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Ethoxycarbonylcholine Picrate Hemihydrate

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(*Received* 11 *January* 1994; *accepted* 16 *March* 1994)

Abstract

The ethoxycarbonylcholine ion in the title compound ($C_8H_{18}NO_3^+.C_6H_2N_3O_7^-.0.5H_2O$) adopts a partly folded conformation with C—O—C—C and O—C—C—N torsion angles of ±174.59 (7) and ∓83.60 (9)°, respectively. The carbonyl C atom has a partial positive charge, and electrostatic interactions are observed between this C atom and the nitro groups of the picrate ion. Interactions between the quaternary ammonium group and the O atoms of the ester group may be described as (CH···O) hydrogen bonds. Each phenolate O atom is involved in a hydrogen bond with a water molecule, forming a picrate–water–picrate linkage. The water molecule is situated on a twofold axis.

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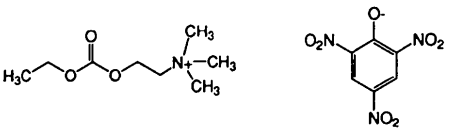
Comment

Acetylcholine is a neurotransmitter in the cholinergic nervous system. Therefore, acetylcholine and its derivatives have been extensively studied to improve our understanding of the function of the cholinergic nervous system. Crystallographic studies of salts of acetylcholine and related compounds (Jensen, 1984) have been performed in order to analyse the conformations of the compounds and their intermolecular contacts. These contacts may be related to the interactions which occur at the receptor site. The crystal structure of ethoxycarbonylcholine picrate hemihydrate (ETCOPI) has been examined as a part of these studies.



The ethoxycarbonylcholine ion adopts the favoured *gauche* conformation (Jensen, 1984) with the O—C—C—N torsion angle ∓83.60 (9)°. The ethoxycarbonyl moiety adopts an extended conformation with all of the chain torsion angles approximately 180° (Table 2).

The conformation of the picrate ion is very similar to that found in the crystal structure of methoxycarbonylcholine picrate hemihydrate (MECOPI; Frydenvang, Grønborg & Jensen, 1988). O262, O21 and O221 are displaced from the best plane through the benzene ring. O21 is on one side of the plane and the other two O atoms are on the opposite side. The planes of two nitro groups are tilted with respect to the benzene ring, in such a way as to relieve the strain around the phenolate O atom, O21 (Table 2). The third nitro group (N24) is nearly in the plane of the benzene ring. This pattern is in agreement with what is observed for many of the picrate salts found in the Cambridge Structural Database (Version 5.05, April 1993; Allen *et al.*, 1991). Deviations of the atoms from the best plane through the benzene ring are shown in Fig. 1(*b*).

A stereoview of the crystal packing of ETCOPI is shown in Fig. 2. The structure is isomorphous with that of MECOPI and the crystal packing is very similar (see Frydenvang, Grønborg & Jensen, 1988). The phenolate O atom is involved in a hydrogen bond to the water molecule, forming a picrate–water–picrate linkage. The water molecule is situated on a twofold axis. Electrostatic interactions are observed between the carbonyl C atom of the ethoxycarbonyl moiety and two nitro groups of the picrate ions [C2···O222 3.045 (1) and C2···O261 ($x+1, y, z$) 3.053 (1) Å]. The carbonyl C atom has a partial positive charge and O222 approaches the carbonyl group from one side of the planar moiety, and O261 from the opposite side. Furthermore, close contacts are observed between the quaternary ammonium

