Motherwell, W. D. S. & Clegg, W. (1978). *PLUTO. Program for Plotting Molecular and Crystal Structures.* University of Cambridge, England.
Nardelli, M. (1983). *Comput. Chem.* **7**, 95–98.
Sheldrick, G. M. (1976). *SHELX76. Program for Crystal Structure Determination.* University of Cambridge, England.
Sheldrick, G. M. (1985). *SHELXS86. Program for the Solution of Crystal Structures.* University of Göttingen, Germany.

Acta Cryst. (1996). C**52**, 1565–1570

Dimethyl 2,6-Dimethyl-4-(3-nitrophenyl)-pyridine-3,5-dicarboxylate, Diethyl 2,6-Dimethyl-4-(3-nitrophenyl)-1,4-dihydro-pyridine-3,5-dicarboxylate, and Diethyl 2,6-Dimethyl-4-(3-nitrophenyl)pyridine-3,5-dicarboxylate

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Abstract

The crystal structure of diethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate, $C_{19}H_{22}N_2O_6$ (FR7534), a member of the 1,4-dihydropyridine class of calcium blockers, and the crystal structures of diethyl 2,6-dimethyl-4-(3-nitrophenyl)-pyridine-3,5-dicarboxylate, $C_{19}H_{20}N_2O_6$, and dimethyl 2,6-dimethyl-4-(3-nitrophenyl)pyridine-3,5-dicarboxylate, $C_{17}H_{16}N_2O_6$, decomposition products of FR7534 and dimethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate, respectively, reveal that the decomposition products display conformational features associated with activity according to structure–activity relationships.

Comment

Compounds of the 1,4-dihydropyridine class exhibit calcium antagonistic activity, as they inhibit the influx of Ca^{2+} ions through plasma membrane channels (Núnez-Vergara, Sunkel & Squella, 1994). Compounds of this class are currently being used in the treatment of a variety of cardiovascular disorders, such as angina and hypertension (Triggle, Langs & Janis, 1989; Hurwitz, Partridge & Leach, 1991). Nifedipine [dimethyl 2,6-dimethyl-4-(2-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate], is the best known member of this class.

The basic 1,4-dihydropyridine (DHP) structure (Fig. 1) has been varied by (i) change of the alkyl groups at positions C2 and C6 to amide or extended alkyl amine groups (Arrowsmith, Campbell, Cross, Stubbs, Burges, Gardiner & Blackburn, 1986; Suzuki, Shiratori, Murayama, Harada, Miyano & Takeya, 1989), (ii) alteration of the ester groups at positions C3 and C5, or substitution of cyano and nitro groups at these positions, (iii) variation of the substituent on the phenyl ring and its position, and (iv) replacement of the H atom at N1 by alkyl or alkylcarboxylate groups (Triggle, Langs & Janis, 1989; Janis, Silver & Triggle, 1987).

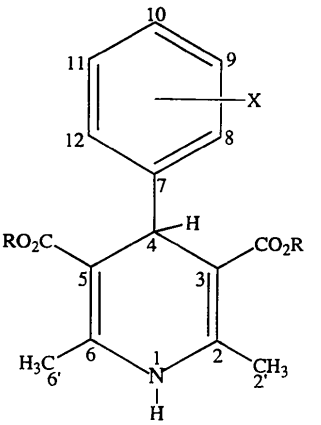


Fig. 1. 1,4-Dihydropyridine skeleton with our crystallographic numbering scheme.

