

Fig. 2. Bond distances (Å) and angles ($^{\circ}$).

as expected, though C(6a)—C(9a) seems to be slightly long.

It has been reported that, at the initial stage of the reaction between thiamine free base and an isocyanate derivative, the S(10)—C(10a) bond is cleaved in a polar solvent (*e.g.* dimethylformamide) to generate the S

anion, but not in a less-polar solvent (*e.g.* chloroform) (Takamizawa, Makino & Yonezawa, 1974). Although the bond length might not directly correspond to the reactivity of the bond, it is interesting that the opening of the thiazolidine ring is probably correlated with the unusually long S—C bond.

References

- ARGAY, G., KÁLMÁN, A., LAZAR, D., RIBÁR, B. & TÓTH, G. (1977). *Acta Cryst.* B33, 99–105.
- International Tables for X-ray Crystallography* (1974). Vol. IV, p. 71. Birmingham: Kynoch Press.
- MAIN, P., GERMAIN, G. & WOOLFSON, M. M. (1970). *MULTAN. A System of Computer Programs for the Automatic Solution of Crystal Structures*. Univs. of York, England, and Louvain, Belgium.
- POPLE, J. A. & BEVERIDGE, D. L. (1970). *Approximate Molecular Orbital Theory*. New York: McGraw-Hill.
- TAKAMIZAWA, A., HIRAI, K., ISHIBA, T. & MAKINO, I. (1971). *Chem. Pharm. Bull.* 19, 759–763.
- TAKAMIZAWA, A., MAKINO, I. & YONEZAWA, S. (1974). *Chem. Pharm. Bull.* 22, 286–292.

Acta Cryst. (1978). B34, 3426–3428

Ethyl 3-[4,5-Dimethoxy-2-(5-methyl-2-pyridylsulfamoyl)phenyl]propionate

By S. HAMODRAKAS

Department of General Biology, University of Athens, Panepistimiopolis, Athens 621, Greece

D. AKRIGG AND B. SHELDRIK

Astbury Department of Biophysics, University of Leeds, Leeds LS2 9JT, England

AND C. CAMOUTSIS

NRC 'Demokritos', Aghia Paraskevi Attikis, Athens, Greece

(Received 11 May 1978; accepted 10 July 1978)

Abstract. C₁₉H₂₄N₂O₆S, *M_r* = 408.47, monoclinic, *P*2₁/*c*, *a* = 10.143 (6), *b* = 9.002 (5), *c* = 22.167 (23) Å, β = 95.48°, *Z* = 4, *D_m* = 1.341, *D_c* = 1.346 g cm⁻³, λ(Cu Kα) = 1.5418 Å. The methoxy groups are nearly coplanar with the phenyl ring, and pairs of molecules, across a centre of symmetry, are connected by N—H⋯N hydrogen bonds.

Introduction. Derivatives of benzothiazinone have been shown to have an effect on the central nervous system (Sianesi, Redaelli, Magistretti & Massarani, 1973) and are known to have anti-inflammatory activity (Lombardino & Wiseman, 1971). A number of sulphonamides, with structural similarities to benzothiazinone, have recently been synthesized (Camoutsis & Catsoulakos,

1976) and are being tested for pharmacological activity. Crystallographic studies are also being carried out in an attempt to relate structure and activity.

Intensity data were collected on an Enraf-Nonius CAD-4 diffractometer and measured by the ω/2θ scan in the range 3 < θ < 70°. 12 289 measurements were made, of which 4983 were too small to measure significantly and 411 were intensity checks. Merging of equivalent reflections gave 3217 unique reflections (merging *R* = 0.0627) but 101 of these had *I* < 3σ(*I*) and were not used in the analysis. The structure was solved by direct methods using the *EEES* program of the *SHELX* package (Sheldrick, 1976). Four sets of phases were produced and *E* maps calculated. On one *E* map 17 of the 28 non-hydrogen atoms were found