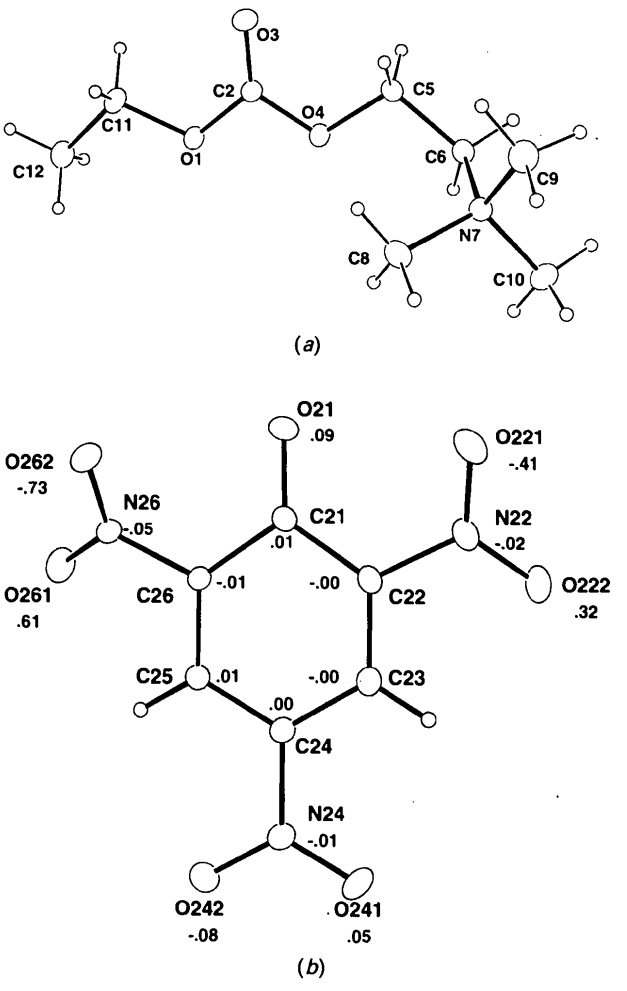


Fig. 1. *ORTEP*II (Johnson, 1976) drawing of (*a*) ethoxycarbonylcholine and (*b*) picrate. The two ions are shown with the atomic labelling. Non-H atoms are represented by displacement ellipsoids at the 50% probability level. Numbers refer to atom displacements from the best plane through the benzene ring (Å).

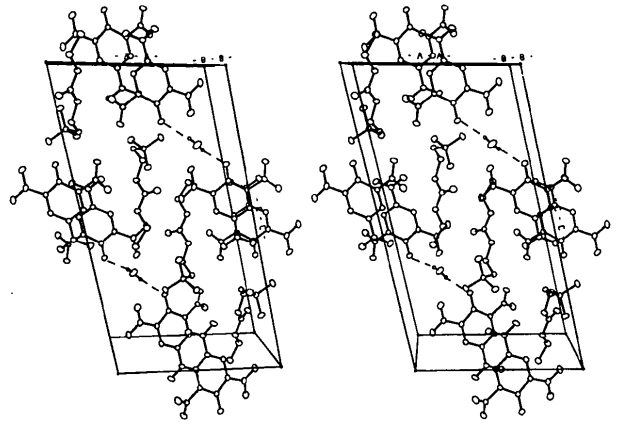


Fig. 2. Stereoview of ETCOPI showing the crystal packing, with *a* horizontal, *c* vertical and *b* into the plane of the paper. Dashed lines indicate hydrogen bonds.

group and different O atoms [*e.g.* C8···O3($x, y+1, z$) 3.102 (1) Å]. These contacts may be described as hydrogen bonds (C—H···O) (details deposited). During the analysis of the structure of MECOPI it was known from preliminary studies that the crystal structures of ETCOPI and MECOPI should be isomorphous. Some calculations were performed in order to estimate the distance for the interionic contacts between the picrate ion and the extra C atom in the ethoxycarbonylcholine ion. The ethoxycarbonylcholine ion was assumed to have the ethoxycarbonyl moiety in an extended conformation. Using the unit-cell dimensions of MECOPI, the distance was calculated to be 2.73 Å. The *a* axis was found to be approximately 0.3 Å longer in the unit cell of ETCOPI and it was expected, therefore, that sufficient room should be present for the assumed conformation. The distance C12···O242($x+1, y, z$) has now been found to be 3.240 (1) Å and the expected extended conformation has been confirmed. The nitro groups of the picrate ion are tilted, slightly differently in the two structures (Table 2), and the contacts observed in the crystal packing of ETCOPI are all longer than those observed in the packing of MECOPI.

Experimental

Ethoxycarbonylcholine picrate was prepared from ethoxycarbonylcholine iodide and picric acid (Sigma Chemical Company) dissolved in hot ethanol [in accord with *Pharmacopoea Nordica, Editio Danica* (1963)]. Single crystals, melting point 388–390 K, were obtained by slow cooling of a hot ethanol solution.

