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cis-(±)-3-Acetoxy-2-(4-methoxyphenyl)-4-oxo-2,3,4,5-tetrahydro-1,5-benzothiazepine 1-Oxide

P. Kumaradhas and K. A. Nirmala*

Department of Physics, Bangalore University, Bangalore 560 056, India. E-mail: bang@sirnetb.ernet.in

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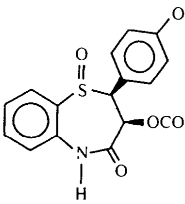
Abstract

The title compound, $C_{18}H_{17}NO_5S$, is a drug intermediate of diltiazem. The molecular packing is stabilized by hydrogen bonding between polar atoms and van der Waals interactions between non-polar atoms. The seven-membered ring is distorted, showing a twist-boat conformation. The relative orientation of the methoxyphenyl and acetoxy groups is *cis*, with the methoxyphenyl group adopting an axial position in the molecule, while the sulfoxide O atom is in an equatorial position.

Comment

The title compound, (I), is a drug intermediate of diltiazem, (II), an enantiomerically pure drug with calcium antagonist activity (Kojic-Prodic, Ruzic-Toros & Sunjic, 1984). The pharmacological action of compound (I) is unknown and so the present X-ray analysis was carried out in order to determine its exact conformation.



(I)

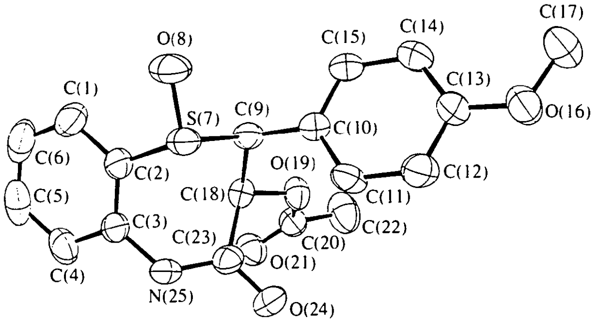


Fig. 1. The molecular structure of (I) showing 50% probability displacement ellipsoids. H atoms have been omitted for clarity.

Fig. 1 presents the molecular structure of (I) and a comparison of selected torsion angles of (I) with those of related seven-membered ring compounds is given in Table 3. Interatomic distances and angles in the 1,5-benzothiazepine ring reflect usual seven-membered ring geometry and hybridization. The S(7)—C(9) [1.84 (3) Å] and C(2)—S(7) [1.792 (9) Å] bond lengths are unequal, one being shortened due to the conjugation of the π-electron system. The C_{sp^3}—C_{sp^3} bonds range from 1.505 (13) to 1.537 (15) Å in length. Bonds involving the carbonyl groups fall into three categories, namely, single C_{sp^3}—O bonds [C(18)—O(19) 1.44 (3) and C(17)—O(16) 1.419 (15) Å], single C_{sp^2}—O bonds [C(13)—O(16) 1.371 (11) and C(20)—O(19) 1.356 (12) Å] and C=O double bonds [C(20)—O(21) 1.200 (8) and C(23)—O(24) 1.216 (10) Å]. The C—N distances are unequal [C(3)—N(25) 1.416 (17) and C(23)—N(25) 1.35 (3) Å] due to different C-atom environments.

The conformation of the 1,5-benzothiazepine ring was determined using the least-squares plane passing through atoms S(7), C(9) and C(18). Atoms C(2) and C(3) lie above, and atoms C(23) and N(25) below this plane. The values of the torsion angles of (I) indicate a twist-boat conformation (Hendrickson, 1961) and are similar to those of both compound (II) and the diltiazem drug intermediate *trans*-(±)-2-(4-methoxyphenyl)-4-oxo-2,3,4,5-tetrahydro-1,5-benzothiazepin-3-yl acetate, (III) (Kumaradhas, Nirmala & Ravikumar, 1995). The methoxyphenyl and acetoxy groups on atoms C(9) and C(18), respectively, are *cis* oriented with respect to each other, as indicated by the torsion angle C(10)—C(9)—C(18)—O(19) of 40.4 (17)°, and the dihedral angle between the methoxyphenyl group and the seven-membered ring is 71.1 (1)°. The methoxyphenyl group adopts an axial position in the molecule, with the sulfoxide O(18) atom equatorial and the carbonyl O(24) atom in a pseudo-equatorial position.

