We thank the SERC and Synthetic Chemicals Ltd for financial support.

References

Clegg, W. (1981). *Acta Cryst.* A37, 22-28.
Hedley, K. A. & Stanforth, S. P. (1992). *Tetrahedron*, 48, 743-750.
Shawcross, A. P. & Stanforth, S. P. (1990). *J. Heterocycl. Chem.* 27, 367-369.
Sheldrick, G. M. (1990). *SHELXTL/PC User's Manual.* Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
Sheldrick, G. M. (1993). *SHELXL93. Program for the Refinement of Crystal Structures.* Univ. of Göttingen, Germany.
Stanforth, S. P. (1993). Unpublished results.
Stoe & Cie (1988). *DIF4. Diffractometer Control Program.* Revision 7.04. Stoe & Cie, Darmstadt, Germany.
Streith, J. & Fizet, C. (1977). *Tetrahedron Lett.* 37, 3297-3300.

Acta Cryst. (1994). C50, 585–587

6-Amino-5-[(*E*)-1,2-bis(methoxycarbonyl)-vinyl]-2-methoxy-3-methylpyrimidin-4(3*H*)-one

JOHN N. LOW AND CLARE EGGLISHAW

Department of Applied Physics and Electronic and Manufacturing Engineering, The University, Dundee DD1 4HN, Scotland

GEORGE FERGUSON

Department of Chemistry and Biochemistry, University of Guelph, Guelph, Ontario, Canada N1G 2W1

JUSTO COBO, CELESTE GARCIA, MANUEL MELGUIZO, MANUEL NOGUERAS AND ADOLFO SANCHEZ

Departamento de Quimica Organica, Facultad de Ciencias Experimentales, Campus de Jaen, E-23071 Jaen, Spain

(*Received* 1 *September* 1993; *accepted* 27 *October* 1993)

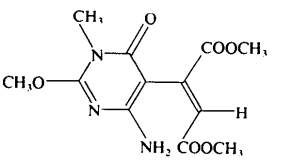
Abstract

The title compound, dimethyl 2-(6-amino-2-methoxy-3-methyl-4-oxo-3,4-dihydro-5-pyrimidyl)butenedioate, $C_{12}H_{15}N_3O_6$, contains a pyrimidine ring and a bis(methoxycarbonyl)vinyl moiety, the planes of which are inclined at an angle of 66.4 (1)°. The molecular dimensions are normal and show that the bonding in the pyrimidine ring is delocalized. The molecules are linked *via* intermolecular N—H···O=C hydrogen bonds [N···O 2.904 (3) and 3.219 (3) Å] to form a three-dimensional network.

Comment

5-Vinylpyrimidine derivatives have been studied because of interest in their pharmacologic activity (De Clerq & Walker, 1984). 6-Amino-5-[(*E*)-1,2-bis(methoxycarbonyl)vinyl]pyrimidine systems are intermediates in the synthesis of the pyrido[2,3-*d*]pyrimidine ring system, which is a part of many biologically active compounds including antitumour (Grivsky, Lee, Sigel, Duch & Nichol, 1980), antibacterial (Suzuki, 1980) and anticonvulsive (Kretzchmar, 1980) agents.

The 6-amino-5-[(*E*)-1,2-bis(methoxycarbonyl)vinyl]-2-methoxy-3-methylpyrimidin-4(3*H*)-one molecule (I) contains two main structural features: a pyrimidine ring and a bis(methoxycarbonyl)vinyl moiety (Fig. 1). A



(I)

search of the April 1993 release of the Cambridge Structural Database (Allen, Kennard & Taylor, 1983) revealed no similar molecules. A comparison with compounds containing pyrimidine, methoxycarbonyl and vinyl moieties showed that all the bond lengths and angles of the molecule lie within the expected ranges. The pyrimidine ring is planar to within two standard deviations and the bond lengths are consistent with substantial delocalization in the pyrimidine ring. In the bis(methoxycarbonyl)vinyl moiety, the C522, C51, C521 and C531 atoms are planar to within one standard deviation. The relative orientation of the pyrimidine ring