Crystal data

$C_8H_{18}NO_3^+.C_6H_2N_3O_7^-.0.5H_2O$
$M_r = 413.35$
Monoclinic
$P2/n$
$a = 11.623\ (3)$ Å
$b = 7.432\ (2)$ Å
$c = 21.197\ (5)$ Å
$\beta = 102.86\ (2)°$
$V = 1785.1\ (8)$ Å^3
$Z = 4$
$D_x = 1.538$ Mg m^{-3}
Mo $K\alpha$ radiation
$\lambda = 0.71073$ Å
Cell parameters from 20 reflections
$\theta = 16.64–22.05°$
$\mu = 0.133$ mm^{-1}
$T = 105\ (2)$ K
Needles
0.30 × 0.25 × 0.20 mm
Yellow

Data collection

Enraf–Nonius CAD-4 diffractometer
Profile data from $\omega/2\theta$ scans
Absorption correction: none
15033 measured reflections
10364 independent reflections
8028 observed reflections [$I > 2\sigma(I)$]
$R_{int} = 0.010$
$\theta_{max} = 38.96°$
$h = -20 \rightarrow 20$
$k = 0 \rightarrow 13$
$l = 0 \rightarrow 37$
5 standard reflections
frequency: 166 min
intensity variation: 0.5%

Refinement

Refinement on F^2
$R(F) = 0.0458$
$wR(F^2) = 0.1073$
$S = 1.096$
10340 reflections
321 parameters
Only coordinates of H atoms refined
$w = 1/[\sigma^2(F_o^2) + (0.0486P)^2 + 0.5810P]$
where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.125$
$\Delta\rho_{max} = 0.563$ e Å^{-3}
$\Delta\rho_{min} = -0.310$ e Å^{-3}
Extinction correction: none
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

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}
C12	0.72773 (9)	0.1457 (1)	0.58765 (4)	0.0192 (2)
C11	0.64002 (8)	0.1154 (1)	0.52487 (4)	0.0182 (2)
O1	0.66793 (6)	0.23929 (9)	0.47713 (3)	0.0157 (1)
C2	0.60276 (7)	0.2142 (1)	0.41765 (4)	0.0135 (1)
O3	0.53192 (6)	0.0959 (1)	0.40046 (3)	0.0191 (1)
O4	0.63013 (6)	0.34367 (9)	0.37971 (3)	0.0153 (1)
C5	0.56825 (8)	0.3305 (1)	0.31244 (4)	0.0145 (1)
C6	0.59953 (7)	0.4947 (1)	0.27776 (4)	0.0133 (1)
N7	0.52781 (6)	0.6615 (1)	0.28283 (3)	0.0130 (1)
C9	0.40504 (8)	0.6401 (1)	0.24266 (5)	0.0190 (2)
C10	0.58457 (9)	0.8179 (1)	0.25668 (5)	0.0197 (2)
C8	0.52281 (9)	0.7017 (1)	0.35149 (4)	0.0196 (2)
C21	0.08136 (7)	0.2310 (1)	0.37701 (4)	0.0129 (1)
C22	0.18049 (7)	0.3097 (1)	0.42361 (4)	0.0133 (1)
C23	0.18016 (7)	0.3445 (1)	0.48747 (4)	0.0138 (1)
C24	0.08024 (7)	0.3042 (1)	0.51062 (4)	0.0134 (1)
C25	−0.01992 (7)	0.2295 (1)	0.47045 (4)	0.0129 (1)
C26	−0.01887 (7)	0.1983 (1)	0.40689 (4)	0.0121 (1)
O21	0.08129 (6)	0.1882 (1)	0.32038 (3)	0.0188 (1)
N22	0.28822 (6)	0.3580 (1)	0.40341 (4)	0.0159 (1)
O221	0.28382 (7)	0.3812 (1)	0.34528 (4)	0.0243 (2)
O222	0.37919 (6)	0.3785 (1)	0.44544 (4)	0.0243 (2)
N24	0.07930 (7)	0.3412 (1)	0.57698 (3)	0.0159 (1)
O241	0.16975 (7)	0.3995 (1)	0.61295 (3)	0.0228 (1)
O242	−0.01223 (7)	0.3136 (1)	0.59560 (3)	0.0255 (2)
N26	−0.12732 (6)	0.1250 (1)	0.36712 (3)	0.0138 (1)
O261	−0.18295 (6)	0.0141 (1)	0.39189 (4)	0.0210 (1)
O262	−0.16004 (6)	0.1783 (1)	0.31133 (3)	0.0234 (2)
O8	1/4	0.0356 (2)	1/4	0.0272 (2)
H8	0.283 (2)	0.101 (3)	0.231 (1)	

