

Fig. 3. Liaison hydrogène (distances en Å) dans la *N*-(phényl-1 éthyl)-acétamide.

toutes les molécules ont des configurations identiques et on passe d'une file à l'autre à l'aide d'axes hélicoïdaux. Dans le composé étudié ici, deux files contiguës se déduisent par un centre de symétrie.

La structure cristalline de la *N*-(phényl-1 éthyl)-isobutyramide racémique montre que les molécules homochirales sont associées par liaisons hydrogène en files parallèles à l'axe *b*. La disposition des cycles aromatiques ne laisse prévoir l'existence d'aucune interaction du type 'stacking'. Deux molécules énantiomères n'échangent entre elles que des interactions du type van der Waals.

Acta Cryst. (1980). B36, 99–102

Stereochemistry of Anticholinergic Agents.

XIII.* Structure of (Dicyclohexylacetoxyethyl)triethylammonium Iodide

BY THOMAS A. HAMOR

Department of Chemistry, University of Birmingham, Birmingham B15 2TT, England

(Received 27 July 1979; accepted 1 September 1979)

Abstract

$C_{22}H_{42}NO_2^+ \cdot I^-$ is orthorhombic, space group *Pbca*, with $a = 10.00$ (1), $b = 46.28$ (3), $c = 10.31$ (1) Å, $Z = 8$. The final $R = 7.84\%$ for 812 observed counter amplitudes. C, N and O atoms were assigned isotropic, the I^- ion anisotropic, temperature factors. The acetylcholine-like moiety of the cation has an unusual

Il semble donc que la cristallisation du racémique est principalement conditionnée par des raisons d'empilement stérique des molécules au sein de la maille cristalline. On peut d'ailleurs signaler que la recherche d'éventuelles interactions stéréosélectives entre molécules homo- ou hétérochirales en solution par spectroscopie infrarouge et résonance magnétique nucléaire protonique n'a donné aucun résultat positif (résultats non publiés). Il est alors probable que les agrégats homochiraux par liaison hydrogène présents dans le cristal se forment lors du processus même de cristallisation.

Ce travail a été supporté financièrement par l'Action thématique programmée N° 3322 'Structures chirales 1977' du CNRS.

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geometry, with the C(=O)–O–C–C grouping synclinal, and O–C–C–N⁺ antiplanar.

Introduction

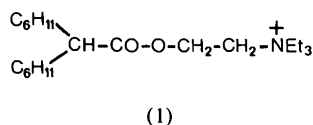
Many derivatives of acetylcholine incorporating ring substituents in the acyl group and larger groups on the N atom act as competitive antagonists of acetylcholine at the parasympathetic postganglionic receptor (Bar-

* Part XII: Chananont & Hamor (1978).

low, 1964). The title compound has an anticholinergic activity of ca 30% of that of hyosine ethiodide (Barlow, Franks, Pearson & Butt, 1972); it differs from other anticholinergic substances of this general type, whose crystal structures have been determined, in that neither of the two ring substituents in the acyl group is aromatic in character.

Experimental

Small irregular crystals were obtained from 2-butanone. The space group and preliminary lattice constants were obtained from photographs (Cu $K\alpha$ radiation). The intensities of the reflexions fell off rapidly with increasing Bragg angle and it became clear that they would be of poor quality. However, as the main interest in this structure lay in the overall conformation of the cation (1) rather than in its precise dimensions, it was decided to proceed with the analysis.



Intensities and final lattice parameters were measured with a Stoe two-circle computer-controlled diffractometer and graphite-monochromated Mo $K\alpha$ radiation, $\lambda = 0.71069 \text{ \AA}$, by the ω -scan technique. With the crystal set up about x , reflexions were scanned in the range $0.10 < \sin \theta/\lambda < 0.54 \text{ \AA}^{-1}$ and of these, 812, with $I > 2.5 \sigma(I)$, were used in the analysis. The scan rate was $0.6^\circ \text{ min}^{-1}$ and 30 s background counts were taken at each end of the scan.

Crystal data

$\text{C}_{22}\text{H}_{42}\text{NO}_2^+ \cdot \text{I}^-$, $M_r = 479.5$, orthorhombic, $a = 10.00 (1)$, $b = 46.28 (3)$, $c = 10.31 (1) \text{ \AA}$, $U = 4771 \text{ \AA}^3$, $Z = 8$, $D_c = 1.335 \text{ Mg m}^{-3}$, $F(000) = 2000$; systematic absences: $0kl$, k odd; $h0l$, l odd; $hk0$, h odd; space group $Pbca$; Mo $K\alpha$ radiation, $\mu(\text{Mo } K\alpha) = 1.248 \text{ mm}^{-1}$.