The molecular packing is stabilized by hydrogen bonding as shown in Fig. 2; N(25)—H(25) 0.844 (13), H(25)···O(8^i) 2.006 (9), N(25)···O(8^i) 2.836 (15) Å and N(25)—H(25)···O(8^i) 167.4 (2)° [symmetry code: (i) $\frac{1}{2}-x, y-\frac{1}{2}, z$]. The molecules are linked into an infinite chain through hydrogen bonds. On the whole, the crystal

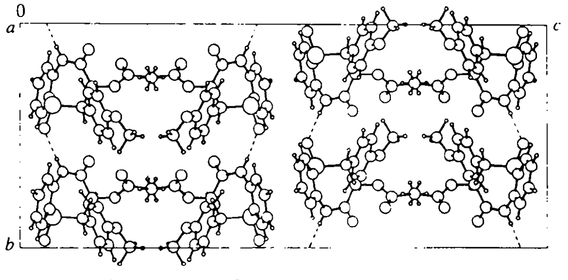


Fig. 2. A packing diagram of (I) viewed down the *a* axis.

packing is stabilized by hydrogen bonding between polar groups and van der Waals interactions between non-polar groups.

Experimental

The title compound was recrystallized from an acetone/ethanol mixture at room temperature.

Crystal data

$C_{18}H_{17}NO_5S$
$M_r = 359.39$
Orthorhombic
$Pbca$
$a = 8.200\,(8)$ Å
$b = 13.326\,(9)$ Å
$c = 32.093\,(6)$ Å
$V = 3507\,(4)$ Å^3
$Z = 8$
$D_x = 1.361$ Mg m^{-3}
$D_m = 1.351$ Mg m^{-3}
D_m measured by flotation in a xylene/CCl_4 mixture

Mo $K\alpha$ radiation
$\lambda = 0.7107$ Å
Cell parameters from 25 reflections
$\theta = 9–15°$
$\mu = 0.213$ mm^{-1}
$T = 294$ K
Flake
$0.50 \times 0.40 \times 0.35$ mm
Colourless

Data collection

Enraf–Nonius CAD-4 diffractometer
$\omega/2\theta$ scans
Absorption correction: none
2302 measured reflections
2302 independent reflections
1855 observed reflections $[I > 2\sigma(I)]$

$\theta_{\max} = 22.5°$
$h = 0 \rightarrow 8$
$k = 0 \rightarrow 14$
$l = 0 \rightarrow 34$
2 standard reflections frequency: 60 min intensity decay: <2%

Refinement

Refinement on F^2
$R(F) = 0.0455$
$wR(F^2) = 0.1374$
$S = 1.205$
2302 reflections
294 parameters
All H-atom parameters refined

$w = 1/[\sigma^2(F_o^2) + (0.1037P)^2 + 0.6091P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{\max} = 0.064$
$\Delta\rho_{\max} = 0.205$ e Å^{-3}
$\Delta\rho_{\min} = -0.305$ e Å^{-3}
Atomic scattering factors from *SHELXL*93 (Sheldrick, 1993)