Table 2. *Bond lengths* (Å), *bond angles* (°), *selected torsion angles* (°), *interplanar angles* (°) *and hydrogen-bond dimensions* (Å, °)

Ethoxycarbonylcholine

C12—C11	1.502 (1)	O1—C11—C12	107.95 (7)
C11—O1	1.457 (1)	C2—O1—C11	113.67 (7)
O1—C2	1.332 (1)	O3—C2—O1	126.52 (8)
C2—O3	1.204 (1)	O3—C2—O4	125.57 (8)
C2—O4	1.337 (1)	O1—C2—O4	107.92 (7)
O4—C5	1.450 (1)	C2—O4—C5	114.23 (7)
C5—C6	1.510 (1)	O4—C5—C6	107.67 (7)
C6—N7	1.511 (1)	C5—C6—N7	115.59 (7)
N7—C8	1.499 (1)	C6—N7—C8	111.94 (7)
N7—C9	1.499 (1)	C6—N7—C9	110.04 (7)
N7—C10	1.502 (1)	C6—N7—C10	108.30 (7)
		C9—N7—C8	109.58 (7)
		C8—N7—C10	108.62 (7)
		C9—N7—C10	108.28 (7)

Picrate

O21—C21	1.242 (1)		
C21—C22	1.463 (1)	C21—C26	1.465 (1)
C22—C23	1.379 (1)	C26—C25	1.370 (1)
C23—C24	1.390 (1)	C25—C24	1.396 (1)
C22—N22	1.456 (1)	C26—N26	1.457 (1)
N22—O221	1.234 (1)	N26—O262	1.225 (1)
N22—O222	1.231 (1)	N26—O261	1.235 (1)
N24—O241	1.232 (1)	N24—O242	1.232 (1)
C24—N24	1.436 (1)		
C26—C21—C22	110.92 (7)		
O21—C21—C22	125.90 (8)	O21—C21—C26	123.10 (8)
C23—C22—C21	124.34 (7)	C25—C26—C21	125.39 (7)
C22—C23—C24	119.42 (8)	C26—C25—C24	118.61 (7)
C23—C24—C25	121.28 (7)		
C21—C22—N22	119.99 (7)	C21—C26—N26	118.73 (7)
C23—C22—N22	115.66 (7)	C25—C26—N26	115.88 (7)
C22—N22—O221	118.76 (8)	C26—N26—O262	118.73 (7)
C22—N22—O222	118.30 (8)	C26—N26—O261	118.10 (7)
O221—N22—O222	122.92 (8)	O261—N26—O262	123.17 (8)
C23—C24—N24	119.58 (7)	C25—C24—N24	119.14 (7)
C24—N24—O241	118.84 (8)	C24—N24—O242	118.52 (7)
O241—N24—O242	122.64 (8)		

Torsion angles

C12—C11—O1—C2	174.21 (8)	O4—C5—C6—N7	−83.60 (9)
C11—O1—C2—O4	175.33 (7)	C5—C6—N7—C8	49.93 (9)
O1—C2—O4—C5	178.17 (7)	C5—C6—N7—C9	−72.17 (9)
C2—O4—C5—C6	174.59 (7)	C5—C6—N7—C10	169.65 (7)

Interplanar angles

Plane 1: C21, C22, C23, C24, C25, C26. Plane 2: C22, N22, O221, O222. Plane 4: C24, N24, O241, O242. Plane 6: C26, N26, O261, O262.

	ETCOPI	MECOPI
1^2	13.73 (4)	26.4
1^4	3.35 (5)	4.3
1^6	38.28 (4)	34.7

Hydrogen-bond dimensions

D—H···A	D—H	H···A	D···A	D—H···A
O8^{i}—H8^{i}···O21	0.78 (2)	2.21 (2)	2.942 (1)	157 (2)

Symmetry code: (i) $\frac{1}{2} - x, y, \frac{1}{2} - z$.

Data reduction: Blessing (1987). Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1985). Program(s) used to refine structure: *SHELXL*93 (Sheldrick, 1993). Molecular graphics: *ORTEP*II (Johnson, 1976).

PharmaBiotec is acknowledged for financial support.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: AB1157). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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