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Acta Cryst. (1994). C**50**, 933–935

(5-Chloro-1,3-benzoxazol-2-ylthio)-acetonitrile

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(*Received* 15 *April* 1993; *accepted* 25 *October* 1993)

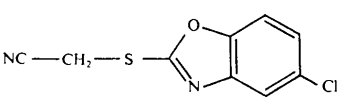
Abstract

(5-Chloro-1,3-benzoxazol-2-ylthio)acetonitrile, $C_9H_5ClN_2OS$, was obtained by the reaction of chloroacetonitrile with 5-chloro-2-mercaptobenzoxazole. The structure of the title compound was indicated by IR, ^1H NMR and ^{13}C NMR spectra, and confirmed by an X-ray analysis. The cyanomethyl group is bonded to the benzoxazole ring through the S atom. The starting compound reacts in the thiol form. Intermolecular bonding includes C—H···N hydrogen bonds.

Comment

Benzoxazole-2-thione (2-mercaptobenzoxazole) exhibits two tautomeric forms (Seidel, 1980). As a result of this prototropic ability, nucleophilic attack of an alkyl halide on the 2-mercaptobenzoxazole could occur at either the N or the S atom, depending upon whether the molecule existed in the thiol or the thione form. Therefore, mixtures of S-substituted and N-substituted benzoxazole derivatives have generally been reported (Desai, Hunter & Khalidi, 1934; Katz & Cohen, 1954).

The present investigation has been undertaken in order to determine the structure of the reactive tautomeric form. The title compound (I) was synthesized by the reaction of chloroacetonitrile with 5-chloro-2-mercaptobenzoxazole (Arçay, Şafak & Abbasoğlu, 1992). NMR spectral data are given in



(I)

the *Experimental*. A long-range correlation was observed between the methylene protons ($\delta = 4.10$) and the atom C(1) ($\delta = 162.3$) in the two-dimensional ^1H and ^{13}C heteronuclear long-range COSY experiments. This finding is in agreement with the literature (Pretsch, Clerc, Seibl & Simon, 1981). It can be seen from this observation that the cyanomethyl group is bonded to the benzoxazole ring through the S atom as shown in Fig. 1. This is confirmed by the X-ray analysis. Consequently, the starting compound reacts in the thiol form in this synthesis. According to the values of the related angles (Table 2), the linear chain formed by the atoms C(8), C(9) and N(2) is linked with the planar 5-chloro-2-benzoxazolylthio moiety so that the

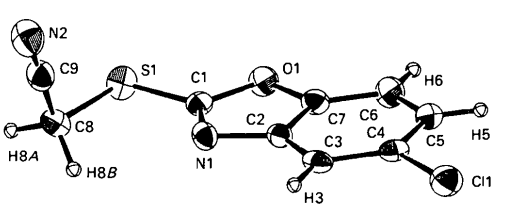


Fig. 1. A view of the molecule showing the labelling of the atoms. Displacement ellipsoids are shown at 50% probability levels.

C(1)—S(1)—C(8)—C(9) torsion angle is 77.9 (6)°. The S(1)—C(1) and S(1)—C(8) bond lengths are approximately the same as those found in the structure of perfragilin (Rizvi, Hossain & van der Helm, 1993). The C(9)—N(2) distance is typical of a C≡N triple-bond length which normally lies within the range 1.12–1.15 Å (Rabinovich & Shakked, 1978). The shortest intermolecular contacts of the hydrogen bonds are given in Table 2 (March, 1985).

Experimental

^{1}H NMR (300 MHz, $CDCl_3$): 4.10 (2H, *s*, —S—CH_2—), 7.28 [*dd*, *J* = 2.0 and 8.2 Hz, H(5)], 7.40 [*d*, *J* = 8.2 Hz, H(6)], 7.64 [*d*, *J* = 2 Hz, H(3)]. ^{13}C NMR (75 MHz, $CDCl_3$): 162.3 *s* (C1), 142.4 *s* (C2), 119.1 *d* (C3), 130.4 *s* (C4), 125.0 *d* (C5), 110.9 *d* (C6), 151.0 *s* (C7), 17.7 *t* (C8), 115.0 *s* (C9).

