-*b*]indole molecular nucleus show very different conformations: the former is planar to within 0.11 Å, while the latter has an envelope conformation, with C2 lying at 0.57 Å from the C1-C3-C4-N1 plane. The folding angle of the envelope is 141.2 (4) for *A* and 142.2 (4)° for *B*. The geneserine residue can therefore be described by three planes: plane 1 C1-C3-C4-N1 (maximum deviation 0.05 Å in *A* and 0.06 Å in *B*); plane 2 C3-C4-N2-C5-C6-C7-C8-C9-C10 (maximum deviation 0.16 for *A* and 0.14 Å for *B*); plane 3 C8-O2-C11-O3-N3-C12 (maximum deviation 0.03 for *A* and 0.05 Å for *B*). The angles between these planes are: $1\wedge2$ 104.5 (2) in *A* and 104.4 (2)° in *B*; $2\wedge3$ 107.4 (2) in *A* and 104.7 (2)° in *B*. So far eight compounds which contain the system of three fused rings like that of geneserine have been structurally characterized (Cambridge Structural Database, 1989); in all cases the indole moiety is found to be essentially planar. The dihedral angles formed by the indole moiety with the approximately planar part of the pyrrolidine ring are similar to those found for residue cations *A* and *B*, while the conformation of the ring varies considerably from case to case [see, for instance, (1S,5S)-geneseroline (Yu, Yeh, Brossi & Flippen-Anderson, 1989)].

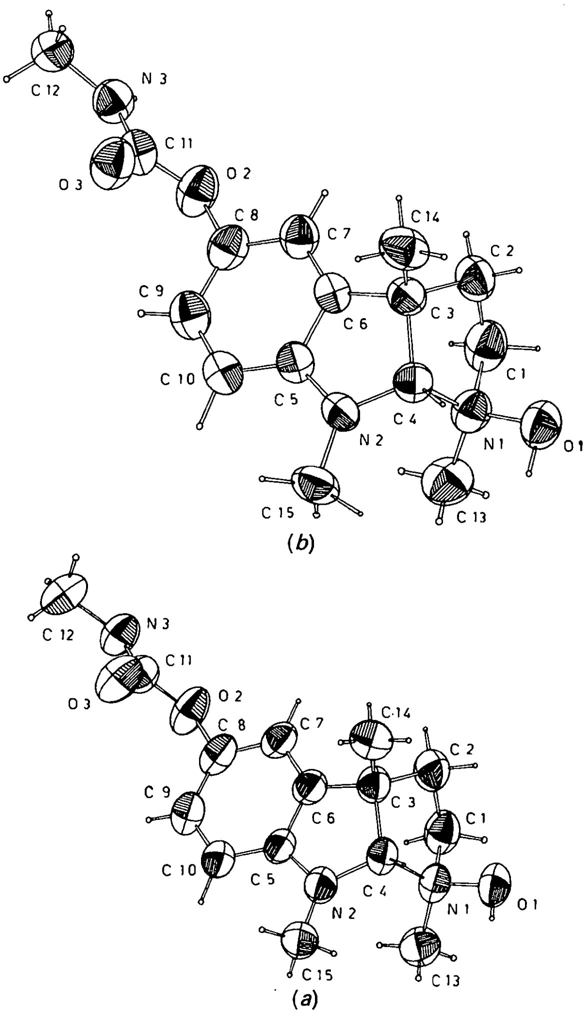


Fig. 1. *ORTEP* (Johnson, 1965) view of (*a*) residue *A* and (*b*) residue *B*, with 50% probability displacement ellipsoids.