Table 1. Atomic coordinates ($\times 10^5$ for non-hydrogen atoms, $\times 10^4$ for H atoms)

	x	y	z
S(1)	21881 (9)	63569 (11)	44700 (4)
N(1)	33518 (27)	52415 (36)	47149 (13)
N(2)	41723 (30)	31247 (37)	51709 (12)
O(1)	11596 (23)	64564 (33)	48750 (11)
O(2)	28492 (25)	77191 (30)	43392 (11)
O(3)	60918 (36)	80606 (50)	31057 (16)
O(4)	53495 (30)	69274 (40)	22547 (14)
O(5)	-6877 (28)	42909 (38)	21798 (12)
O(6)	-18675 (25)	42825 (37)	31590 (12)
C(1)	14164 (34)	56670 (43)	37672 (15)
C(2)	21013 (36)	56014 (43)	32538 (16)
C(3)	13763 (38)	51507 (49)	27130 (17)
C(4)	699 (38)	47359 (48)	26887 (16)
C(5)	-5817 (37)	47568 (46)	32210 (16)
C(6)	926 (34)	52416 (46)	37526 (15)
C(7)	30773 (33)	38866 (44)	49303 (14)
C(8)	18670 (36)	31473 (49)	49450 (16)
C(9)	18134 (37)	17642 (49)	51882 (17)
C(10)	29372 (39)	10154 (45)	54348 (17)
C(11)	41081 (39)	17412 (46)	54111 (17)
C(12)	35421 (36)	59527 (46)	32276 (17)
C(13)	37981 (43)	74800 (54)	29615 (20)
C(14)	51972 (43)	75551 (52)	27933 (19)
C(15)	66847 (47)	67652 (57)	20789 (20)
C(16)	66173 (87)	66840 (89)	14103 (29)
C(17)	-811 (59)	43405 (80)	16184 (21)
C(18)	-26262 (49)	44571 (70)	36631 (21)
C(19)	28904 (56)	-4969 (58)	57176 (24)
H(1)	4297	5725	4792
H(3)	1867	5058	2387
H(6)	-328	5271	4096
H(8)	1120	3582	4785
H(9)	997	1275	5193
H(11)	4935	1301	5599
H(121)	4082	5959	3640
H(122)	3976	5216	3030
H(131)	3224	7698	2630
H(132)	3894	6604	2607
H(151)	7102	5956	2272
H(152)	7292	7618	2213
H(161)	7648	6418	1277
H(162)	6352	7450	1251
H(163)	5994	5823	1281
H(171)	790	3759	1632
H(172)	337	5374	1566
H(173)	-841	4006	1307
H(181)	-2123	3850	3988
H(182)	-3532	3988	3534
H(183)	-2648	5511	3749
H(191)	1932	-917	5665
H(192)	2742	-348	6085
H(193)	3665	-1179	5599

Table 2. Bond lengths [\AA ($\sigma \times 10^3$)]

S(1)—N(1)	1.604 (3)	O(6)—C(5)	1.367 (4)
S(1)—O(1)	1.443 (2)	O(6)—C(18)	1.425 (5)
S(1)—O(2)	1.440 (3)	C(1)—C(2)	1.390 (5)
S(1)—C(1)	1.787 (3)	C(1)—C(6)	1.394 (5)
N(1)—C(7)	1.348 (5)	C(2)—C(3)	1.405 (5)
N(2)—C(7)	1.369 (4)	C(2)—C(12)	1.502 (5)
N(2)—C(11)	1.358 (5)	C(3)—C(4)	1.373 (5)
O(3)—C(14)	1.179 (5)	C(4)—C(5)	1.406 (5)
O(4)—C(14)	1.343 (5)	C(5)—C(6)	1.376 (5)
O(4)—C(15)	1.452 (5)	C(7)—C(8)	1.399 (5)
O(5)—C(4)	1.363 (4)	C(8)—C(9)	1.360 (6)
O(5)—C(17)	1.441 (5)	C(9)—C(10)	1.390 (6)
C(10)—C(11)	1.361 (5)	C(10)—C(19)	1.501 (6)
C(12)—C(13)	1.528 (6)	C(13)—C(14)	1.503 (6)
C(15)—C(16)	1.479 (7)		

Table 3. Bond angles [$^\circ$ ($\sigma \times 10$)]

