The authors would also like to thank the Malaysian Government for research grant R&D No. 190-9609-2801. KC thanks the Universiti Sains Malaysia for a Visiting Postdoctoral Fellowship.

Supplementary data for this paper are available from the IUCr electronic archives (Reference: SK1283). Services for accessing these data are described at the back of the journal.

References

Allen, F. H., Kennard, O., Watson, D. G., Brammer, L., Orpen, A. G. & Taylor, R. (1987). *J. Chem. Soc. Perkin Trans.* 2, pp. S1–19.
Bunce, R. A. (1995). *Tetrahedron*, **51**, 13013–13159.
Duax, W. L., Weeks, C. M. & Rohrer, D. C. (1976). *Topics in Stereochemistry*, Vol. 9, edited by N. L. Allinger & E. L. Eliel, pp. 271–383. New York: John Wiley.
Sarkar, T. K., Ghosh, S. K., Nandy, S. K. & Chow, T. J. (1999). *Tetrahedron Lett.* **40**, 397–398.
Sheldrick, G. M. (1996). *SADABS. Program for Empirical Absorption Correction of Area Detector Data.* University of Göttingen, Germany.
Sheldrick, G. M. (1997). *SHELXTL. Structure Determination Software Programs.* Version 5.10. Bruker Analytical X-ray Systems Inc., Madison, Wisconsin, USA.
Siemens (1996). *SMART* and *SAINT. Area Detector Control and Integration Software.* Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
Spek, A. L. (1990). *Acta Cryst.* A**46**, C-34.
Tietze, L. F. (1996). *Chem. Rev.* **96**, 115–136.

Acta Cryst. (1999). C**55**, 1140–1142

Trimethyl (5*SR*,6*SR*)-1,3-dichloro-8-diethylamino-5,6-dihydro-5-hydroxyisoquinoline-5,6,7-tricarboxylate

TARUN KUMAR SARKAR,[a] SUNIL KUMAR GHOSH,[a] GUR DAYAL NIGAM,[b] KANDASAMY CHINNAKALI[c]† AND HOONG-KUN FUN[c]

[a]*Department of Chemistry, Indian Institute of Technology, Kharagpur 721 302, West Bengal, India,* [b]*Department of Physics and Meteorology, Indian Institute of Technology, Kharagpur 721 302, West Bengal, India, and* [c]*X-ray Crystallography Unit, School of Physics, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia. E-mail: hkfun@usm.my*

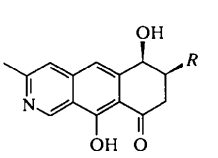
(*Received 3 February 1999; accepted 22 February 1999*)

Abstract

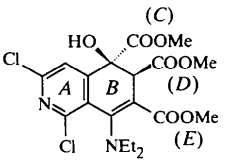
The title compound, $C_{19}H_{22}Cl_2N_2O_7$, has four independent molecules in the asymmetric unit with no pseudo-symmetry. In each of the four molecules the fused cyclohexadiene ring adopts a skew-boat conformation, with two of the three methoxycarbonyl groups in the axial orientation and the third methoxycarbonyl and the diethylamino groups attached equatorially. The hydroxyl groups are involved in O—H···O intermolecular hydrogen bonds with carbonyl-O atoms to form infinite chains in the [2$\bar{1}$0] direction.

Comment

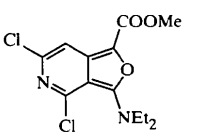
Pyrenophora teres, the causative fungus of net blotch disease, is a significant pathogen of barley (*Hordeum vulgare*). Net blotch disease occurs wherever barley is grown in temperate and humid regions of the world (Dickson, 1956). Diseases such as net blotch have received increasing attention in view of the growing popularity of barley (Shipton *et al.*, 1973). Several research groups have previously isolated bioactive compounds from *Pyrenophora teres* (Nukina *et al.*, 1980; Gordon & Webster, 1985; Smedegard-Peterson, 1977). Recently, two novel phytotoxic isoquinoline derivatives, pyrenoline A, (I), and pyrenoline B, (II), have been isolated from the culture fluid of *Pyrenophora teres* and characterized by spectroscopic and X-ray diffraction techniques (Coval *et al.*, 1990). In view of their significant biological activities, pyrenoline A and pyrenoline B are considered to be good candidates for a structure–activity relationship investigation. Accordingly, a synthetic program was undertaken which would allow preparation of large amounts of pyrenoline A and B and their congeners. During the course of this work, we have synthesized the title triester, (III), from the Diels–Alder reaction of (IV) (Sarkar *et al.*, 1999) with dimethyl fumarate. The X-ray structure determination of compound (III) was undertaken in order to establish the relative stereochemistry of the two stereogenic centres, which could not be ascertained by spectroscopic techniques.