The geometric parameters of cations *A* and *B* have been compared by a half-normal probability plot analysis (Abrahams & Keve, 1971) of the interatomic distances less than 4.650 Å between non-H atoms (this value should account for bond distances, bond angles and torsion angles); the resulting best regression line $y = 2.90(7)x - 0.40(7)$ (correlation coefficient = 0.967) indicates a substantial conformational similarity for the two cations but suggests the presence of systematic error (intercept $\neq 0$) and of underestimation of standard deviations (slope $\gg 1$). Residues *A* and *B* can be overlapped almost perfectly by rotating *A* around a pseudo-2_1 non-crystallographic screw axis nearly parallel to *a*, the sum of square deviations between corresponding atoms being 0.09 Å^2. The molecular packing shown in Fig. 2 is based on the hydrogen bonds given in Table 3. The hydrogen bonds generate $(A\cdots Cl2\cdots B\cdots Cl1)_n$ chains along the **a** direction; these chains are bridged by the water molecules hydrogen bonded to the Cl atoms, giving two-dimensional corrugated layers lying in the $(01\bar{1})$ planes. The shortest intralayer contacts between *A* and *B* are: O3*A*···C1*B* 3.270 (9) and C13*A*···O3*B*($x + 1, y, z$) 3.331 (9) Å. The minimum distance between different layers is C2*A*···O3*A*($x, y, z + 1$) 3.297 (8) Å; residue *B* seems not to exert a relevant steric influence on the stacking of the layers: the minimum *B*···*B* distance is C12*B*···C14*B*($x, y, z + 1$) 3.916 (9) Å while the minimum interlayer *A*···*B* distance is C10*B*···N3*A*($x - 1, y, z + 1$) 3.536 (6) Å.

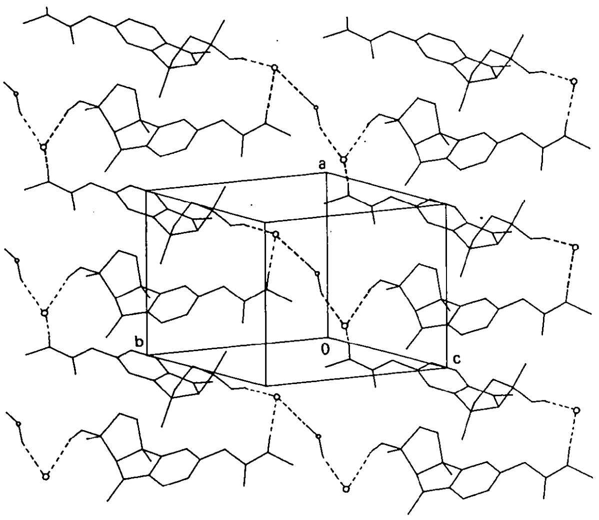


Fig. 2. Crystal packing showing hydrogen bonds.

Experimental

To a stirred solution of physostigmine (3.6 mmol) in acetone (15 ml) and phosphate buffer (pH 7.2, 15 ml), 35% hydrogen peroxide (10 ml) was added. The solution was stirred for 16 h at room temperature and acetone was evaporated under vacuum. The aqueous solution was extracted with chloroform and the organic layer was evaporated under vacuum. The residue was purified by flash chromatography (chloroform/methanol/acetic acid 90/8/2, silica gel 32-63). The resulting oil was dissolved in diethyl ether (20 ml), washed with saturated aqueous $NaHCO_3$ and dried with Na_2SO_4. The solution was acidified with HCl (diethyl ether solution) and evaporated under vacuum. The resulting solid foam solution was dissolved in acetone (4 ml), diethyl ether was added and the solution was stirred for 1 h at room temperature. The crystalline white solid was filtered and dried at room temperature, yield 71%; m.p. 425-427 K; $[\alpha]_D = -166°$.

A Buchi apparatus was used for melting point determination. $[\alpha]_D$ was measured at room temperature on a Perkin-Elmer 241 automatic polarimeter using a 10 cm cell path in water (c = 1.02%). The IR spectrum was measured using a KBr disk on a model 297 Perkin-Elmer spectrometer. The ^{1}H spectrum was obtained at 200.13 MHz in $CDCl_3$ on a Bruker ACF 200 spectrometer. Tetramethylsilane was used as an internal standard. IR: 1730 cm^{-1} (C=O carbamate). ^{1}H NMR: 1.6 (*s*, 3H, $\underline{CH_3}$—C3a), 2.3 (*dd*, $^2J = -12.5$ Hz, 1H, H3′), 2.7 (*dt*, $^2J = -12.5$ Hz, 1H, H3), 2.90 (*d*, J = 7 Hz, 3H, $\underline{CH_3}$—NHCO), 2.95 (*dt*, $^2J = -11$ Hz, 1H, H2′), 3.32 (*s*, 3H, CH_3—N8), 3.55 (*s*, 3H, CH_3—N1), 3.95 (*dd*, $^2J = -11$ Hz, 1H, H2), 5.10 (*br*, 1H, N—H), 5.85 (*s*, 1H, H8a), 6.6 (*d*, J_{ortho} = 8.2 Hz, 1H, H7), 6.9 (*d*, J_{meta} = 2.3 Hz, 1H, H4), 7.0 (*dd*, J_{ortho} = 8.2 Hz, J_{meta} = 2.3 Hz, 1H, H6), 13.1 (*br*, 1H, O—H).