Determination of the structure

The structure was solved by Patterson and Fourier methods and refined by full-matrix least squares. The I^- ion was allowed to vibrate anisotropically but the lighter atoms (C, N and O) were refined with isotropic temperature factors. H atoms were not considered. In the final cycle all calculated shifts were $< 0.2\sigma$ and R was 7.84% for the 812 observed amplitudes.* The

* A list of structure factors has been deposited with the British Library Lending Division as Supplementary Publication No. SUP 34787 (6 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

weighting scheme was $w = 1/\sigma^2(F)$ where $\sigma(F)$ is the standard deviation in the observed amplitudes based on counting statistics. The final atomic coordinates and thermal parameters are listed in Table 1.

Computations were carried out on the Birmingham University ICL 1906A computer with *SHELX* (Sheldrick, 1975).

Results and discussion

The conformation of the cation and the atom numbering are shown in Fig. 1. Table 2 contains molecular

Table 1. Fractional atomic coordinates ($\times 10^4$) and temperature factors ($\times 10^3$)

	x	y	z	$U (\text{\AA}^2)$
C(1)	2807 (26)	576 (5)	7297 (28)	43 (8)
C(2)	4027 (26)	367 (5)	7330 (26)	43 (8)
C(3)	3744 (27)	94 (5)	8195 (27)	50 (9)
C(4)	3460 (27)	189 (5)	9606 (27)	55 (9)
C(5)	2146 (24)	402 (5)	9599 (25)	43 (8)
C(6)	2465 (28)	681 (6)	8735 (29)	50 (8)
C(7)	3761 (22)	808 (5)	5224 (27)	42 (7)
C(8)	4191 (33)	1115 (6)	4667 (36)	88 (12)
C(9)	4943 (44)	1054 (5)	3275 (28)	74 (9)
C(10)	4058 (31)	869 (7)	2304 (31)	70 (9)
C(11)	3707 (36)	573 (7)	2976 (29)	74 (10)
C(12)	2906 (26)	630 (6)	4275 (27)	50 (9)
C(13)	3211 (23)	870 (5)	6585 (23)	32 (7)
C(14)	1978 (28)	1047 (6)	6500 (27)	45 (8)
C(15)	1059 (26)	1516 (6)	6947 (26)	46 (8)
C(16)	1073 (31)	1652 (6)	5531 (28)	53 (10)
C(17)	177 (37)	1992 (7)	4010 (25)	69 (9)
C(18)	-966 (34)	2210 (7)	3691 (30)	68 (10)
C(19)	171 (41)	2126 (6)	6386 (27)	70 (10)
C(20)	1449 (38)	2267 (8)	6385 (34)	85 (11)
C(21)	-1429 (31)	1742 (7)	5649 (28)	53 (10)
C(22)	-1681 (36)	1490 (8)	4740 (43)	111 (13)
N	-64 (27)	1885 (4)	5393 (17)	57 (6)
O(1)	2171 (18)	1314 (4)	6951 (17)	56 (6)
O(2)	901 (19)	971 (4)	6032 (17)	54 (5)
I	-114 (2)	3048 (0.4)	5144 (2)	*

* Anisotropic temperature factors:

U_{11}	U_{22}	U_{33}	U_{12}	U_{13}	U_{23}
79 (1)	71 (1)	61 (1)	7 (2)	-8 (2)	9 (2)

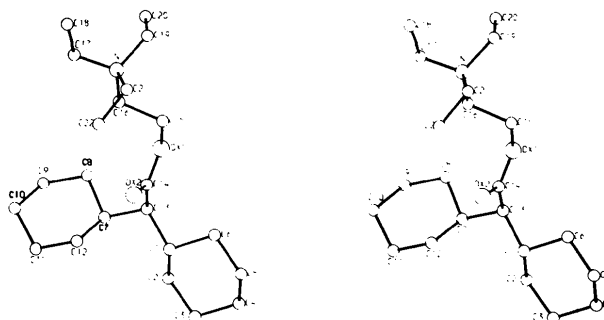


Fig. 1. Stereoscopic view of the cation (1).