(I) *R*=OMe
(II) *R*=H



(III)



(IV)

The asymmetric unit of compound (III) consists of four independent molecules, *A*, *B*, *C* and *D*, without

† On leave from: Department of Physics, Anna University, Chennai 600 025, India.

any pseudosymmetry. Except for significant deviations in the C4—C5—C10 and C12—C6—C7 bond angles, the corresponding bond lengths and angles of the four molecules are in close agreement. The torsion angles (Table 1) indicate that the orientations of the methoxycarbonyl groups at C5 and C6 are completely different in the four molecules.

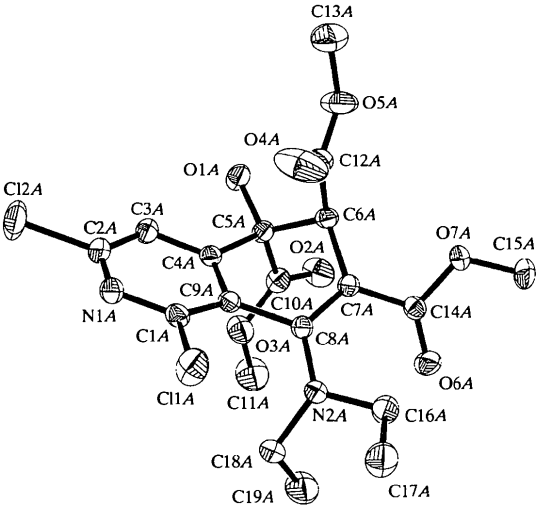


Fig. 1. The structure of (III) showing 50% probability displacement ellipsoids and the atom-numbering scheme. For clarity, only one of the four molecules in the asymmetric unit is shown.

In each of the independent molecules, the pyridine ring is planar and the fused cyclohexadiene ring adopts a skew-boat conformation with the asymmetry parameter ΔC_2(C6—C5) = 0.022 (1), 0.004 (1), 0.014 (1) and 0.025 (1), respectively (Nardelli, 1983). The individual methoxycarbonyl groups are nearly planar. In all four molecules the hydroxy, ethylamino and one of the methoxycarbonyl (C7—C14) groups are attached in the equatorial positions and the remaining methoxycarbonyl groups occupy the axial positions. The dihedral angles formed by the pyridine ring and the four-atom plane (excluding the attached ring atom) of the methoxycarbonyl groups with the mean plane through all six atoms in the cyclohexadiene ring are given in Table 2. In the solid state, the hydroxy groups are involved in O—H···O intermolecular hydrogen bonds with the carbonyl atom O6 to form infinite $\cdots A\cdots B\cdots C\cdots D\cdots A\cdots$ molecular chains running in the [2$\bar{1}$0] direction (Table 3).

Experimental

A solution of (IV) and dimethyl fumarate in benzene was stirred at room temperature under an atmosphere of argon. The solvent was evaporated under vacuum and the residue was purified by chromatography on silica gel. Elution with ethyl acetate–petroleum ether (1:5) gave a yellow solid which was crystallized from dichloromethane–petroleum ether (333–353 K) to give shiny pale-yellow crystals (m.p. 422–423 K).

Crystal data

$C_{19}H_{22}Cl_2N_2O_7$
M_r = 461.29
Triclinic
$P\bar{1}$
a = 11.9440 (2) Å
b = 16.5410 (3) Å
c = 24.4068 (4) Å
α = 71.432 (1)°
β = 78.541 (1)°
γ = 74.630 (1)°
V = 4372.89 (13) Å^3
Z = 8
D_x = 1.401 Mg m^{-3}
D_m not measured

Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 7809 reflections
θ = 0.89–28.28°
μ = 0.339 mm^{-1}
T = 293 (2) K
Parallelepiped
0.42 × 0.40 × 0.36 mm
Yellow

Data collection

Siemens SMART CCD area-detector diffractometer
ω scans
Absorption correction: empirical multi-scan using *SADABS* (Sheldrick, 1996)
T_{min} = 0.871, T_{max} = 0.888
34 885 measured reflections
20 392 independent reflections