Crystal data

$C_{15}H_{22}N_3O_3^+.Cl^-.0.5H_2O$
$M_r = 336.82$
Triclinic
$P1$
$a = 10.230$ (3) Å
$b = 9.858$ (3) Å
$c = 9.761$ (3) Å
$\alpha = 108.39$ (4)°
$\beta = 72.85$ (2)°
$\gamma = 83.00$ (3)°
$V = 867.1$ (5) Å^3
$Z = 2$

$D_x = 1.290$ Mg m^{-3}
Cu $K\alpha$ radiation
$\lambda = 1.54178$ Å
Cell parameters from 24 reflections
$\theta = 9.76-17.05°$
$\mu = 2.119$ mm^{-1}
$T = 293$ (2) K
Irregular prisms
0.40 × 0.15 × 0.10 mm
Colourless

Data collection

Siemens AED diffractometer
$\omega/2\theta$ scans
Absorption correction: empirical [*ABSORB*; Ugozzoli (1987), according to Walker & Stuart (1983)]
$T_{min} = 0.834$, $T_{max} = 1.189$
3274 measured reflections
3274 independent reflections

2222 observed reflections [$I > 2\sigma(I)$]
$\theta_{max} = 69.85°$
$h = -12 \rightarrow 5$
$k = -12 \rightarrow 11$
$l = -11 \rightarrow 8$
1 standard reflection monitored every 50 reflections
intensity variation: none

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)] = 0.0457$
$wR(F^2) = 0.1237$
$S = 1.059$
3274 reflections
421 parameters
$w = 1/[\sigma^2(F_o^2)+(0.0794P)^2]$ where $P = (F_o^2+2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.14$
$\Delta\rho_{max} = 0.27$ e Å^{-3}
$\Delta\rho_{min} = -0.33$ e Å^{-3}

Extinction correction: none
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8, 6.1.1.4)
Absolute configuration: Flack parameter = 0.01 (2)

Table 1. *Fractional atomic coordinates and equivalent isotropic displacement parameters* (Å^2)