Table 2. *Molecular dimensions*

(a) Bond lengths (Å)			
C(1)–C(2)	1.56 (3)	C(12)–C(7)	1.54 (3)
C(2)–C(3)	1.57 (3)	C(13)–C(14)	1.48 (3)
C(3)–C(4)	1.55 (3)	C(14)–O(1)	1.33 (3)
C(4)–C(5)	1.64 (4)	C(14)–O(2)	1.23 (3)
C(5)–C(6)	1.60 (3)	O(1)–C(15)	1.45 (3)
C(6)–C(1)	1.60 (4)	C(15)–C(16)	1.59 (3)
C(1)–C(13)	1.59 (3)	C(16)–N	1.57 (3)
C(7)–C(13)	1.53 (3)	N–C(17)	1.53 (3)
C(7)–C(8)	1.59 (4)	C(17)–C(18)	1.56 (4)
C(8)–C(9)	1.64 (4)	N–C(19)	1.53 (3)
C(9)–C(10)	1.59 (4)	C(19)–C(20)	1.43 (5)
C(10)–C(11)	1.58 (4)	N–C(21)	1.54 (4)
C(11)–C(12)	1.58 (4)	C(21)–C(22)	1.52 (4)

(b) Selected non-bonded distances (Å); mean e.s.d. 0.09 Å

N...O(1)	3.82	N...centre of ring	8.33
N...C(14)	4.53	C(1)–(6)	
N...O(2)	4.39	N...centre of ring	6.63
N...C(13)	5.86	C(7)–(12)	

(c) Bond angles (°)

C(6)–C(1)–C(2)	110 (2)	C(14)–C(13)–C(1)	107 (2)
C(13)–C(1)–C(2)	110 (2)	C(14)–C(13)–C(7)	110 (2)
C(13)–C(1)–C(6)	103 (2)	O(1)–C(14)–C(13)	112 (2)
C(3)–C(2)–C(1)	112 (2)	O(2)–C(14)–C(13)	126 (2)
C(4)–C(3)–C(2)	110 (2)	O(2)–C(14)–O(1)	122 (2)
C(5)–C(4)–C(3)	108 (2)	O(1)–C(15)–C(16)	104 (2)
C(6)–C(5)–C(4)	109 (2)	N–C(16)–C(15)	110 (2)
C(5)–C(6)–C(1)	108 (2)	N–C(17)–C(18)	107 (3)
C(12)–C(7)–C(8)	113 (2)	N–C(19)–C(20)	118 (3)
C(13)–C(7)–C(8)	105 (2)	N–C(21)–C(22)	112 (3)
C(13)–C(7)–C(12)	119 (2)	C(17)–N–C(16)	101 (2)
C(9)–C(8)–C(7)	106 (2)	C(19)–N–C(16)	109 (2)
C(10)–C(9)–C(8)	113 (3)	C(19)–N–C(17)	111 (2)
C(11)–C(10)–C(9)	108 (2)	C(21)–N–C(16)	109 (2)
C(12)–C(11)–C(10)	110 (3)	C(21)–N–C(17)	116 (2)
C(11)–C(12)–C(7)	110 (2)	C(21)–N–C(19)	110 (2)
C(7)–C(13)–C(1)	111 (2)	C(15)–O(1)–C(14)	119 (2)

(d) Selected torsion angles (°); mean e.s.d. 3°

Also present in the crystal are the centrosymmetrically related rotamers with torsion angles of opposite sign.