10 941 reflections with $I > 2\sigma(I)$
R_{int} = 0.044
θ_{max} = 28.28°
h = −15 → 15
k = −20 → 20
l = 0 → 32
Intensity decay: negligible

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.055
$wR(F^2)$ = 0.168
S = 1.006
20 392 reflections
1105 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0729P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 0.42 e Å^{-3}
$\Delta\rho_{min}$ = −0.30 e Å^{-3}
Extinction correction: none
Scattering factors from *International Tables for Crystallography* (Vol. C)

Table 1. *Selected geometric parameters (Å, °)*

O1*A*—C5*A*	1.412 (3)	O1*C*—C5*C*	1.416 (3)
O2*A*—C10*A*	1.202 (3)	O2*C*—C10*C*	1.189 (3)
N1*A*—C2*A*	1.310 (3)	N1*C*—C2*C*	1.318 (4)
N1*A*—C1*A*	1.330 (3)	N1*C*—C1*C*	1.325 (3)
N2*A*—C8*A*	1.371 (3)	N2*C*—C8*C*	1.374 (3)
C7*A*—C8*A*	1.366 (3)	C7*C*—C8*C*	1.366 (3)
O1*B*—C5*B*	1.411 (3)	N1*D*—C2*D*	1.323 (3)
O2*B*—C10*B*	1.204 (3)	N1*D*—C1*D*	1.337 (3)
C1*B*—N1*B*	1.331 (3)	N2*D*—C8*D*	1.379 (3)
C2*B*—N1*B*	1.314 (4)	O1*D*—C5*D*	1.414 (3)
C7*B*—C8*B*	1.367 (3)	O2*D*—C10*D*	1.199 (3)
C8*B*—N2*B*	1.378 (3)	C7*D*—C8*D*	1.365 (3)
C4*A*—C5*A*—C10*A*	112.8 (2)	C4*C*—C5*C*—C10*C*	109.1 (2)
C12*A*—C6*A*—C7*A*	114.3 (2)	C12*C*—C6*C*—C7*C*	116.5 (2)
C4*B*—C5*B*—C10*B*	112.4 (2)	C4*D*—C5*D*—C10*D*	109.3 (2)
C12*B*—C6*B*—C7*B*	119.5 (2)	C12*D*—C6*D*—C7*D*	115.1 (2)

C4A—C5A—C10A—O2A	−173.3 (3)
C5A—C6A—C12A—O4A	86.5 (4)
C4B—C5B—C10B—O2B	−169.7 (3)
C5B—C6B—C12B—O4B	−58.4 (4)
C4C—C5C—C10C—O2C	16.5 (4)
C5C—C6C—C12C—O4C	−72.1 (4)
C4D—C5D—C10D—O2D	17.3 (4)
C5D—C6D—C12D—O4D	92.9 (3)

Table 2. *Dihedral angles (°)*

Plane†	Plane	Molecule *A*	Molecule *B*	Molecule *C*	Molecule *D*
(*A*)	(*B*)	23.4 (1)	23.2 (1)	24.0 (1)	21.6 (1)
(*B*)	(*C*)	81.6 (2)	80.7 (1)	78.0 (2)	82.7 (1)
(*B*)	(*D*)	79.3 (2)	89.0 (1)	82.7 (2)	81.1 (1)
(*B*)	(*E*)	55.7 (1)	57.8 (1)	51.1 (1)	54.1 (1)

† Planes (*A*) to (*E*) are as defined in the scheme.

Table 3. *Hydrogen-bonding geometry (Å, °)*

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O1*B*—H1*BA*···O6*C*^{i}	0.82	2.06	2.836 (3)	159
O1*A*—H1*AA*···O6*B*^{ii}	0.82	1.95	2.755 (3)	166
O1*D*—H1*DB*···O6*A*	0.82	1.95	2.738 (3)	160
O1*C*—H1*CA*···O6*D*^{iii}	0.82	2.00	2.782 (3)	159
C13*A*—H13*C*···Cl2*A*^{iv}	0.96	2.78	3.675 (5)	154

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

The asymmetric unit contains four independent molecules (*A*–*D*), with their individual centroids at (0.738,0.180,−0.381), (1.154,0.855,−0.108), (0.712,0.684,0.627) and (0.202,0.358,−0.122), respectively. The molecules are in two pairs (*A*/*C* and *B*/*D*) and the relationship within a pair is close to a shift of 0.5 along the *b* axis. However, halving the *b* axis is not likely since the reflections with *k* odd are not weak, and the orientations of the methoxycarbonyl groups at C5 and C6 are significantly different within each pair.