$$U_{eq} = (1/3)\Sigma_i\Sigma_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	U_{eq}
N1A	−0.1984 (5)	−1.4651 (5)	−0.1557 (5)	0.0603 (9)
N2A	−0.2957 (5)	−1.4982 (4)	−0.3703 (5)	0.0591 (10)
N3A	−0.0861 (5)	−0.9610 (5)	−0.7587 (5)	0.0643 (10)
O1A	−0.2598 (5)	−1.4719 (5)	−0.0078 (4)	0.0748 (10)
O2A	−0.0869 (4)	−1.1125 (5)	−0.6320 (5)	0.0753 (10)
O3A	−0.2621 (5)	−1.0787 (5)	−0.7228 (5)	0.0820 (11)
C1A	−0.1300 (6)	−1.3379 (7)	−0.1286 (7)	0.077 (2)
C2A	−0.2485 (7)	−1.2069 (6)	−0.0835 (6)	0.0733 (15)
C3A	−0.3292 (5)	−1.2582 (5)	−0.1919 (6)	0.0557 (11)
C4A	−0.3237 (5)	−1.4224 (5)	−0.2122 (6)	0.0543 (10)
C5A	−0.2417 (5)	−1.4161 (5)	−0.4565 (6)	0.0546 (10)
C6A	−0.2545 (5)	−1.2717 (6)	−0.3564 (6)	0.0527 (10)
C7A	−0.2061 (6)	−1.1721 (6)	−0.4160 (6)	0.0600 (11)
C8A	−0.1457 (5)	−1.2121 (6)	−0.5738 (6)	0.0629 (12)
C9A	−0.1354 (6)	−1.3548 (7)	−0.6736 (6)	0.0699 (13)
C10A	−0.1841 (6)	−1.4554 (6)	−0.6157 (6)	0.0675 (13)
C11A	−0.1541 (6)	−1.0523 (6)	−0.7069 (6)	0.0601 (11)
C12A	−0.1416 (7)	−0.8786 (6)	−0.8360 (6)	0.0710 (13)
C13A	−0.0922 (6)	−1.6078 (7)	−0.2626 (8)	0.083 (2)
C14A	−0.4785 (6)	−1.1620 (6)	−0.1286 (7)	0.0767 (15)
C15A	−0.3167 (7)	−1.6451 (6)	−0.4363 (7)	0.0724 (14)
N1B	−0.6168 (5)	−1.1239 (5)	−0.5858 (5)	0.0643 (10)
N2B	−0.8308 (5)	−1.1010 (5)	−0.3614 (5)	0.0659 (11)
N3B	−0.6766 (5)	−1.6982 (5)	−0.0562 (6)	0.0742 (12)
O1B	−0.6067 (5)	−1.1161 (5)	−0.7314 (5)	0.0821 (11)
O2B	−0.6583 (4)	−1.5248 (5)	−0.1529 (5)	0.0848 (12)
O3B	−0.8715 (5)	−1.5740 (5)	−0.0687 (6)	0.0901 (12)
C1B	−0.5031 (6)	−1.2532 (7)	−0.6207 (7)	0.0770 (15)
C2B	−0.5606 (6)	−1.3842 (7)	−0.6719 (7)	0.0749 (14)
C3B	−0.7156 (5)	−1.3373 (6)	−0.5589 (6)	0.0618 (12)
C4B	−0.7632 (5)	−1.1706 (6)	−0.5241 (6)	0.0612 (12)
C5B	−0.8033 (5)	−1.1958 (5)	−0.2890 (6)	0.0589 (11)
C6B	−0.7282 (5)	−1.3356 (6)	−0.3997 (6)	0.0586 (11)
C7B	−0.6849 (5)	−1.4473 (6)	−0.3540 (7)	0.0650 (13)
C8B	−0.7162 (6)	−1.4165 (6)	−0.1980 (7)	0.0698 (14)
C9B	−0.7918 (6)	−1.2798 (7)	−0.0880 (7)	0.0711 (14)
C10B	−0.8374 (6)	−1.1675 (6)	−0.1324 (6)	0.0650 (12)
C11B	−0.7470 (6)	−1.5995 (6)	−0.0903 (6)	0.0652 (12)
C12B	−0.7462 (8)	−1.7850 (7)	0.0229 (9)	0.094 (2)
C13B	−0.6014 (7)	−0.9835 (7)	−0.4831 (7)	0.080 (2)
C14B	−0.8084 (7)	−1.4255 (7)	−0.6229 (8)	0.0786 (15)
C15B	−0.9382 (6)	−0.9632 (6)	−0.2861 (7)	0.0715 (14)
Cl1	−0.8393†	−0.8555†	−0.6381†	0.0859 (4)
Cl2	−0.3530 (2)	−1.7563 (2)	−0.0652 (3)	0.0900 (5)
O1W	−0.5212 (6)	−0.7494 (6)	−0.7091 (6)	0.112 (2)

† Coordinate fixed to define origin.

Table 2. *Selected geometric parameters* (Å, °)