C(2)–C(1)–C(13)–C(14)	176	C(10)–C(11)–C(12)–C(7)	–61
C(6)–C(1)–C(13)–C(14)	–68	C(11)–C(12)–C(7)–C(8)	60
C(8)–C(7)–C(13)–C(14)	65	C(12)–C(7)–C(8)–C(9)	–55
C(12)–C(7)–C(13)–C(14)	–63	C(13)–C(7)–C(8)–C(9)	174
C(2)–C(1)–C(13)–C(7)	56	C(13)–C(7)–C(12)–C(11)	–176
C(6)–C(1)–C(13)–C(7)	172	C(1)–C(13)–C(14)–O(1)	129
C(1)–C(13)–C(7)–C(8)	–177	C(1)–C(13)–C(14)–O(2)	–54
C(1)–C(13)–C(7)–C(12)	55	C(7)–C(13)–C(14)–O(1)	–111
C(1)–C(2)–C(3)–C(4)	–61	C(7)–C(13)–C(14)–O(2)	66
C(2)–C(3)–C(4)–C(5)	60	C(13)–C(14)–O(1)–C(15)	180
C(3)–C(4)–C(5)–C(6)	–61	O(2)–C(14)–O(1)–C(15)	3
C(4)–C(5)–C(6)–C(1)	60	C(14)–O(1)–C(15)–C(16)	–85
C(5)–C(6)–C(1)–C(2)	–59	O(1)–C(15)–C(16)–N	–178
C(6)–C(1)–C(2)–C(3)	59	C(15)–C(16)–N–C(17)	178
C(13)–C(1)–C(2)–C(3)	172	C(15)–C(16)–N–C(19)	60
C(13)–C(1)–C(6)–C(5)	–176	C(15)–C(16)–N–C(21)	–59
C(7)–C(8)–C(9)–C(10)	54	C(16)–N–C(17)–C(18)	175
C(8)–C(9)–C(10)–C(11)	–58	C(16)–N–C(19)–C(20)	54
C(9)–C(10)–C(11)–C(12)	60	C(16)–N–C(21)–C(22)	–57

dimensions and the results of mean-plane calculations are in Table 3.

The two cyclohexyl rings are in the chair conformation and C(13) is substituted equatorially with respect to both rings. Ring torsion angles are 59–61°, mean 60°, and 54–61°, mean 58°, for the two rings.

Table 3. *Mean-plane calculations*

(a) Deviations (Å) of atoms from least-squares planes; e.s.d.'s are *ca* 0.03 Å. In the equations of the planes, *x*, *y* and *z* are fractional coordinates relative to the cell axes.

Plane (i): C(1)–(6)

$$-7.876x - 22.662y - 3.856z = -6.582$$

C(1)	–0.25	C(2)	0.25	C(3)	–0.26
C(4)	0.27	C(5)	–0.28	C(6)	0.27

Plane (ii): C(7)–(12)

$$-8.394x + 23.279y - 2.123z = -2.142$$

C(7)	0.24	C(8)	–0.23	C(9)	0.25
C(10)	–0.27	C(11)	0.27	C(12)	–0.26

Plane (iii): C(13)–(15), O(1), O(2)

$$2.847x + 14.625y - 9.331z = -3.958$$

C(13)	0.00	C(14)	0.01	C(15)	0.01
O(1)	–0.01	O(2)	–0.01	C(1)	1.21
C(7)	–1.34	N	–1.66		

(b) Interplanar angles (°); e.s.d.'s are *ca* 2°

(i)–(ii)	61	(ii)–(iii)	84
(i)–(iii)	88		

The ester group C(13)–(15), O(1), O(2) is planar to within ± 0.01 Å and adopts the antiplanar conformation typical of esters [torsion angle C(13)–C(14)–O(1)–C(15), 180°]. The arrangement about O(1)–C(15) is synclinal [torsion angle C(14)–O(1)–C(15)–C(16), $\mp 85^\circ$] and about C(15)–C(16) antiplanar [torsion angle O(1)–C(15)–C(16)–N⁺, $\mp 178^\circ$]. The antiplanar conformation about C(15)–C(16) is unusual; almost invariably in crystal structures of compounds containing an acetylcholine-like C–C(=O)–O–C–C–N⁺ chain the O–C–C–N⁺ torsion angle is within the range 60–100° (Baker, Chothia, Pauling & Petcher, 1971). The synclinal conformation about O(1)–C(15) is also unexpected, since in compounds of this type, with an open-chain acetylcholine-like system, the conformation about this bond is normally antiplanar (Guy & Hamor, 1974a), although a similar arrangement is observed in acetylcholine bromide (Svinning & Sørum, 1975). The arrangement about the C–N⁺ bonds deviates only slightly from the ideally staggered conformation (Table 2d).

