C7—N2—C8	119.6 (3)	N2—C8—C9	101.6 (3)
C9—N3—C10	112.7 (3)	O1—C9—N3	125.1 (4)
C9—N3—C11	123.8 (4)	O1—C9—C8	128.2 (4)
C10—N3—C11	123.2 (4)	N3—C9—C8	106.8 (4)
C6—C1—C2	120.8 (4)	N2—C10—N3	106.3 (3)
C6—C1—S1	110.7 (3)	N2—C10—S2	128.8 (3)
C2—C1—S1	128.4 (3)	N3—C10—S2	124.9 (3)
C3—C2—C1	117.8 (4)	N3—C11—C12	111.7 (3)
C2—C3—C4	121.4 (5)	O2—C12—O3	125.5 (4)
C5—C4—C3	121.2 (5)	O2—C12—C11	124.2 (4)
C4—C5—C6	118.3 (4)	O3—C12—C11	110.3 (4)
C5—C6—C1	120.4 (4)	C12—O3—C13	117.1 (4)
C5—C6—N1	124.8 (4)		

The structure was solved by Patterson methods using *SHELX*86 (Sheldrick, 1990) and refined by least squares with *SHELXL*93 (Sheldrick, 1993). Calculations were carried out using *PARST* (Nardelli, 1983), which was also used to prepare material for publication. The figure was produced with *ORTEP*II (Johnson, 1971).

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry, including H-atom geometry, have been deposited with the IUCr (Reference: HR1040). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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A 1,5-Diarylpyrrole Derivative

FIORELLA BACHECHI AND ENRICO GAVUZZO

Istituto di Strutturistica Chimica 'Giordano Giacomello', CNR, Area della Ricerca di Roma, PO Box 10, I-00016 Monterotondo Stazione, Roma, Italy

FELICE CERRETO AND MARCELLO SCALZO

Dipartimento di Studi di Chimica e Tecnologia delle Sostanze Biologicamente Attive, Facolta' di Farmacia, Università La Sapienza di Roma, Roma, Italy

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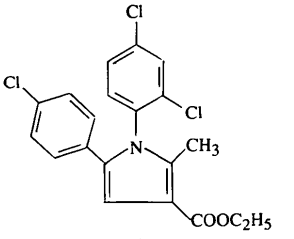
Abstract

The structure of the 1,5-diarylpyrrole derivative, ethyl 5-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-2-methyl-3-pyrrolecarboxylate, $C_{20}H_{16}Cl_3NO_2$, has been determined. The orientation assumed by the phenyl rings corresponds to the deepest of the two minima obtained from *ab initio* calculations. All bond distances and angles are in the expected ranges.

Comment

A large number of diarylpyrrole derivatives have been synthesized in order to develop new fungicides against *Candida* strains (Scalzo, Biava, Porretta & Cerreto, 1991; Cerreto, Villa, Retico & Scalzo, 1992). In the course of this study, the compound 5-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-3-(dimethylamino)-2-methylpyrrole, (1), along with some of its analogs, was found to be remarkably active. Studies of the structure–activity relationships of this class of compound (Scalzo *et al.*, 1991), together with structural analogies to some azole antifungal agents, suggested that their biological activity could be related to interactions with the heme group of the fungicide target enzyme (cytochrome P-450). In order to optimize the antifungal activity of these compounds, a computer graphic study was undertaken using (1) as a model structure. Several attempts were made to obtain crystals suitable for X-ray analysis. Finally, a crystal structure determination was undertaken on the title 1,5-diarylpyrrole derivative, ethyl 5-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-2-methyl-3-pyrrolecarboxylate, (2). Though inactive, compound (2) could give valuable information on the orientation of the phenyl rings, which is critical for the mode of interaction in the active site of the enzyme.



(2)

A view of the title compound projected onto the plane of the pyrrole ring is shown in Fig. 1. One phenyl ring, Ph1 (C6–C11), is almost perpendicular to the plane of the pyrrole ring (76°) and the other phenyl ring, Ph2 (C17–C22), is a little twisted out of this plane (28°). The dihedral angles in three pyrrole derivatives (De Kimpe, Sulmon, De Buyck, Verhe, Schamp, Declercq & Van Meerssche, 1984; Toupet, Mazari, Texier & Carrie, 1991), which describe the relative positions of the planes of adjacent phenyl rings, are given in Table 3. In these compounds, one phenyl ring is oriented similar to Ph1 in (2), while the other assumes a slightly different orientation with an increased inclination on the pyrrole plane. This feature is also present