N1A—O1A	1.422 (5)	N1B—O1B	1.422 (5)
N1A—C1A	1.498 (7)	N1B—C1B	1.491 (7)
N1A—C13A	1.510 (7)	N1B—C13B	1.489 (7)
N1A—C4A	1.599 (6)	N1B—C4B	1.621 (6)
N2A—C5A	1.390 (6)	N2B—C5B	1.386 (6)
N2A—C4A	1.407 (6)	N2B—C4B	1.421 (7)
N2A—C15A	1.458 (6)	N2B—C15B	1.457 (7)
N3A—C11A	1.334 (6)	N3B—C11B	1.324 (7)
N3A—C12A	1.442 (7)	N3B—C12B	1.440 (7)
O2A—C11A	1.353 (6)	O2B—C11B	1.364 (6)
O2A—C8A	1.394 (6)	O2B—C8B	1.407 (6)
O3A—C11A	1.208 (6)	O3B—C11B	1.208 (7)
C1A—C2A	1.508 (8)	C1B—C2B	1.489 (8)
C2A—C3A	1.528 (7)	C2B—C3B	1.552 (7)
C3A—C6A	1.516 (7)	C3B—C6B	1.516 (7)
C3A—C14A	1.528 (7)	C3B—C14B	1.503 (8)
C3A—C4A	1.559 (6)	C3B—C4B	1.552 (7)
C5A—C10A	1.392 (7)	C5B—C10B	1.389 (7)
C5A—C6A	1.414 (7)	C5B—C6B	1.404 (7)
C6A—C7A	1.363 (7)	C6B—C7B	1.384 (7)
C7A—C8A	1.381 (7)	C7B—C8B	1.383 (8)
C8A—C9A	1.406 (8)	C8B—C9B	1.382 (8)
C9A—C10A	1.363 (7)	C9B—C10B	1.389 (7)
O1A—N1A—C1A	105.3 (4)	O1B—N1B—C1B	105.3 (4)
O1A—N1A—C13A	109.6 (4)	O1B—N1B—C13B	109.9 (4)
C1A—N1A—C13A	111.6 (4)	C1B—N1B—C13B	113.1 (4)
O1A—N1A—C4A	107.6 (3)	O1B—N1B—C4B	106.1 (4)
C1A—N1A—C4A	107.1 (4)	C1B—N1B—C4B	105.5 (4)
C13A—N1A—C4A	115.1 (4)	C13B—N1B—C4B	116.1 (4)
C5A—N2A—C4A	111.0 (4)	C5B—N2B—C4B	110.6 (4)
C5A—N2A—C15A	124.2 (4)	C5B—N2B—C15B	124.4 (4)
C4A—N2A—C15A	124.8 (4)	C4B—N2B—C15B	123.6 (4)
C11A—N3A—C12A	121.2 (5)	C11B—N3B—C12B	121.9 (5)
C11A—O2A—C8A	117.3 (4)	C11B—O2B—C8B	117.3 (4)
N1A—C1A—C2A	103.5 (4)	N1B—C1B—C2B	105.3 (5)
C1A—C2A—C3A	105.0 (4)	C1B—C2B—C3B	104.1 (4)
C6A—C3A—C2A	114.3 (4)	C6B—C3B—C2B	112.9 (4)
C6A—C3A—C14A	110.3 (4)	C6B—C3B—C14B	111.4 (4)
C2A—C3A—C14A	111.8 (4)	C2B—C3B—C14B	112.8 (5)
C6A—C3A—C4A	101.6 (4)	C6B—C3B—C4B	101.1 (4)
C2A—C3A—C4A	104.6 (4)	C2B—C3B—C4B	105.0 (4)
C14A—C3A—C4A	113.8 (4)	C14B—C3B—C4B	112.9 (4)
N2A—C4A—C3A	105.7 (4)	N2B—C4B—C3B	106.6 (4)
N2A—C4A—N1A	113.9 (4)	N2B—C4B—N1B	112.1 (4)
C3A—C4A—N1A	103.4 (3)	C3B—C4B—N1B	103.6 (4)
N2A—C5A—C10A	130.1 (4)	N2B—C5B—C10B	129.1 (5)
N2A—C5A—C6A	109.7 (4)	N2B—C5B—C6B	110.0 (4)
C10A—C5A—C6A	120.2 (4)	C10B—C5B—C6B	120.9 (4)
C7A—C6A—C5A	119.9 (4)	C7B—C6B—C5B	120.2 (5)
C7A—C6A—C3A	131.6 (4)	C7B—C6B—C3B	130.4 (5)
C5A—C6A—C3A	108.5 (4)	C5B—C6B—C3B	109.3 (4)
C6A—C7A—C8A	119.9 (5)	C6B—C7B—C8B	118.3 (5)
C7A—C8A—C9A	120.3 (5)	C7B—C8B—C9B	122.0 (5)
C7A—C8A—O2A	119.0 (5)	C7B—C8B—O2B	118.1 (5)
C9A—C8A—O2A	120.5 (5)	C9B—C8B—O2B	119.8 (5)
C10A—C9A—C8A	120.4 (5)	C10B—C9B—C8B	120.3 (5)
C9A—C10A—C5A	119.2 (5)	C9B—C10B—C5B	118.3 (5)
O3A—C11A—N3A	125.3 (5)	O3B—C11B—N3B	127.0 (5)
O3A—C11A—O2A	123.4 (5)	O3B—C11B—O2B	123.1 (5)
N3A—C11A—O2A	111.3 (4)	N3B—C11B—O2B	109.9 (5)