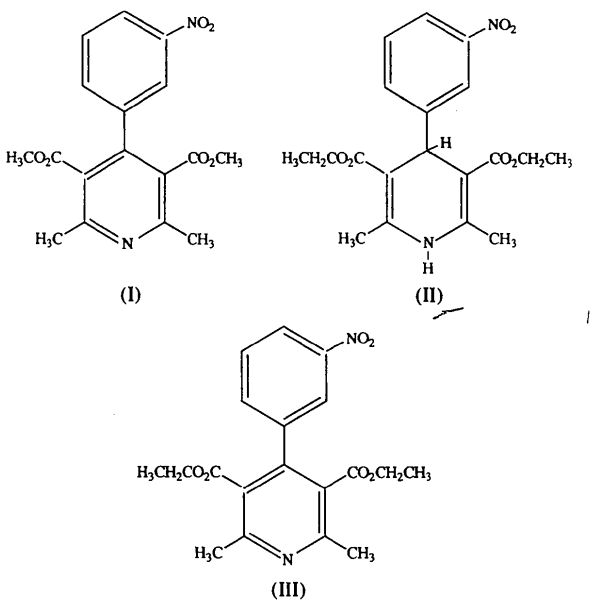
The structure–activity relationships (SAR's) of a number of these compounds have been documented. Factors associated with high activity include the presence of (*a*) the 1,4-dihydropyridine moiety with an H atom on N1, (*b*) alkyl groups (preferably methyl) substituted at the 2 and 6 positions, (*c*) ester groups at the 3 and 5 positions, and (*d*) a phenyl ring at position 4 with a substituent (preference $o > m > p$). The three-dimensional characteristics that correspond to high activity in this class of compounds are a flattened boat conformation of the DHP ring and a near perpendicular orientation of the phenyl ring with respect to the plane of the base of the DHP ring (Triggle, Langs & Janis, 1989; Morad, Goldmann & Trentham, 1983; Loev, Goodman, Snader, Tedeschi & Macko, 1974; Janis, Silver & Triggle, 1987).

Nifedipine and some of its derivatives undergo a photodecomposition sequence to form nitroso-pyridine derivatives (Núnez-Vergara, Sunkel & Squella, 1994; Sadana & Ghogare, 1991; Hayase, Itagaki, Ogawa, Akutsu, Inagaki & Abiko, 1994), which are then oxidized to the nitro-pyridine form. We have analyzed the solid-state structures of two decomposition products of nifedipine and have observed that these structures dis-

play many of the factors associated with activity (Rowan & Holt, 1995).

Oxidation of the 1,4-dihydropyridine ring to pyridine is reported to diminish activity significantly in some cases. However, some of the oxidized derivatives do display activity (Loev, Goodman, Snader, Tedeschi & Macko, 1974). A detailed study of the calcium-blocking efficiency of the parent compounds and their oxidized derivatives can lead to an understanding of the activity factors associated with the relative configurations of the two rings and the ester groups.

To observe the influence of moving the nitro group from the *ortho* to the *meta* position upon the structural parameters of the pharmaceutical and the decomposition product, we have performed the single crystal analysis of dimethyl 2,6-dimethyl-4-(3-nitrophenyl)pyridine-3,5-dicarboxylate, (I). The structure of its parent compound, dimethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate is known (Fossheim, Svarteng, Mostad, Romming, Shefter & Triggle, 1982). To observe the effect of a bulkier esterification group at positions 3 and 5, we have examined the solid-state structures of diethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate, (II), and its decomposition product, diethyl 2,6-dimethyl-4-(3-nitrophenyl)-pyridine-3,5-dicarboxylate, (III) (Fig. 2).



The structure of compound (II) (the drug FR7534) reflects the normal characteristics of this class of pharmaceutical compounds [including dimethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate, the unoxidized form of (I)]. The nitro group is only approximately coplanar with the phenyl ring and the carbonyl groups of the ester functional groups point in opposite directions, but both are coplanar with the C=C groups of the DHP ring.