A somewhat similar geometry is, however, found in the hydrochloride of the anticholinergic thiol ester thiphenamil (Guy & Hamor, 1974b). Here the corresponding torsion angles C(13)–C(14)–S–C(15), C(14)–S–C(15)–C(16) and S–C(15)–C(16)–N⁺ are ± 174 , ∓ 82 , $\mp 174^\circ$, respectively. The similarity extends also to the conformation about C(13)–C(14), torsion angles C(1)–C(13)–C(14)–O(1) or S and C(7)–C(13)–C(14)–O(1) [S] being ± 129 and $\mp 111^\circ$ in (I) and ± 147 and $\mp 86.5^\circ$ in thiphenamil hydro-

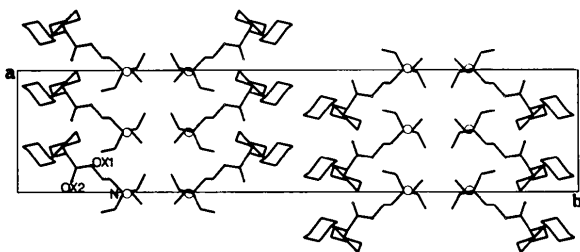


Fig. 2. The contents of the unit cell projected along *c*. Circles denote iodide ions.

Table 4. The shorter intermolecular contacts (Å) excluding hydrogen atoms; *e.s.d.*'s are ca 0.08 Å

C(21)···O(1 ^l)	3.46	O(2)···C(13 ^l)	3.67
C(20)···C(18 ^{ll})	3.54	C(21)···C(15 ^l)	3.68
C(4)···C(4 ^{lll})	3.63	C(22)···O(1 ^l)	3.69
C(22)···C(10 ^{lv})	3.64	O(2)···C(6 ^l)	3.70

Symmetry code

- | | |
|--|---|
| (i) $-\frac{1}{2} + x, y, 1\frac{1}{2} - z$ | (iii) $1 - x, -y, 2 - z$ |
| (ii) $\frac{1}{2} + x, \frac{1}{2} - y, 1 - z$ | (iv) $-\frac{1}{2} + x, y, \frac{1}{2} - z$ |

chloride. The orientation of the ring substituents about C(1)—C(13) and C(7)—C(13) is, however, different, although in both structures they are steeply inclined to one another and to the plane of the ester moiety.

C(*sp*³)—C(*sp*³) lengths range from 1.43 (5) to 1.64 (4) Å, mean 1.57 Å, and the four C—N⁺ lengths are in the range 1.53 (3)—1.57 (3) Å, mean 1.54 Å.

Acta Cryst. (1980). B36, 102–107

The Crystal Structure of 3-(*p*-Chlorophenyl)-3a-methyl-4-oxo-5,6,6a-triphenyl-3a,4-dihydrocyclopenta[2,3-*d*]isoxazoline

By A. P. BOZOPOULOS, S. C. KOKKOU AND P. J. RENTZEPERIS

Applied Physics Laboratory, Aristotle University of Thessaloniki, Thessaloniki, Greece

(Received 18 May 1979; accepted 22 August 1979)

Abstract

The crystal structure of 3-(*p*-chlorophenyl)-3a-methyl-4-oxo-5,6,6a-triphenyl-3a,4-dihydrocyclopenta[2,3-*d*]isoxazoline, C₃₁H₂₂ClNO₂, has been determined from three-dimensional data, measured with an automated Philips PW 1100 single-crystal diffractometer (915 independent non-zero reflexions). The cell constants, obtained by least-squares calculations from direct θ -value measurements on the diffractometer, are $a =$

0567-7408/80/010102-06\$01.00

None of the individual bond lengths differs significantly from standard values. The C—O bonds of the ester group also agree to within the limits of experimental error with expected values.

The packing is shown in Fig. 2, and the shorter intermolecular contacts are in Table 4. None of these is shorter than the sum of the van der Waals radii. The closest contact involving the I⁻ ion is 3.90 Å to C(21) of the cation at $\frac{1}{2} + x, \frac{1}{2} - y, 1 - z$.

I thank Dr R. B. Barlow for supplying the sample, the University of Birmingham for funds to purchase the diffractometer, and the staff of the Computer Centre for their assistance.

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14.0021 (2), $b = 10.6218$ (10), $c = 9.5188$ (8) Å, $\alpha = 64.89$ (1), $\beta = 101.62$ (1), $\gamma = 100.68$ (1)°, $Z = 2$; the space group is $P\bar{1}$. The structure was solved by direct phase determination with *MULTAN*. The positional and vibrational parameters, with anisotropic temperature factors for the non-hydrogen atoms, were refined by full-matrix least-squares calculations to a final $R = 0.097$. The molecule of the compound has a cyclopentenone-isoxazoline structure. To the two central five-membered isoxazoline and cyclopentenone

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