O(1)—S(1)—N(1)	112.4 (2)	O(2)—S(1)—N(1)	105.0 (2)
O(2)—S(1)—O(1)	116.8 (2)	C(1)—S(1)—N(1)	108.9 (2)
C(1)—S(1)—O(1)	106.4 (2)	C(1)—S(1)—O(2)	107.1 (2)
C(7)—N(1)—S(1)	121.1 (2)	C(11)—N(2)—C(7)	123.0 (3)
C(15)—O(4)—C(14)	118.1 (3)	C(17)—O(5)—C(4)	116.9 (3)
C(18)—O(6)—C(5)	117.9 (3)	C(2)—C(1)—S(1)	121.1 (3)
C(6)—C(1)—S(1)	117.2 (3)	C(6)—C(1)—C(2)	121.7 (3)
C(3)—C(2)—C(1)	116.7 (3)	C(12)—C(2)—C(1)	125.9 (3)
C(12)—C(2)—C(3)	117.4 (3)	C(4)—C(3)—C(2)	122.4 (3)
C(3)—C(4)—O(5)	125.3 (3)	C(5)—C(4)—O(5)	115.2 (3)
C(5)—C(4)—C(3)	119.5 (3)	C(4)—C(5)—O(6)	115.6 (3)
C(6)—C(5)—O(6)	125.2 (3)	C(6)—C(5)—C(4)	119.2 (3)
C(5)—C(6)—C(1)	120.4 (3)	N(2)—C(7)—N(1)	113.8 (3)
C(8)—C(7)—N(1)	130.5 (3)	C(8)—C(7)—N(2)	115.7 (3)
C(9)—C(8)—C(7)	120.9 (4)	C(10)—C(9)—C(8)	122.5 (4)
C(11)—C(10)—C(9)	116.0 (4)	C(19)—C(10)—C(9)	123.1 (4)
C(19)—C(10)—C(11)	120.9 (4)	C(10)—C(11)—N(2)	122.0 (4)
C(13)—C(12)—C(2)	114.0 (3)	C(14)—C(13)—C(12)	109.6 (4)
O(4)—C(14)—O(3)	122.5 (4)	C(13)—C(14)—O(3)	124.3 (4)
C(13)—C(14)—O(4)	113.1 (4)	C(16)—C(15)—O(4)	108.6 (5)

showed the positions of all the H atoms. These were included in the list, with the final isotropic thermal parameter (0.03 \AA^2), and two cycles of refinement of the non-hydrogen atoms gave $R = 0.075$. Each H atom was then assigned a U_{iso} equal to the average U_{ii} of the atom to which it was bonded and two cycles of refinement of the non-hydrogen atoms gave $R = 0.068$. Examination of the structure factors showed that seven reflections of low $\sin \theta/\lambda$ gave poor agreement between F_o and F_c with F_c greater than F_o in each case. These seven reflections were removed and a further two cycles of refinement gave $R = 0.062$. The H atom coordinates were now allowed to refine and five cycles of refinement gave a final $R = 0.058$.*

* Lists of structure factors and thermal parameters have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 33761 (21 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

and an electron-density map, calculated with the phases specified by these atoms, revealed the remaining non-hydrogen atoms of the molecule. Four cycles of full-matrix structure factor least-squares refinement with isotropic thermal parameters gave $R = 0.116$ (for 3106 reflections). Two cycles of structure factor least-squares refinement with anisotropic thermal parameters gave $R = 0.088$. An electron density difference map then

The atom coordinates, calculated bond lengths, angles and torsion angles are listed in Tables 1, 2, 3 and 4 respectively. An *ORTEP* drawing, showing the atom numbering scheme, is given in Fig. 1 (Johnson, 1971).

Discussion. The results of this study are comparable with those of related compounds (Hamodrakas, Filippakis & Sheldrick, 1977; Hamodrakas & Filippakis, 1977). The ester group, C(13), C(14), O(3), O(4), C(15) and C(16), is almost planar, with dimensions similar to other observations (Geddes, Hamodrakas & Sheldrick, 1974). The average C—C lengths are, in the phenyl ring, 1.391 (5) Å and, in the pyridine ring, 1.378 (5) Å and the average C—N length is 1.363 (5) Å. The methoxy groups, O(5)—C(17) and O(6)—C(18), are almost coplanar with the phenyl ring (torsion angles of 176.3 and -172.2° respectively) as observed previously (Hamodrakas, 1974). The bonds O(5)—C(4)

Table 4. *Torsion angles* (°)

C(5)—C(4)—O(5)—C(17)	176.3
C(4)—C(5)—O(6)—C(18)	-172.2
C(1)—C(2)—C(12)—C(13)	-102.2
C(2)—C(12)—C(13)—C(14)	-164.2
C(12)—C(13)—C(14)—O(3)	-96.0
C(12)—C(13)—C(14)—O(4)	81.4
C(13)—C(14)—O(4)—C(15)	-172.4
C(14)—O(4)—C(15)—C(16)	-155.9
C(2)—C(1)—S(1)—O(1)	172.4
C(2)—C(1)—S(1)—O(2)	46.9
C(2)—C(1)—S(1)—N(1)	-66.2
C(1)—S(1)—N(1)—C(7)	-71.2
S(1)—N(1)—C(7)—N(2)	-174.5