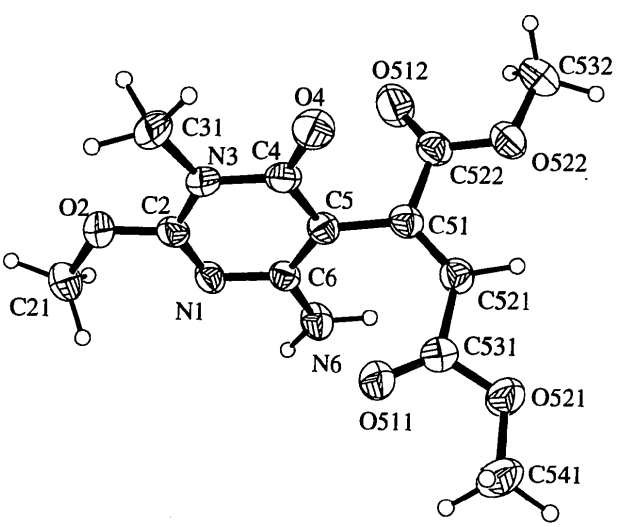


Fig. 1. An *ORTEPII* (Johnson, 1976) view of the molecule showing the numbering scheme. Non-H atoms are shown with displacement ellipsoids drawn at the 50% probability level. For clarity, the H atoms are drawn as small spheres of arbitrary size.

and the bis(methoxycarbonyl)vinyl moiety is defined by the C4—C5—C51—C522 and C6—C5—C51—C521 torsion angles [−65.2 (2) and −65.0 (2)°, respectively]. Intermolecular N—H···O=C hydrogen bonds link the molecules into a three-dimensional network.

Experimental

Crystal data

$C_{12}H_{15}N_3O_6$
M_r = 297.26
Monoclinic
Pc
a = 7.4731 (7) Å
b = 10.8843 (8) Å
c = 9.0286 (6) Å
β = 112.992 (7)°
V = 676.04 (9) Å^3
Z = 2
D_x = 1.460 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71067 Å
Cell parameters from 25 reflections
θ = 10.00–16.00°
μ = 0.11 mm^{-1}
T = 293 K
Plate
0.60 × 0.40 × 0.20 mm
Yellow

Data collection

Nonius CAD-4 diffractometer
$\theta/2\theta$ scans
Absorption correction: none
2098 measured reflections
2098 independent reflections
1850 observed reflections [$I_{net} > 3.0\sigma(I_{net})$]
θ_{max} = 29.90°
$h = -10 \rightarrow 9$
$k = 0 \rightarrow 15$
$l = 0 \rightarrow 12$
3 standard reflections
frequency: 120 min
intensity variation: <0.1%

Refinement

Refinement on F
R = 0.032
wR = 0.045
S = 1.25
1850 reflections
249 parameters
All H-atom parameters refined isotropically
$w = 1/[\sigma^2(F) + 0.0010F^2]$
$(\Delta/\sigma)_{max}$ = 0.005
$\Delta\rho_{max}$ = 0.23 e Å^{-3}
$\Delta\rho_{min}$ = −0.18 e Å^{-3}
Extinction correction: Larson (1970)
Extinction coefficient: 1043 (887)
Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV, Table 2.2B)

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

$U_{eq} = (1/3)\sum_i\sum_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	U_{eq}
N1	0.0480 (3)	0.17907 (14)	0.8405 (3)	0.0334 (6)
C2	−0.0665 (4)	0.12080 (15)	0.8925 (3)	0.0339 (8)
O2	0	0.03042 (14)	1	0.0463 (7)
C21	0.2039 (4)	0.00407 (24)	1.0582 (4)	0.0567 (12)
N3	−0.2593 (3)	0.14083 (15)	0.8480 (3)	0.0371 (7)
C31	−0.3755 (4)	0.07351 (25)	0.9205 (4)	0.0541 (13)
C4	−0.3517 (4)	0.23492 (16)	0.7360 (3)	0.0352 (8)
O4	−0.5259 (3)	0.25504 (16)	0.6988 (3)	0.0532 (9)
C5	−0.2298 (3)	0.30023 (15)	0.6763 (3)	0.0320 (7)
C51	−0.3235 (3)	0.39140 (16)	0.5482 (3)	0.0328 (7)
C521	−0.2857 (4)	0.51171 (17)	0.5551 (3)	0.0364 (8)
C531	−0.1527 (4)	0.57804 (17)	0.7010 (3)	0.0362 (9)
O511	−0.0660 (3)	0.53775 (15)	0.8334 (3)	0.0480 (9)
O521	−0.1447 (4)	0.69622 (15)	0.6629 (3)	0.0574 (10)
C541	−0.0305 (7)	0.7753 (3)	0.7937 (4)	0.0659 (19)
C522	−0.4640 (4)	0.33957 (18)	0.3903 (3)	0.0387 (8)
O512	−0.4775 (4)	0.23265 (17)	0.3604 (3)	0.0730 (12)
O522	−0.5637 (4)	0.42511 (16)	0.2864 (3)	0.0555 (9)
C532	−0.6851 (5)	0.3843 (3)	0.1266 (4)	0.0598 (14)
C6	−0.0336 (3)	0.27035 (15)	0.7299 (3)	0.0301 (7)
N6	0.0905 (3)	0.32675 (18)	0.6774 (3)	0.0410 (8)