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}
C(1)	0.5020 (5)	0.3967 (3)	0.4597 (1)	0.057 (9)
C(2)	0.3898 (4)	0.3293 (2)	0.4444 (9)	0.043 (8)
C(3)	0.4335 (4)	0.2293 (2)	0.4375 (8)	0.043 (8)
C(4)	0.5891 (4)	0.1975 (3)	0.4481 (1)	0.055 (9)
C(5)	0.6981 (5)	0.2668 (4)	0.4647 (1)	0.070 (1)
C(6)	0.6577 (5)	0.3650 (4)	0.4693 (1)	0.070 (1)
S(7)	0.1795 (9)	0.3628 (5)	0.4382 (2)	0.042 (3)
O(8)	0.1620 (3)	0.4675 (2)	0.4540 (7)	0.060 (7)
C(9)	0.1765 (3)	0.3709 (2)	0.3811 (9)	0.038 (7)
C(10)	0.0037 (3)	0.3849 (2)	0.3664 (9)	0.040 (7)
C(11)	−0.1118 (4)	0.3079 (2)	0.3687 (1)	0.046 (8)
C(12)	−0.2656 (4)	0.3201 (2)	0.3519 (1)	0.049 (8)
C(13)	−0.3088 (3)	0.4092 (2)	0.3333 (1)	0.045 (8)
C(14)	−0.1977 (4)	0.4875 (2)	0.3318 (1)	0.056 (9)
C(15)	−0.0427 (4)	0.4739 (2)	0.3484 (1)	0.054 (9)
O(16)	−0.4626 (3)	0.4128 (2)	0.3166 (8)	0.060 (7)
C(17)	−0.5050 (5)	0.4958 (3)	0.2911 (1)	0.066 (1)
C(18)	0.2665 (4)	0.2802 (2)	0.3625 (8)	0.038 (7)
O(19)	0.2198 (2)	0.2778 (2)	0.3194 (6)	0.045 (5)
C(20)	0.3200 (4)	0.2257 (2)	0.2937 (1)	0.044 (8)
O(21)	0.4333 (3)	0.1772 (2)	0.3061 (6)	0.053 (6)
C(22)	0.2720 (6)	0.2386 (4)	0.2499 (1)	0.074 (1)
C(23)	0.2359 (4)	0.1790 (2)	0.3836 (1)	0.041 (7)
O(24)	0.1466 (3)	0.1159 (2)	0.3685 (7)	0.057 (6)
N(25)	0.3197 (3)	0.1628 (2)	0.4191 (9)	0.046 (7)

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

C(1)—C(2)	1.377 (11)	C(11)—C(12)	1.382 (5)
C(1)—C(6)	1.379 (6)	C(12)—C(13)	1.375 (5)
C(2)—C(3)	1.398 (4)	C(13)—O(16)	1.371 (11)
C(2)—S(7)	1.792 (9)	C(13)—C(14)	1.385 (4)
C(3)—C(4)	1.387 (5)	C(14)—C(15)	1.390 (5)
C(3)—N(25)	1.416 (17)	O(16)—C(17)	1.419 (15)
C(4)—C(5)	1.391 (6)	C(18)—O(19)	1.437 (3)
C(5)—C(6)	1.358 (6)	C(18)—C(23)	1.530 (12)
S(7)—O(8)	1.491 (10)	O(19)—C(20)	1.356 (12)
S(7)—C(9)	1.84 (3)	C(20)—O(21)	1.200 (8)
C(9)—C(10)	1.505 (13)	C(20)—C(22)	1.469 (5)
C(9)—C(18)	1.537 (15)	C(23)—O(24)	1.216 (10)
C(10)—C(15)	1.373 (13)	C(23)—N(25)	1.35 (3)
C(10)—C(11)	1.398 (4)		
C(2)—C(1)—C(6)	119.8 (4)	C(12)—C(11)—C(10)	120.7 (3)
C(1)—C(2)—C(3)	120.5 (3)	C(13)—C(12)—C(11)	120.4 (3)
C(1)—C(2)—S(7)	121.3 (3)	O(16)—C(13)—C(12)	115.8 (3)
C(3)—C(2)—S(7)	117.8 (2)	O(16)—C(13)—C(14)	124.4 (3)
C(4)—C(3)—C(2)	119.2 (3)	C(12)—C(13)—C(14)	119.7 (3)
C(4)—C(3)—N(25)	121.2 (3)	C(13)—C(14)—C(15)	119.3 (3)
C(2)—C(3)—N(25)	119.6 (3)	C(10)—C(15)—C(14)	121.8 (3)
C(3)—C(4)—C(5)	118.8 (4)	C(13)—O(16)—C(17)	118.5 (3)
C(6)—C(5)—C(4)	121.6 (4)	O(19)—C(18)—C(23)	111.3 (2)
C(5)—C(6)—C(1)	119.8 (4)	O(19)—C(18)—C(9)	105.3 (2)
O(8)—S(7)—C(2)	106.8 (1)	C(23)—C(18)—C(9)	116.2 (2)
O(8)—S(7)—C(9)	106.4 (6)	C(20)—O(19)—C(18)	115.9 (2)
C(2)—S(7)—C(9)	97.9 (1)	O(21)—C(20)—O(19)	122.9 (3)
C(10)—C(9)—C(18)	115.3 (2)	O(21)—C(20)—C(22)	126.0 (3)
C(10)—C(9)—S(7)	109.5 (2)	O(19)—C(20)—C(22)	111.1 (3)
C(18)—C(9)—S(7)	109.6 (2)	O(24)—C(23)—N(25)	122.3 (3)
C(15)—C(10)—C(11)	118.0 (3)	O(24)—C(23)—C(18)	122.1 (3)
C(15)—C(10)—C(9)	120.0 (3)	N(25)—C(23)—C(18)	115.6 (3)
C(11)—C(10)—C(9)	121.9 (3)	C(23)—N(25)—C(3)	126.0 (3)