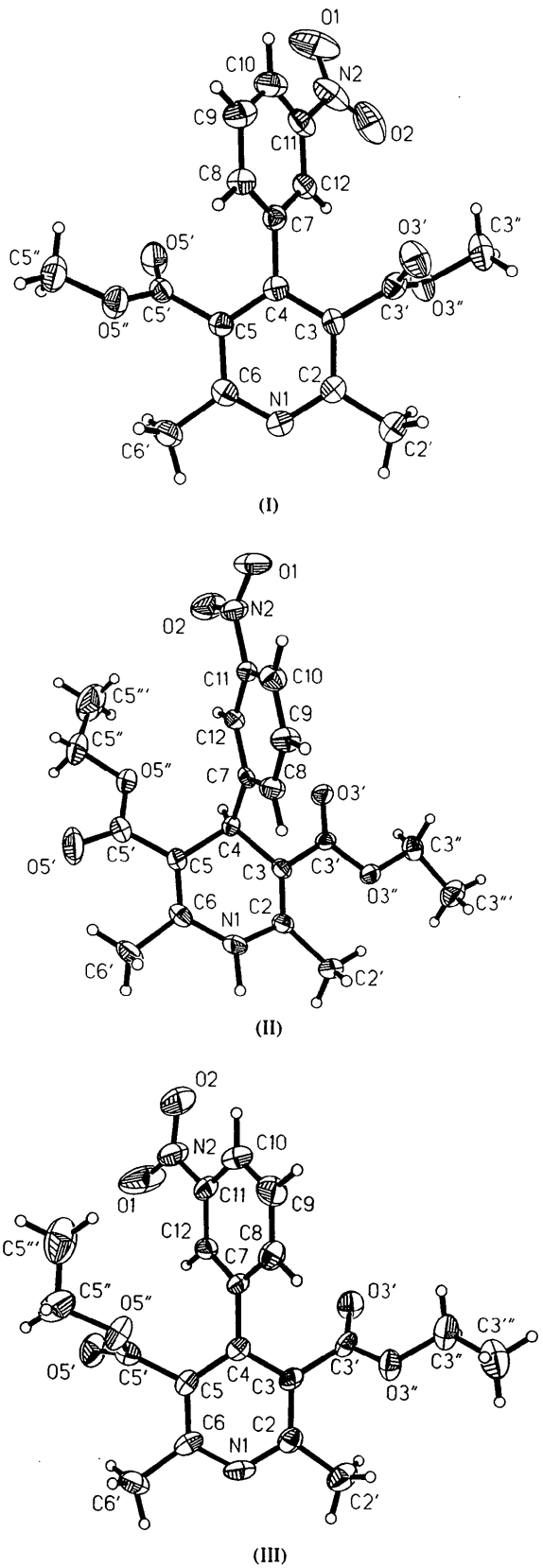


Fig. 2. Projection views of (I), (II) and (III).

Both decomposition products (I) and (III) show aromatization of the DHP ring with loss of H at N1, the NO_2 group greatly rotated from a coplanar position with the phenyl ring, and the carbonyl groups of the ester functional groups at C3 and C5 pointing in opposite directions but rotated from coplanarity with the pyridine ring [(I) 69.5(7), 59.2(7)°; (III) 67.5(7), 49.8(9)°].

In order to parameterize the conformations of the rings, tabulations of specific torsion angles are of use (Table 7). The SUM of the absolute values of the internal torsion angles of the hetero ring is a measure of its planarity. Published SAR's have indicated that increased planarity of this ring (SUM close to zero) correlates with higher activity of the compound. The decomposition products display SUM values of 5.19–12.6°, indicating the near planarities of these aromatic rings. The parent compounds, however, display a wide range (SUM = 52.1–90.2°), indicating a large variation in the degree of 'pucker' observed for these boat form rings.

Larger SUM values are observed, in general, for parent compounds with the nitro group in the *meta* position. This is an indication of the decreased planarity of the DHP ring and hence the lower activity of compounds with a *meta* substituent.

The conformation of the phenyl ring with respect to the hetero ring may be described in terms of the torsion angles about the C4—C7 bond (*i.e.* deviation from perfect bisection of the DHP/pyridine ring). All parent compounds crystallize with the substituents at C8 or C9 of the phenyl ring directed away from the open side of the boat form of the 1,4-dihydropyridine ring. Thus, the C3—C4—C7—C8 and C5—C4—C7—C8 angles for these compounds will be 60° in the idealized case (when the plane of the phenyl ring bisects the plane of the 1,4-dihydropyridine boat). The decomposition products will show idealized values of 90° for the C3—C4—C7—C8 and C5—C4—C7—C8 angles when the two rings are perpendicular (Fig. 3). Deviations from these values indicate a rotation of the phenyl ring about the C4—C7 bond. SAR's indicated that enhanced activity is associated with compounds in which the orientation of the phenyl ring is close to the bisecting position.

In nifedipine (*ortho*-NO_2), the deviation from bisection is 13.5° from the ideal value of 60°, whereas the two *meta*-NO_2 examples of Table 7 show analogous angles to be closer to the theoretical value for perpendicular orientation of the two rings. Thus, change of the substituent position from the *ortho* to *meta* position (reported to negatively influence the SAR) results in greater perpendicularity of the two rings (reported to be a positive factor for the SAR) (Triggle, Langs & Janis, 1989)

However, whereas a nifedipine decomposition product, isolated as a $CuCl_2$ complex, displays perpendicular conformation of the two aromatic rings, the *meta*-NO_2 decomposition products, compounds (I) and (III), show a greater than 30° deviation from perpendicularity.