in the conformations obtained from *ab initio* calculations, also reported in Table 3. The theoretical study of the possible energetic conformational minima was undertaken on a model structure of (1) having the geometry of compound (2), where the substituent group at atom C3 was considered irrelevant and substituted by an H atom. The intention was to detect all the possible orientations that the two phenyl rings can assume and also to approximately determine the relevant potential energy profiles of the isolated molecule. The analysis was computed as a function of the two internal rotation angles C2—N1—C6—C7 (φ_1) and N1—C5—C17—C18 (φ_2), using increments of 10° from 50 to 130° for φ_1 and from 0 to 180° for φ_2. The total energy, within the quantum mechanical framework, was computed by the HFR–MO–LCAO–SCF method (Hartree–Fock–Roothaan–molecular orbital–linear combination of atomic orbitals–self consistent field) of *GAUSSIAN*92 (Frisch *et al.*, 1992). The basis set used is a minimal one (Slater type orbitals, STO-3G).

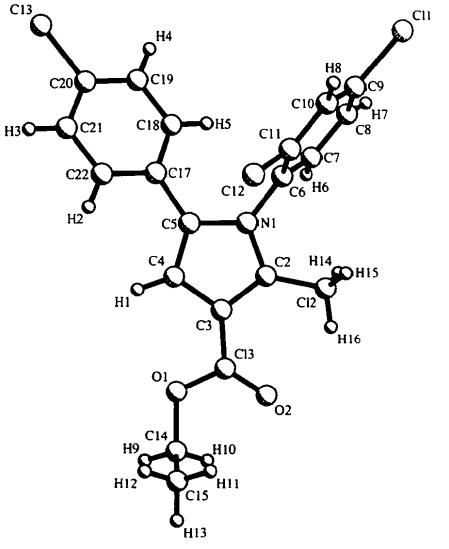


Fig. 1. A view of the title molecule showing the labelling of the non-H atoms.

Two independent minima were obtained with almost identical energies (within 0.42 kJ mol^{-1}). The deepest minimum corresponds to a conformation with torsion angles (φ_1 = 70 and φ_2 = 40°) similar to those found in the solid state of compound (2) (φ_1 = 81 and φ_2 = 29°). The other minimum corresponds to a conformation with a similar value of φ_1 but a different (by 90°) value of φ_2 (φ_1 = 100 and φ_2 = 130°). The potential barrier between these two minima is very low (less than 8.37 kJ mol^{-1}). Consequently, both conformations will be taken into account in the study of the interactions between compound (1) and the active site of the target enzyme.

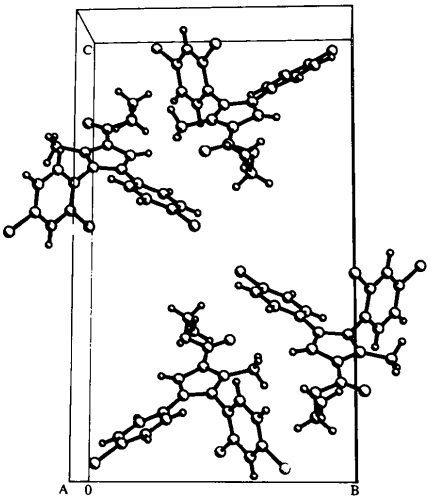


Fig. 2. A view of the crystal packing in the unit cell.

Experimental

The title compound was prepared as described by Cerreto, Villa, Retico & Scalzo (1992).

Crystal data

$C_{20}H_{16}Cl_3NO_2$
M_r = 408.71
Monoclinic
$P2_1/c$
a = 6.504 (2) Å
b = 13.121 (2) Å
c = 22.192 (2) Å
β = 92.37 (2)°
V = 1892.2 (7) Å^3
Z = 4
D_x = 1.434 Mg m^{-3}
Cu $K\alpha$ radiation
λ = 1.54178 Å
Cell parameters from 15 reflections
θ = 39.0–40.0°
μ = 4.594 mm^{-1}
T = 295 K
Prism
0.5 × 0.1 × 0.1 mm
Colorless

Data collection

Rigaku AFC-5*R* diffractometer
Profile data from ω–2θ scans
Absorption correction: *via* ψ scan at χ = 90° (North, Phillips & Mathews, 1968)
T_{min} = 0.78, T_{max} = 1.00
3046 measured reflections
2743 independent reflections
1955 observed reflections [$I > 3\sigma(I)$]
R_{int} = 0.027
θ_{max} = 62.0°
$h = 0 \rightarrow 6$
$k = 0 \rightarrow 15$
$l = -21 \rightarrow 21$
3 standard reflections monitored every 150 reflections
intensity decay: none