Crystal data

$C_9H_5ClN_2OS$
M_r = 224.66
Triclinic
$P\bar{1}$
a = 9.384 (2) Å
b = 12.059 (3) Å
c = 4.595 (2) Å
α = 95.32 (3)°
β = 95.97 (3)°
γ = 110.13 (2)°
V = 480.9 (3) Å^3
Z = 2
D_x = 1.551 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71069 Å
Cell parameters from 25 reflections
θ = 11.8–17.25°
μ = 0.567 mm^{-1}
T = 296 K
Bar
0.20 × 0.14 × 0.06 mm
Colourless
Crystal source: crystallized from ethanol

Data collection

Rigaku AFC-5*S* diffractometer
ω-2θ scans
Absorption correction: empirical (*DIFABS*; Walker & Stuart, 1983)
T_{min} = 0.79, T_{max} = 1.18
1816 measured reflections
1701 independent reflections
1076 observed reflections [$I > 2\sigma(I)$]
R_{int} = 0.032
θ_{max} = 25°
$h = 0 \rightarrow 11$
$k = -14 \rightarrow 13$
$l = -5 \rightarrow 5$
3 standard reflections monitored every 150 reflections
intensity variation: −0.90%

Refinement

Refinement on F
R = 0.066
wR = 0.079
S = 2.38
1076 reflections
127 parameters
H-atom parameters not refined
$w = 4F_o^2/\sigma^2(F_o^2)$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.50 e Å^{-3}
$\Delta\rho_{min}$ = −0.34 e Å^{-3}
Extinction correction: none
Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV)

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

$B_{eq} = (8\pi^2/3)\sum_i\sum_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	B_{eq}
Cl(1)	0.1753 (2)	−0.0981 (2)	−0.7725 (5)	4.87 (9)
S(1)	0.6492 (2)	0.4368 (2)	0.4381 (5)	4.36 (8)
O(1)	0.4162 (5)	0.3500 (4)	0.012 (1)	3.9 (2)
N(1)	0.5362 (6)	0.2203 (5)	0.090 (1)	3.3 (2)
N(2)	0.9749 (8)	0.3600 (7)	0.231 (2)	5.3 (3)
C(1)	0.5302 (8)	0.3239 (6)	0.168 (2)	3.2 (3)
C(2)	0.4151 (8)	0.1686 (6)	−0.146 (1)	2.9 (2)
C(3)	0.3670 (8)	0.0598 (6)	−0.318 (2)	3.3 (3)
C(4)	0.2430 (8)	0.0367 (6)	−0.543 (2)	3.4 (3)
C(5)	0.1715 (8)	0.1182 (7)	−0.589 (2)	4.0 (3)
C(6)	0.2197 (8)	0.2267 (7)	−0.408 (2)	4.5 (3)
C(7)	0.3429 (8)	0.2487 (6)	−0.193 (2)	3.4 (3)
C(8)	0.772 (1)	0.3603 (7)	0.573 (2)	4.4 (3)
C(9)	0.886 (1)	0.3589 (7)	0.378 (2)	4.3 (3)

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

S(1)—C(1)	1.730 (7)	S(1)—C(8)—C(9)	112.1 (5)
S(1)—C(8)	1.804 (8)	N(2)—C(9)—C(8)	178.5 (9)
N(2)—C(9)	1.13 (1)	C(1)—S(1)—C(8)	97.8 (4)
C(2)—N(1)—C(1)—S(1)	−177.9 (5)	N(2)···C(8^i)	2.620
N(1)—C(1)—S(1)—C(8)	−1.9 (7)	N(2)···C(6^{ii})	2.735
Cl(1)—C(4)—C(3)—C(2)	179.8 (5)	N(2)···C(8^{iii})	2.859

Symmetry codes: (i) $x, y, z-1$; (ii) $1+x, y, 1+z$; (iii) $2-x, 1-y, 1-z$.

The structure was solved by direct methods (Gilmore, 1984; Beurskens, 1984). Non-H atoms were refined anisotropically. All calculations were performed using the *TEXSAN* (Molecular Structure Corporation, 1985) crystallographic software package and molecular graphics were obtained with *ORTEP*II (Johnson, 1976).