Decomposition products (I) and (III) possess only the approximate conformation of the two rings that is associated with activity (*i.e.* approximately perpendicular). Aromatization of the 1,4-dihydropyridine ring results in the loss of the H atom at N1, removing any possible hydrogen-bonding interaction with the receptor site. However, the rotation of the 3,5 ester groups of (I) and (III) out of conjugation with the π bonds of the ring may permit increased hydrogen bonding to these groups.

Thus, structural changes on decomposition of pharmaceuticals of the 1,4-dihydropyridine class do not rule out pharmacological activity of these products. In fact they suggest that there should be residual activity, especially when the nitro substituent on the phenyl ring is in the *ortho* position.

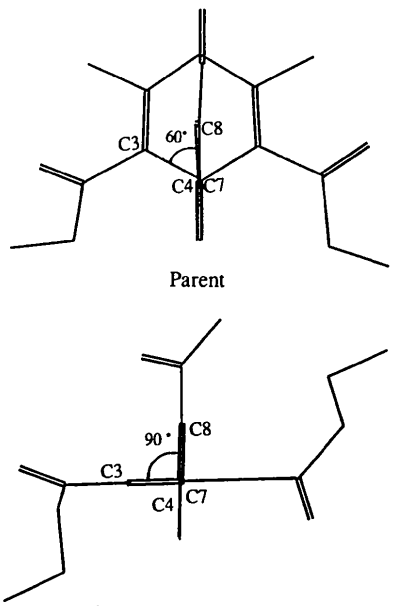


Fig. 3. Identification of pertinent torsional angles for 1,4-dihydropyridine derivatives and their decomposition products.

Experimental

Compound (I) was prepared when a solution of dimethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate was warmed with 110 ml of 5 *N* HNO_3 for approximately 30 min. The resulting solution was extracted with methylene chloride and the extract washed with water, aqueous $NaHCO_3$, again with water, and then dried over Na_2SO_4. Transparent crystals of (I) were obtained upon slow evaporation of the methylene chloride layer.

Compound (II) was prepared by known synthetic methods (Hantzsch, 1882) and recrystallized from ethanol/water. Slow evaporation of an ethanol solution yielded yellow plate-like crystals.

Compound (III) was prepared by mixing diethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxyl-

ate with 50 ml of 2 *N* HNO_3 followed by heating. The resulting solution was extracted with chloroform. The chloroform layer was dried over Na_2SO_4 and evaporated under reduced pressure yielding a yellow oil. Following addition of acetonitrile to the oil, transparent crystals were obtained on slow evaporation.

Compound (I)

Crystal data

$C_{17}H_{16}N_2O_6$
M_r = 344.3
Monoclinic
$P2_1/c$
a = 11.598 (1) Å
b = 14.526 (1) Å
c = 10.612 (1) Å
β = 111.50 (1)°
V = 1663.4 (2) Å^3
Z = 4
D_x = 1.375 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 44 reflections
θ = 4.04–12.47°
μ = 0.106 mm^{-1}
T = 298K K
Chunk
0.3 × 0.2 × 0.2 mm
Clear

Data collection

Siemens *P*4 four-circle diffractometer
$\theta/2\theta$ scans
Absorption correction: none
2068 measured reflections
1549 independent reflections
1173 observed reflections [$F > 4\sigma(F)$]
R_{int} = 0.0452
θ_{max} = 20.0°
$h = -11 \rightarrow 10$
$k = -13 \rightarrow 1$
$l = -1 \rightarrow 10$
3 standard reflections monitored every 97 reflections
intensity decay: 1.0%

Refinement

Refinement on F
R = 0.0471
wR = 0.0648
S = 1.53
1549 reflections
227 parameters
H-atom parameters not refined
$w = 1/[\sigma^2(F_o) + 0.0008F^2]$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.21 e Å^{-3}
$\Delta\rho_{min}$ = −0.18 e Å^{-3}
Extinction correction: *SHELXS*86 (Sheldrick, 1990)
Extinction coefficient: 0.0045 (9)
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