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

N1—C2	1.292 (3)	C51—C522	1.512 (3)
N1—C6	1.371 (3)	C521—C531	1.490 (3)
C2—O2	1.3341 (23)	C531—O511	1.198 (3)
C2—N3	1.354 (3)	C531—O521	1.339 (3)
O2—C21	1.433 (3)	O521—C541	1.441 (3)
N3—C31	1.471 (4)	C522—O512	1.190 (3)
N3—C4	1.415 (3)	C522—O522	1.325 (3)
C4—O4	1.231 (3)	O522—C532	1.442 (4)
C4—C5	1.417 (3)	C6—N6	1.343 (3)
C5—C51	1.476 (3)	N6···O4^{i}	2.904 (3)
C5—C6	1.391 (3)	N6···O511^{ii}	3.219 (3)
C51—C521	1.336 (3)		
C2—N1—C6	116.83 (21)	C5—C51—C522	115.47 (16)
N1—C2—O2	121.01 (20)	C521—C51—C522	117.77 (20)
N1—C2—N3	126.31 (20)	C51—C521—C531	124.88 (20)
O2—C2—N3	112.69 (19)	C521—C531—O511	128.19 (18)
C2—O2—C21	117.07 (17)	C521—C531—O521	108.65 (20)
C2—N3—C31	122.17 (21)	O511—C531—O521	123.16 (21)
C2—N3—C4	119.62 (21)	C531—O521—C541	115.78 (22)
C31—N3—C4	118.08 (22)	C51—C522—O512	123.04 (23)
N3—C4—O4	119.50 (22)	C51—C522—O522	113.38 (18)
N3—C4—C5	115.35 (21)	O512—C522—O522	123.52 (25)
O4—C4—C5	125.15 (21)	C522—O522—C532	116.87 (21)
C4—C5—C51	117.16 (20)	N1—C6—C5	122.08 (21)
C4—C5—C6	119.80 (19)	N1—C6—N6	114.60 (21)
C51—C5—C6	122.85 (21)	C5—C6—N6	123.32 (19)
C5—C51—C521	126.56 (21)		

Symmetry codes: (i) $1+x, y, z$; (ii) $x, 1-y, z-\frac{1}{2}$.

Because of the small anomalous-scattering contributions for C, N and O atoms, it was not possible to determine the direction of the chiral axis for the crystal chosen for the data collection; calculations with the molecule and its inverse yielded the same R factors and were indistinguishable (Rogers, 1981). All H atoms were clearly visible in difference maps computed at an intermediate stage of refinement; they were included in the calculations and allowed to refine isotropically. Data collection and cell refinement: *CAD-4 Software* (Enraf-Nonius, 1989). Data reduction: *NRCVAX DATRD2* (Gabe, Le Page, Charland, Lee & White, 1989). Programs used to solve and refine structure: *NRCVAX SOLVER* and *NRCVAX LSTSQ*. Software used to prepare material for publication: *NRCVAX TABLES*.

GF thanks NSERC Canada for research grants.

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 71794 (19 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England. [CIF reference: HA1082]

References

Allen, F. H., Kennard, O. & Taylor, R. (1983). *Acc. Chem. Res.* **16**, 146–153.
De Clerq, E. & Walker, R. T. (1984). *Pharmacol. Ther.* **26**, 1–44.
Enraf-Nonius (1989). *CAD-4 Software*. Version 5.0. Enraf-Nonius, Delft, The Netherlands.

Gabe, E. J., Le Page, Y., Charland, J.-P., Lee, F. L. & White, P. S. (1989). *J. Appl. Cryst.* **22**, 384-387.
Grivsky, E. M., Lee, S., Sigel, C. W., Duch, D. S. & Nichol, C. A. (1980). *J. Med. Chem.* **23**, 327-329.
Johnson, C. K. (1976). *ORTEP*II. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.
Kretzchmar, E. (1980). *Pharmazie*, **35**, 253-255.
Larson, A. C. (1970). *Crystallographic Computing*, edited by F. R. Ahmed, S. R. Hall & C. P. Huber, pp. 291-294. Copenhagen: Munksgaard.
Rogers, D. (1981). *Acta Cryst.* A**37**, 734-741.
Suzuki, N. (1980). *Chem. Pharm. Bull.* **28**, 761-763.