Table 3. *Comparision of selected torsion angles (°) of the seven-membered ring of (I) with those of similar rings of the related compounds (II) and (III)*

	(I)[a]	(II)[b]	(III)[c]
S(7)—C(9)—C(18)—C(23)	40.8 (15)	−48.9 (2)	−42.1 (1)
C(9)—C(18)—C(23)—N(25)	−79.4 (15)	86.9 (3)	90.6 (5)
C(18)—C(23)—N(25)—C(3)	−1.4 (20)	−8.8 (4)	13.3 (7)
C(2)—C(3)—N(25)—C(23)	51.2 (23)	−44.3 (4)	−48.0 (6)
S(7)—C(2)—C(3)—N(25)	11.0 (21)	−6.1 (4)	0.6 (8)
C(3)—C(2)—S(7)—C(9)	−79.2 (14)	66.4 (3)	69.4 (5)
C(2)—S(7)—C(9)—C(18)	44.8 (13)	−32.8 (2)	42.0 (4)

References: (*a*) present compound; (*b*) Kojic-Prodic, Ruzic-Toros & Sunjic (1984); (*c*) Kumaradhas, Nirmala & Ravikumar (1995).

All non-H atoms were found by direct methods and the parameters were refined successfully with a full-matrix least-squares procedure. H atoms were located on a difference Fourier map and included in the refinement.

Data collection: *CAD*-4 *Software* (Enraf–Nonius, 1989). Cell refinement: *CAD*-4 *Software*. Data reduction: *DATRD*2 in *NRCVAX* (Gabe, Le Page, White & Lee, 1989). Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1990). Program(s) used to refine structure: *SHELXL*93 (Sheldrick, 1993).

Molecular graphics: *ORTEP*II (Johnson, 1976) in *NRCVAX*. Software used to prepare material for publication: *SHELXL*93 (Sheldrick, 1993). Geometric calculations: *PARST* (Nardelli, 1983).

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Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: BK1150). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

References

Enraf–Nonius (1989). *CAD-4 Software*. Version 5.0. Enraf–Nonius, Delft, The Netherlands.

Gabe, E. J., Le Page, Y., White, P. S. & Lee, F. L. (1987). *Acta Cryst.* A**43**, C-294.

Hendrickson, J. B. (1961). *J. Am. Chem. Soc.* **83**, 4537–4547.

Johnson, C. K. (1976). *ORTEP*II. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.

Kojic-Prodic, B., Ruzic-Toros, Z. & Sunjic, V. (1984). *Helv. Chim. Acta*, **67**, 916–926.

Kumaradhas, P., Nirmala, K. A. & Ravikumar, K. (1995). *Acta Cryst.* C**51**, 1932–1934.