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

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

	x	y	z	U_{eq}
N1	0.0313 (3)	0.3562 (3)	−0.1119 (4)	0.055 (2)
C2	0.0916 (4)	0.3135 (3)	0.0056 (5)	0.051 (2)
C2′	0.0462 (4)	0.2193 (3)	0.0210 (5)	0.075 (3)
C3	0.1916 (4)	0.3545 (3)	0.1072 (4)	0.048 (2)
C3′	0.2482 (4)	0.3098 (3)	0.2434 (5)	0.050 (2)
C3″	0.3750 (5)	0.1882 (4)	0.3673 (5)	0.083 (3)
O3′	0.2351 (3)	0.3364 (3)	0.3431 (4)	0.077 (2)
O3″	0.3165 (3)	0.2368 (2)	0.2403 (3)	0.068 (2)
C4	0.2343 (4)	0.4406 (3)	0.0850 (5)	0.044 (2)
C5	0.1737 (4)	0.4823 (3)	−0.0402 (5)	0.044 (2)
C5′	0.2280 (5)	0.5664 (3)	−0.0759 (4)	0.046 (2)
C5″	0.1944 (5)	0.7212 (3)	−0.1478 (5)	0.081 (3)
O5′	0.3291 (3)	0.5691 (2)	−0.0811 (3)	0.076 (2)
O5″	0.1515 (3)	0.6378 (2)	−0.1037 (3)	0.066 (2)
C6	0.0697 (4)	0.4390 (3)	−0.1358 (4)	0.050 (2)
C6′	−0.0011 (4)	0.4811 (3)	−0.2698 (5)	0.065 (2)
C7	0.3431 (4)	0.4843 (3)	0.1893 (4)	0.045 (2)
C8	0.3354 (4)	0.5711 (3)	0.2391 (5)	0.055 (2)
C9	0.4366 (5)	0.6113 (4)	0.3342 (5)	0.070 (3)
C10	0.5496 (5)	0.5670 (4)	0.3815 (5)	0.070 (3)
C11	0.5555 (4)	0.4811 (4)	0.3320 (5)	0.059 (2)
C12	0.4559 (4)	0.4384 (3)	0.2378 (5)	0.052 (2)
N2	0.6741 (5)	0.4315 (5)	0.3812 (5)	0.094 (3)
O1	0.7693 (4)	0.4763 (4)	0.4279 (5)	0.144 (3)
O2	0.6703 (4)	0.3476 (4)	0.3695 (5)	0.116 (3)

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

N1—C2	1.337 (6)	C4—C5	1.394 (6)
N1—C6	1.338 (7)	C4—C7	1.482 (5)
C2—C2′	1.497 (7)	C5—C5′	1.485 (7)
C2—C3	1.395 (6)	C5—C6	1.408 (5)
C3—C3′	1.498 (6)	C5′—O5′	1.194 (7)
C3—C4	1.397 (6)	C5′—O5″	1.327 (6)
C3′—O3′	1.187 (7)	C5″—O5″	1.450 (6)
C3′—O3″	1.331 (6)	C6—C6′	1.489 (6)
C3″—O3″	1.452 (6)		
C6—N1—C2—C3	2.5 (8)	C3—C4—C5—C6	3.0 (7)
C2—N1—C6—C5	0.7 (8)	C3—C4—C7—C8	−123.8 (5)
N1—C2—C3—C4	−2.9 (8)	C4—C5—C6—N1	−3.5 (8)
C2—C3—C4—C5	0.0 (7)		

Compound (II)

Crystal data

$C_{19}H_{22}N_2O_6$
M_r = 374.4
Orthorhombic
$Pna2_1$
a = 14.328 (4) Å
b = 15.292 (3) Å
c = 8.673 (2) Å
V = 1900.5 (8) Å^3
Z = 4
D_x = 1.308 Mg m^{-3}
Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 45 reflections
θ = 5.86–12.73°
μ = 0.098 mm^{-1}
T = 298 K
Plate
0.5 × 0.4 × 0.4 mm
Yellow

Data collection

Syntex *P*4 four-circle diffractometer
$\theta/2\theta$ scans
Absorption correction: none
3024 measured reflections
2620 independent reflections
1238 observed reflections [$F > 5\sigma(F)$]
R_{int} = 0.0154
θ_{max} = 27.5°
$h = -1 \rightarrow 18$
$k = -1 \rightarrow 19$
$l = -1 \rightarrow 11$
3 standard reflections monitored every 97 reflections reflections
intensity decay: 4.0%