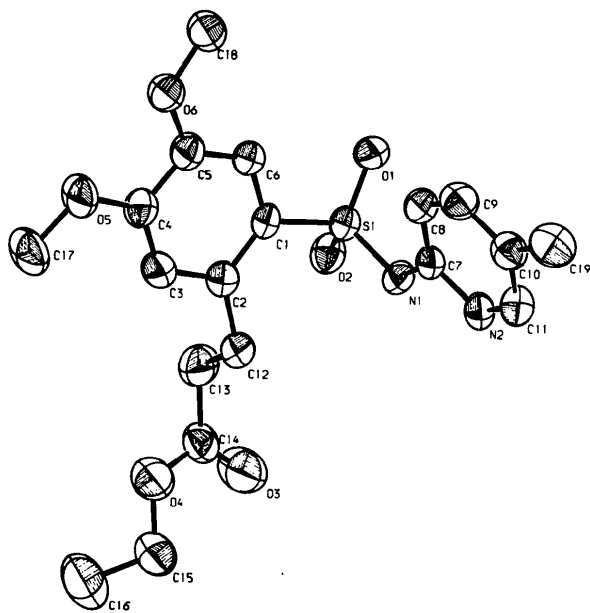


Fig. 1. *ORTEP* drawing of the molecule showing numbering of the atoms.

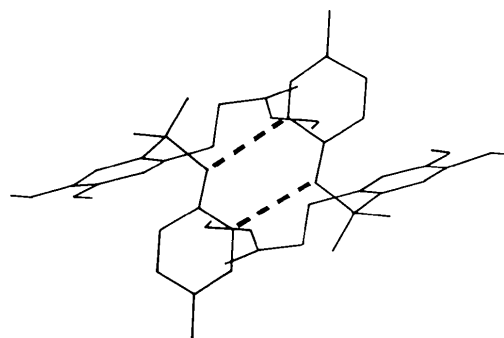


Fig. 2. Diagram of two symmetry-related molecules showing postulated hydrogen bonds.

and O(6)—C(5) have values of 1.363 (4) and 1.367 (4) Å respectively, indicating partial double-bond character (*cf.* Hamodrakas, 1974).

The tetrahedral conformation of the atoms around the S atom is distorted, with the O(1)—S(1)—O(2) angle being 116.8°, larger than the normal tetrahedral value, possibly due to repulsions between the sulphonamide O atoms O(1) and O(2). The S(1)—O(1) and S(1)—O(2) bond lengths of 1.443 (2) and 1.440 (3) Å indicate π -bond character of over 60% (Cruickshank, 1961) while the S(1)—C(1) and S(1)—N(1) bond lengths of 1.787 (3) and 1.604 (3) Å are close to values obtained for other sulphonamides (Kálmán, Duffin & Kucsman, 1971). Two molecules, related by a centre of symmetry, are probably held together by a pair of N(1)—H...N(2) hydrogen bonds [$N(1)\cdots N(2) = 2.900$ Å] as shown in Fig. 2 projected onto (001), with possible hydrogen bonds indicated by dashed lines.

References

- CAMOUTSIS, CH. & CATSOULAKOS, P. (1976). Private communication.
- CRUICKSHANK, D. W. J. (1961). *J. Chem. Soc.* pp. 5486–5504.
- GEDDES, A. J., HAMODRAKAS, S. & SHELDRIK, B. (1974). *Cryst. Struct. Commun.* **3**, 97–102.
- HAMODRAKAS, S. (1974). PhD Thesis, Univ. of Leeds.
- HAMODRAKAS, S. & FILIPPAKIS, S. E. (1977). *Cryst. Struct. Commun.* **6**, 301–306.
- HAMODRAKAS, S., FILIPPAKIS, S. E. & SHELDRIK, B. (1977). *Cryst. Struct. Commun.* **6**, 209–214.
- JOHNSON, C. K. (1971). *ORTEP*. Report ORNL-3794. Oak Ridge National Laboratory, Tennessee.
- KÁLMÁN, A., DUFFIN, B. & KUCSMAN, Á. (1971). *Acta Cryst.* **B27**, 586–594.
- LOMBARDINO, J. G. & WISEMAN, E. H. (1971). *J. Med. Chem.* **14**, 973–977.
- SHELDRIK, G. M. (1976). Private communication.
- SIANESI, E., REDAELLI, R., MAGISTRETTI, M. S. & MASSARANI, E. (1973). *J. Med. Chem.* **16**, 1133–1137.