Refinement

Refinement on F
R = 0.048
wR = 0.064
S = 2.36
1955 reflections
235 parameters
$w = 1/\sigma^2(F)$
$(\Delta/\sigma)_{max}$ = 0.69
$\Delta\rho_{max}$ = 1.45 e Å^{-3}
$\Delta\rho_{min}$ = −1.65 e Å^{-3}
Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV, Tables 2.2A, 2.2C, 2.3.1)

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

$B_{eq} = (4/3)\Sigma_i\Sigma_j\beta_{ij}\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	B_{eq}
Cl1	0.8185 (2)	0.7468 (1)	0.02791 (5)	6.94 (7)
Cl2	0.1788 (2)	0.4999 (1)	0.06449 (5)	5.75 (6)
Cl3	0.8160 (2)	0.0747 (1)	0.03820 (6)	7.45 (8)
O1	−0.0855 (5)	0.3567 (2)	0.3204 (1)	5.9 (2)
O2	−0.0912 (5)	0.5267 (2)	0.3161 (1)	6.4 (2)
N1	0.3676 (5)	0.4742 (2)	0.1888 (1)	3.4 (1)
C2	0.2362 (6)	0.5142 (3)	0.2296 (2)	3.6 (2)
C3	0.1256 (6)	0.4347 (3)	0.2521 (2)	3.7 (2)
C4	0.1912 (6)	0.3443 (3)	0.2241 (2)	3.9 (2)
C5	0.3387 (6)	0.3681 (3)	0.1850 (2)	3.5 (2)
C6	0.4796 (6)	0.5367 (3)	0.1487 (2)	3.4 (2)
C7	0.6583 (6)	0.5844 (3)	0.1691 (2)	4.1 (2)
C8	0.7634 (6)	0.6487 (3)	0.1322 (2)	4.6 (2)
C9	0.6896 (7)	0.6641 (3)	0.0744 (2)	4.3 (2)
C10	0.5117 (7)	0.6183 (3)	0.0526 (2)	4.2 (2)
C11	0.4064 (6)	0.5546 (3)	0.0902 (2)	3.6 (2)
C12	0.2350 (7)	0.6255 (3)	0.2440 (2)	4.7 (2)
C13	−0.0240 (6)	0.4464 (3)	0.2982 (2)	4.5 (2)
C14	−0.2305 (8)	0.3602 (4)	0.3710 (2)	6.2 (3)
C15	−0.4353 (9)	0.3763 (4)	0.3442 (3)	7.4 (3)
C17	0.4594 (6)	0.3008 (3)	0.1467 (2)	3.5 (2)
C18	0.6597 (6)	0.3203 (3)	0.1313 (2)	4.4 (2)
C19	0.7694 (7)	0.2522 (3)	0.0974 (2)	4.9 (2)
C20	0.6790 (7)	0.1623 (3)	0.0795 (2)	4.6 (2)
C21	0.4812 (7)	0.1398 (3)	0.0942 (2)	4.8 (2)
C22	0.3726 (6)	0.2085 (3)	0.1277 (2)	4.2 (2)