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 71787 (11 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: AB1087]

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Acta Cryst. (1994). C50, 935–938

[2α(2*S*,3*S*,4*R*,6*R*),3β,5α]-14-Hydroxy-19-oxo-3,2-[(tetrahydro-3,4-dihydroxy-6-methyl-2*H*-pyran-2,3-diyl)bis(oxy)]card-20(22)-enolide Dihydrate (Calactin), $C_{29}H_{39}O_9.2H_2O$, a Cardenolide from *Asclepias linaria*

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(*Received* 25 *March* 1993; *accepted* 5 *October* 1993)

Abstract

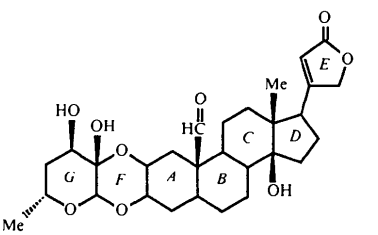
This X-ray diffraction study establishes the molecular structure of the title compound. The asymmetric unit comprises two independent molecules (*A* and *B*). Both molecules are closely similar with regard to bond lengths and angles. In both molecules, the six-membered rings all adopt chair conformations. The *D* ring of the steroid moiety has an envelope conformation and the lactone ring is almost flat. The *A*/*B*, *B*/*C* and *A*/*F* ring junctions are *trans* and the *C*/*D* and *F*/*G* ring junctions are *cis*. The crystal structure is stabilized by a three-dimensional network of hyrogen bonds and C—H···O interactions.

† Contribution No. 1206 of the Instituto de Química, UNAM.

Comment

Cardenolides constitute one of several groups of plant secondary compounds that are sequestered by phytophagous insects for defense against predation. Most members of the genus *Asclepias* (*Asclepiadaceae*) produce the cardiactive steroids at varying concentrations. Plants of *Asclepias* have also been studied for high proteolytic enzyme content (Brockbank & Lynn, 1979; Barragan, Cruz, Del Castillo & Castañeda-Agulló, 1985). These enzymes are named asclepains.

Calactin (I) is a naturally occurring cardenolide which was isolated from extracts of the aerial parts of the plant *Asclepias linaria*. The sample was collected in the southeast of the State of Durango, Mexico. The chemical and spectroscopic studies led to the proposal of the chemical structure of calactin (Brüschweiler, Stöckel & Reichstein, 1969).



(I)

The molecular packing diagram viewed along the *b* axis is presented in Fig. 2, showing the hydrogen-bonding scheme. The water molecules are hydrogen bonded to hydroxyl O atoms. The molecules in the crystal are stabilized by a three-dimensional network of hydrogen bonds: O(2)···O(1) 2.960 (13), O(8*B*)···O(7*B*) 2.728 (7) and O(1*A*)···O(3*B*)(2 − *x*, 1 − *y*, *z*), 2.898 (7), O(1)···O(8*B*)(0.5 + *x*, 0.5 + *y*, 2 − *z*) 2.856 (8), O(2)···O(7*A*)(1.5 − *x*, −0.5 + *y*, 1 − *z*) 2.740 (10), O(1*B*)···O(3*A*)(2 − *x*, 1 − *y*, 1 + *z*) 2.768 (6) Å; and five intermolecular C—H···O interactions < 3.4 Å: C(12*A*)···O(5*A*)(1.5 − *x*, −0.5 + *y*, 1 − *z*) 3.304 (7), C(23*A*)···O(8*A*)(0.5 + *x*, 1.5 − *y*, 1 − *z*) 3.112 (9), C(26*A*)···O(3*B*)(1.5 − *x*, 0.5 + *y*, 1 − *z*)

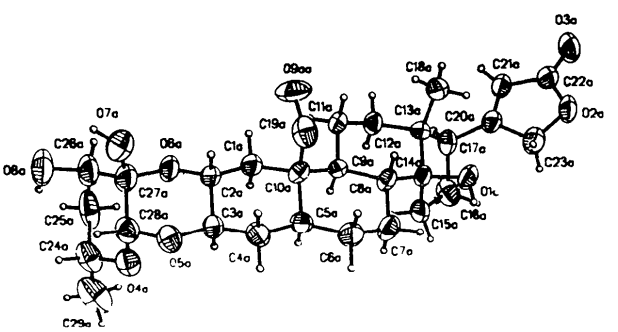


Fig. 1. The molecular structure of the title compound with numbering scheme.