Nardelli, M. (1983). *Comput. Chem.* **7**, 95–98.

Sheldrick, G. M. (1990). *Acta Cryst.* A**46**, 467–473.

Sheldrick, G. M. (1993). *SHELXL93. Program for the Refinement of Crystal Structures*. University of Göttingen, Germany.

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n-Undecylammonium Chloride Monohydrate

JACK SILVER,[a] STEVEN MARTIN,[a] PAUL J. MARSH[a] AND CHRISTOPHER S. FRAMPTON[b]*

[a]*Department of Chemistry and Biological Chemistry, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, England, and* [b]*Roche Research Centre, PO Box 8, Welwyn Garden City, Hertfordshire AL7 3AY, England. E-mail: framptoc@rwep03.dnet.roche.com*

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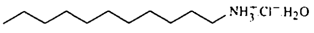
Abstract

The structure of $C_{11}H_{26}N^+.Cl^-.H_2O$ is the first of a new class of monoalkylammonium halide compounds containing a water molecule. The latter is hydrogen bonded both to the N and Cl atoms. The structure may be a useful model for the interface between biological membranes and aqueous solutions.

Comment

Complex polymorphism has been described in long-chain monoalkylammonium chlorides (Gilson, Kertes, Manley, Tsau & Donnay, 1976). The structures of *n*-decylammonium chloride (DACl; Schenk & Chapuis, 1986; Pinto, Vencato, Gallardo & Mascarenhas, 1987) and *n*-dodecylammonium chloride (DDACl; Pinto, Vencato, Gallardo & Mascarenhas, 1987; Silver, Marsh & Frampton, 1995) have been described and used to interpret solid-solid phase transitions (Gault, Gallardo & Muller, 1985; Kind *et al.*, 1982; Seliger, Žagra, Blinc, Arend & Chapuis, 1983; Silver, Marsh & Frampton, 1995). The title compound, *n*-undecylammonium chloride monohydrate, $UDAClH_2O$, represents the first of what appears to be a new class of these compounds containing a hydrogen-bonded water molecule.



$UDAClH_2O$

The structure of a single molecule of $UDAClH_2O$ is shown in Fig. 1. The C—C distances vary between 1.514 (2) and 1.526 (2) Å, the C—N distance is 1.494 (2) Å and the C—C—C(N) angles are in the range 111.3 (1)–113.9 (1)°. Unlike previous findings for DACl and DDACl (Pinto, Vencato, Gallardo & Mascarenhas, 1987; Silver, Marsh & Frampton, 1995), there is no evidence of stress in the bond lengths and angles, although the torsion angles and Fig. 2 show that the UDA chains are distorted from a fully extended conformation on packing.

The structure of $UDAClH_2O$ consists of layers built of N, Cl and O atoms alternating with layers of UDA cations (Fig. 2). The two layers are linked by hydrogen bonds between the N atoms of the UDA chains and the Cl and water O atoms, such that each N atom

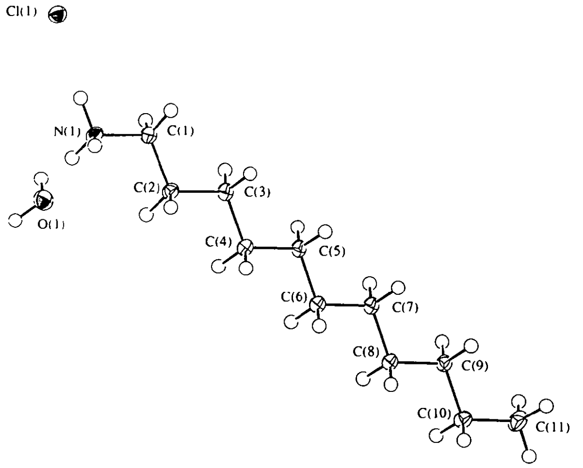


Fig. 1. View of the title molecule showing the atom-labelling scheme. The displacement ellipsoids are drawn at the 50% probability level and H atoms are drawn as small circles of arbitary radii.