Data collection: *SMART* (Siemens, 1996). Cell refinement: *SAINT* (Siemens, 1996). Data reduction: *SAINT*. Program(s) used to solve structure: *SHELXTL* (Sheldrick, 1997). Program(s) used to refine structure: *SHELXTL*. Molecular graphics: *SHELXTL*. Software used to prepare material for publication: *SHELXTL* and *PARST* (Nardelli, 1995).

The authors would like to thank the Malaysian Government for research grant R&D No. 190-9609-2801. TKS and SKG thank the CSIR and DST, New Delhi, India, for financial assistance. KC thanks the Universiti Sains Malaysia for a Visiting Postdoctoral Fellowship. Drs S. Djuric and T. S. Yim (Abbott, USA) are also thanked for their help.

Supplementary data for this paper are available from the IUCr electronic archives (Reference: LN1080). Services for accessing these data are described at the back of the journal.

References

Coval, S. J., Hradil, C. M., Lu, H. S. M., Clardy, J., Satouri, S. & Strobel, G. A. (1990). *Tetrahedron Lett.* **31**, 2117–2120.
Dickson, J. G. (1956). In *Diseases of Field Crops*, 2nd ed. New York: McGraw-Hill.
Gordon, T. R. & Webster, R. K. (1985). *Can. J. Microbiol.* **32**, 69–71.
Nardelli, M. (1983). *Acta Cryst.* C**39**, 1141–1142.
Nardelli, M. (1995). *J. Appl. Cryst.* **28**, 659.
Nukina, M., Sassa, T. & Ikeda, M. (1980). *Tetrahedron Lett.* **21**, 301–302.
Sarkar, T. K., Ghosh, S. K., Nandy, S. K. & Chow, T. J. (1999). *Tetrahedron Lett.* In the press.
Sheldrick, G. M. (1996). *SADABS. Program for Empirical Absorption Correction of Area Dectector Data.* University of Göttingen, Germany.
Sheldrick, G. M. (1997). *SHELXTL. Structure Determination Software Programs.* Version 5.1. Bruker Analytical X-ray Systems Inc., Madison, Wisconsin, USA.
Shipton, W. A., Khan, T. N. & Boyd, W. J. R. (1973). *Plant Pathol.* **52**, 269–290.
Siemens (1996). *SMART* and *SAINT. Area Detector Control and Integration Software.* Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.
Smedegard-Peterson, V. (1977). *Physiol. Plant Pathol.* **10**, 203–211.

Acta Cryst. (1999). C**55**, 1142–1144

Imidazole-4-acetic acid monohydrate

NOBUO OKABE AND TOMOMI HAYASHI

Faculty of Pharmaceutical Sciences, Kinki University, Kowakae 3-4-1, Higashiosaka, Osaka 577, Japan. E-mail: okabe@phar.kindai.ac.jp

(*Received 24 December 1998; accepted 11 March 1999*)

Abstract

The title compound, $C_5H_6N_2O_2\cdot H_2O$, is a zwitterion (imidazolio-4-acetate monohydrate) consisting of a carboxylate group and a protonated imidazole ring. The carboxylate group is nearly perpendicular to the imidazole plane. The molecules are linked by a three-dimensional hydrogen-bond network through the water molecule.

Comment

Imidazole-4-acetic acid (IAA) is a catabolite of histamine and is present in the brain (Khandelwal *et al.*, 1989; Prell & Morrishow, 1989; Prell *et al.*, 1996), although its precursor(s) in the brain is yet unknown (Prell & Morrishow, 1997). It is also a γ-aminobutyric acid (GABA) agonist (Godfraind *et al.*, 1973; Haas *et al.*, 1973) and acts at the GABA receptor. The crystal structure of IAA has already been analyzed in the hydrochloride form, in which the carboxyl group was not ionized and the imidazole ring was not protonated. The crystal structures of GABA show that this acid is zwitterionic, as in α-amino acids, and does not have a planar carbon skeletal conformation (Tomita, 1971; Tomita *et al.*, 1971, 1973; Craven & Weber, 1983; Weber *et al.*, 1983; Dobson & Gerkin, 1996). For these reasons, we redetermined the crystal structure