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

Cl1—C9	1.736 (4)	C5—C17	1.475 (5)
Cl2—C11	1.721 (4)	C6—C7	1.380 (5)
Cl3—C20	1.739 (4)	C6—C11	1.383 (5)
O1—C14	1.497 (5)	C7—C8	1.375 (5)
O1—C13	1.344 (5)	C8—C9	1.367 (5)
O2—C13	1.213 (5)	C9—C10	1.374 (6)
N1—C2	1.375 (5)	C10—C11	1.383 (5)
N1—C5	1.407 (4)	C14—C15	1.452 (7)
N1—C6	1.432 (4)	C17—C18	1.384 (5)
C2—C3	1.372 (5)	C17—C22	1.394 (5)
C2—C12	1.495 (5)	C18—C19	1.385 (5)
C3—C4	1.413 (5)	C19—C20	1.369 (6)
C3—C13	1.449 (5)	C20—C21	1.373 (6)
C4—C5	1.356 (5)	C21—C22	1.380 (5)
C13—O1—C14	117.1 (3)	Cl1—C9—C10	119.0 (3)
C2—N1—C5	109.4 (3)	C8—C9—C10	121.6 (4)
C2—N1—C6	122.5 (3)	C9—C10—C11	118.9 (3)
C5—N1—C6	126.8 (3)	Cl2—C11—C6	119.9 (3)
N1—C2—C3	107.3 (3)	Cl2—C11—C10	119.5 (3)
N1—C2—C12	121.5 (3)	C6—C11—C10	120.6 (4)
C3—C2—C12	131.1 (3)	O1—C14—C15	107.0 (4)
C2—C3—C4	107.8 (3)	O1—C13—O2	121.5 (4)
C2—C3—C13	123.6 (3)	O1—C13—C3	112.7 (3)
C4—C3—C13	128.5 (3)	O2—C13—C3	125.8 (4)
C3—C4—C5	108.8 (3)	C5—C17—C18	124.1 (3)
N1—C5—C4	106.6 (3)	C5—C17—C22	118.4 (3)
N1—C5—C17	123.6 (3)	C18—C17—C22	117.3 (3)
C4—C5—C17	129.7 (3)	C17—C18—C19	121.8 (4)
N1—C6—C7	119.9 (3)	C18—C19—C20	119.3 (4)
N1—C6—C11	121.1 (3)	Cl3—C20—C19	119.9 (4)
C7—C6—C11	118.9 (3)	Cl3—C20—C21	119.3 (3)
C6—C7—C8	121.1 (3)	C19—C20—C21	120.7 (4)
C7—C8—C9	119.0 (4)	C20—C21—C22	119.6 (4)
Cl1—C9—C8	119.4 (3)	C17—C22—C21	121.3 (4)
C2—N1—C6—C7	80.6 (5)	N1—C5—C17—C18	28.9 (6)

Table 3. *Dihedral angles* (°) *formed by the phenyl rings in three pyrrole derivatives*

	Ph1[a]/Pyr[b]	Ph2[a]/Pyr[b]	Ph1[a]/Ph2[a]
DCDC[c]	79	54	72
MMMDC[d]	86	31	86
MMNDC[e]	68	58	82
Compound (2)[f]	76	28	76
Minimum energy (1)	66	40	68
Minimum energy (2)	85	51	75

Notes: (*a*) Ph1 and Ph2 are the least-squares planes of the phenyl rings; in compound (2) of the present work Ph1 is C7–C11 and Ph2 is C17–C22; (*b*) Pyr is the least-squares plane of the pyrrole ring; (*c*) DCDC is dimethyl 2-chloro-1,5-diphenyl-3,4-pyrroledicarboxylate (De Kimpe, Sulmon, De Buyck, Verhe, Schamp, Declercq & Van Meerssche, 1984); (*d*) MMMDC is methyl 2-methoxyphenyl-1-methyl-4,5-diphenyl-3-pyrrolecarboxylate (Toupet, Mazari, Texier & Carrie, 1991); (*e*) MMNDC is methyl 1-methyl-2-nitrophenyl-4,5-diphenyl-3-pyrrolecarboxylate (Toupet, Mazari, Texier & Carrie, 1991); (*f*) present work.

An ω-scan width of $(1.57 + 0.31\tan\theta)°$ and an ω-scan rate of 32° min^{-1} were used. Background counts were measured at the beginning and end of each scan, each for 50% of the total scan time. The weak reflections [$I < 6\sigma(I)$] were rescanned and the counts accumulated to ensure good counting statistics. The structure was solved by direct methods using *TEXSAN* (Molecular Structure Corporation, 1985) and refined by full-matrix least-squares methods. The H atoms were introduced at calculated positions and not refined. All the non-H atoms were refined anisotropically.

Data collection: *MSC/AFC Diffractometer Control Software* (Molecular Structure Corporation, 1988). Cell refinement: *MSC/AFC Diffractometer Control Software*. Data reduction: *TEXSAN* (Molecular Structure Corporation, 1985). Molecular graphics: *TEXSAN*.

The authors are grateful to Dr A. Talamo for performing the *ab initio* calculations at ICMAT-CNR (Rome).

Lists of structure factors, anisotropic displacement parameters and H-atom coordinates have been deposited with the IUCr (Reference: NA1117). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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Acta Cryst. (1995). C**51**, 1434–1435

(*Z*)-2-(4-Fluorophenyl)-3-(3-nitrophenyl)-5-phenylisoxazolidine: the Major Isomer Formed by 1,3-Dipolar Addition of an Arylnitrone to Styrene

R. E. Banks, R. A. DuBoisson, R. G. Pritchard and A. E. Tipping

Department of Chemistry, University of Manchester Institute of Science and Technology, PO Box 88, Manchester M60 1QD, England

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Abstract

In the title molecule, $C_{21}H_{17}FN_2O_3$, the five-membered ring adopts an envelope conformation, folded between sites 2 and 5, with a flap angle of 42.0°. This configuration places the three substituents in axial positions with the fluorophenyl group attached to the N atoms *trans* to the other two aromatic rings.