Acta Cryst. (1994). C**50**, 587–589

Stable Conformations of Hinokitiol and Tropolone

HIROFUMI OHISHI, HIROSHI TSUJIBO, MASATOSHI INOUE AND YOSHIHIKO INAMORI*

Osaka University of Pharmaceutical Sciences, 2-10-65 Kawai, Matsubara, Osaka 580, Japan

NAKAO ISHIDA

The Sendai Institute of Microbiology, Toho Seimei Building 6F, Ichiban-cho 2-5-22, Aoba-ku, Sendai 980, Japan

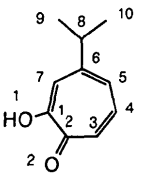
(*Received* 21 *December* 1992; *accepted* 2 *August* 1993)

Abstract

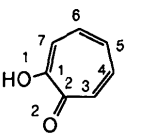
Hinokitiol (6-isopropyltropolone; IUPAC nomenclature: 2-hydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one; $C_{10}H_{12}O_2$) has strong insecticidal and phytogrowth-inhibitory activities, and has a much more stable conformation than related brominated compounds. The hinokitiol molecule adopts a planar form and the two O atoms are hydrogen bonded to symmetry-related molecules. Furthermore, the tropolone ring is stacked with another symmetry-related tropolone ring, so that the molecule may be stabilized by resonance energy.

Comment

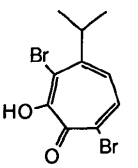
Hinokitiol (I) (Nozoe, 1936), one of the tropolone (II) (Dewar, 1945) related compounds, was isolated by T. Nozoe from the wood of *Chamacyparis taiwanesis*. Since then the compound has been reported to show the following biological activities: phytogrowth-inhibitory activity (Inamori *et al.*, 1991), antimicrobial effects (Okazaki & Homma, 1953; Taga & Ozaki, 1955; Katsura, Tamura, Hatori & Maeda, 1948; Shibasaki & Terui, 1955; Erdtmann & Gripenberg, 1948), plant growth stimulation, and repellent effects on ticks. (II) was also found to have inhibitory activity on tumour cells *in vitro* (Yamato, Hashigaki, Kokubu, Tsuruo & Tashiro, 1984; Yamato, Hashigaki, Kokubu, Tashiro & Tsuruo, 1986) and exterminatory effects on termites on logs. Recently, the authors reported the inhibitory effect of both compounds on the growth of mammalian cells and on blastogenesis of mouse splenic T cells (Inamori *et al.*, 1993). There have been many reports on the chemical reactions of (II) because of its unique chemical structure. Regarding compound (I), only three structures of hinokitiol derivatives [3,7-dibromohinokitiol (III) (Ito, Fukazawa & Iitaka, 1972*a*); 3,5,7-tribromohinokitiol (IV) and 5,7-dibromohinokitiol (Ito, Fukazawa & Iitaka, 1972*b*)] have been determined by X-ray diffraction methods; furthermore, conformational data about 5,7-dibromohinokitiol were not reported. We cannot clarify the mechanisms of biological activity of hinokitiol, because the structure of hinokitiol is still unknown.



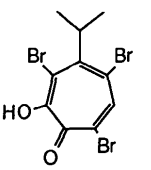
(I)



(II)



(III)



(IV)

The molecular structure of 4-isopropyltropolone has been reported (Derry & Hamor, 1972). Since hinokitiol is extracted from different material to 4-isopropyltropolone and the activities of those materials are different, we have not compared hinokitiol with 4-isopropyltropolone.

In this work, as a preliminary step to elucidating the relationship between the biological activity of hinokitiol and its conformation, we analysed the structure of hinokitiol by X-ray diffraction. The molecular structure of hinokitiol including H atoms is presented in Fig. 1. Bond distances and angles coincide, to within experimental error, with those of 3,7-dibromohinokitiol and 3,5,7-tribromohinokitiol. Torsion angles involving non-H atoms are listed in Table 2. Side drawings viewed from the C6—C7 bonds of the three compounds are shown in Fig. 2. A stereoscopic diagram of the crystal packing of