Table 3. *Hydrogen-bonding geometry* (Å, °)

D	H	A	$D\cdots A$	D—H$\cdots A$
O1A	H1A	Cl2	3.009 (5)	
O1B	H1B	Cl1	2.974 (5)	
N3A	H3A	Cl1^{i}	3.234 (5)	
N3B	H3B	Cl2	3.260 (6)	
O1W	H1W	Cl1	3.481 (6)	153 (4)
O1W	H2W	Cl2^{ii}	3.368 (7)	151 (4)

Symmetry codes: (i) $x + 1, y, z$; (ii) $x, y + 1, z - 1$.

The X-ray structure was solved and refined with standard procedures. After the last isotropic refinement the empirical absorption correction of Walker & Stuart (1983) was applied on F. All non-H atoms were refined anisotropically. H atoms were introduced at calculated positions except those belonging to the water molecule, which were localized by a ΔF map and refined. The correct absolute configuration has been determined by calculating the Flack (1983) parameter using the *SHELXL92* (Sheldrick, 1992) method.

Calculations were performed on ENCORE-GOULD-6040 POWERNODE and ENCORE 91 computers of the Centro di Studio per la Strutturistica Diffrattometrica del CNR (Parma). Program(s) used to solve structure: *SHELXS86* (Sheldrick, 1985). Program(s) used to refine structure: *SHELXL92* (Sheldrick, 1992). Molecular graphics: *ORTEP* (Johnson, 1965) and *PLUTO* (Motherwell & Clegg, 1976). Software used to prepare material for publication: *PARST* (Nardelli, 1983), *ABRAHAMS* (Gilli, 1977).

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: MU1071). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Hydrogen-Bonded Trimers of Methyl 4-Trifluoromethylpyrazole-3-carboxylate Solvated by Chloroform

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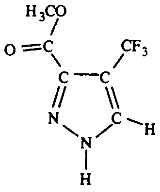
Abstract

The title compound, $C_6H_5F_3N_2O_2.\frac{1}{6}CHCl_3$, crystallizes from chloroform with three molecules of the ester and half a disordered chloroform molecule in the asymmetric unit. The three ester molecules form a hydrogen-bonded trimer *via* a cyclic arrangement of three N1—H···N2 hydrogen bonds. Corresponding bond lengths in all three molecules are similar.

Comment

The title pyrazole derivative (I) along with the 3- and 5-carbomethoxy isomers of 1-methyl-4-trifluoropyrazole are formed by the reaction of diazomethane and 4,4,4-trifluorobut-1-ynoic acid (Tajammal, 1988, 1991; Tajammal & Tipping, 1990). After chromatographic separation of the mixture of pyrazole derivatives, the title compound was recrystallized from chloroform, which supplies one solvate molecule for every six pyrazole molecules.



(I)

In the absence of 1-substitution, the N—H group at position 1 is available for hydrogen bonding and the novel trimerization seen in Fig. 1 occurs. The similar bond lengths in the pyrazole rings of the three molecules are in the range of lengths observed in 1-substituted pyrazoles (Beagley, Brown, Pritchard, Tajammal & Tipping, 1994). The N1···N2 distances for the three hydrogen bonds are N11···N32 = 2.902 (5), N21···N12 = 2.874 (6) and N31···N22 = 2.964 (5) Å. The third of these is significantly longer than the other two and is associated with a short N1 to carbonyl O atom distance,