Comment

The structure determination reported here was carried out as part of a detailed investigation into 1,3-dipolar cycloadditions of fluorine-containing arylnitrones to alkenes to afford isoxazolidines (DuBoisson, 1986). Such additions involving nitrones of type ArCH=N$^+$(O$^-$)C$_6$H$_4$F-*p* (1) (Ar = C$_6$H$_5$, 4-HOC$_6$H$_4$, 4-MeOC$_6$H$_4$) gave mixtures of (*E*)- and (*Z*)-isoxazolidines which are oils. In order to determine which isomer was formed as the major product in these cycloadditions, the reaction with the nitrone (1*a*) (Ar = 3-O$_2$NC$_6$H$_4$) was carried out. This gave a solid mixture of the (*E*)- and (*Z*)-isoxazolidines, (2), from which the major isomer was obtained on crystallization and identified as the (*Z*)-isomer, (2*a*).

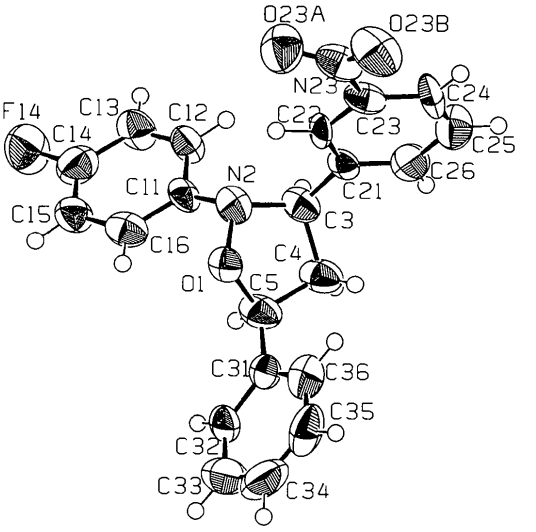
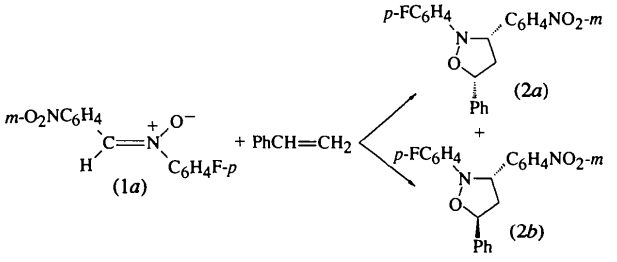


Fig. 1. The title molecule, including atomic numbering scheme, drawn using *ORTEP*II (Johnson, 1976). Displacement ellipsoids are plotted at the 50% probability level.

Experimental

A mixture of *N*-(4-fluorophenyl)-*C*-(3-nitrophenyl)nitrone (1*a*) (1.30 g, 5.00 mmol), toluene (20 ml) and styrene (0.52 g, 5.00 mol) was heated under reflux for 4 h. The solvent was removed from the hot mixture under reduced pressure and the residue was stored at 263 K for 3 d. Trituration of the resulting solid with light petroleum (b.p. 313–333 K) gave a pale buff, amorphous solid which was identified as a mixture of (*E*)- and (*Z*)-2-(4-fluorophenyl)-3-(3-nitrophenyl)-5-phenylisoxazolidine, (2) (ratio 8:94, ^{19}F NMR) (1.75 g, 4.81 mmol, 96%; found C 69.4, H 4.7, F 5.1, N 7.7%, M^+ 364: $C_{21}H_{17}FN_2O_3$ requires C 69.2, H 4.7, F 5.2, N 7.7%, *M* 364; m.p. 378–380 K). The major isomer was isolated by fractional crystallization (CCl_4/light petroleum 1:1 *v*/*v*) and identified as (*Z*)-2-(4-fluorophenyl)-3-(3-nitrophenyl)-5-phenylisoxazolidine, (2*a*) (found: C 69.2, H 4.7, F 5.2, N 7.6%, M^+ 364; m.p. 383–384 K).



Crystal data

$C_{21}H_{17}FN_2O_3$
M_r = 364.38
Monoclinic
$P2_1$
a = 5.556 (2) Å
b = 15.332 (4) Å
c = 10.427 (4) Å
β = 90.47 (2)°

Mo $K\alpha$ radiation
λ = 0.71069 Å
Cell parameters from 20 reflections
θ = 6.00–12.50°
μ = 0.0929 mm^{-1}
T = 296 K
Needle