Refinement

Refinement on F
R = 0.0482
wR = 0.0537
S = 1.16
2620 reflections
244 parameters
H-atom parameters not refined
$w = 1/[\sigma^2(F_o) + 0.0008F^2]$
$(\Delta/\sigma)_{max}$ = 0.018
$\Delta\rho_{max}$ = 0.220 e Å^{-3}
$\Delta\rho_{min}$ = −0.210 e Å^{-3}
Extinction correction: *SHELXS*86 (Sheldrick 1990)
Extinction coefficient: 0.0004 (3)
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

Table 3. *Fractional atomic coordinates and equivalent isotropic displacement parameters (Å²) for (II)*

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

	x	y	z	U_{eq}
N1	0.2054 (3)	0.2890 (3)	0.635 (1)	0.048 (2)
C2	0.1452 (4)	0.2315 (3)	0.705 (1)	0.040 (2)
C2′	0.1939 (4)	0.1541 (4)	0.776 (1)	0.053 (2)
C3	0.0533 (4)	0.2483 (4)	0.704 (1)	0.038 (2)
C3′	−0.0203 (4)	0.1948 (3)	0.773 (1)	0.038 (2)
C3′′	−0.0609 (4)	0.0644 (4)	0.907 (1)	0.050 (2)
C3′′′	−0.0092 (5)	−0.0056 (5)	0.991 (1)	0.082 (3)
O3′	−0.1022 (3)	0.2123 (3)	0.765 (6)	0.054 (2)
O3′′	0.0094 (3)	0.1224 (2)	0.847 (2)	0.047 (1)
C4	0.0131 (3)	0.3279 (3)	0.6182	0.036 (2)
C5	0.0899 (4)	0.3945 (3)	0.582 (1)	0.043 (2)
C5′	0.0615 (4)	0.4840 (4)	0.543 (1)	0.060 (3)
C5′′	−0.0678 (6)	0.5800 (4)	0.527 (1)	0.093 (4)
C5′′′	−0.1642 (6)	0.5832 (5)	0.556 (1)	0.121 (5)
O5′	0.1102 (3)	0.5418 (3)	0.497 (1)	0.117 (3)
O5′′	−0.0301 (3)	0.4963 (2)	0.5635 (9)	0.062 (2)
C6	0.1802 (4)	0.3717 (4)	0.586 (1)	0.045 (2)
C6′	0.2612 (4)	0.4276 (4)	0.535 (1)	0.068 (3)
C7	−0.0344 (3)	0.3006 (3)	0.468 (1)	0.036 (2)
C8	0.0098 (4)	0.2474 (4)	0.362 (1)	0.049 (2)
C9	−0.0327 (4)	0.2266 (4)	0.225 (1)	0.055 (2)
C10	−0.1207 (4)	0.2572 (4)	0.188 (1)	0.053 (2)
C11	−0.1637 (4)	0.3099 (4)	0.293 (1)	0.042 (2)
C12	−0.1224 (4)	0.3324 (3)	0.433 (1)	0.039 (2)
N2	−0.2567 (4)	0.3435 (4)	0.261 (1)	0.062 (2)
O1	−0.2986 (3)	0.3143 (4)	0.148 (1)	0.088 (2)
O2	−0.2914 (4)	0.3974 (3)	0.348 (1)	0.089 (2)

Table 4. *Selected geometric parameters (Å, °) for (II)*

N1—C2	1.374 (8)	C3′′—C3′′′	1.494 (11)
N1—C6	1.382 (8)	C3′′—O3′′	1.439 (8)
C2—C2′	1.507 (9)	C4—C5	1.531 (7)
C2—C3	1.341 (7)	C4—C7	1.524 (8)
C3—C3′	1.463 (9)	C5—C5′	1.468 (8)
C3—C4	1.539 (8)	C5—C6	1.340 (8)
C3′—O3′	1.205 (7)	C5′—O5′	1.196 (9)
H1A···O3′^{i}	2.039	C5′—O5′′	1.337 (7)
N1—H1A	1.001	C5′′—C5′′′	1.405 (12)
N1···O3′^{i}	2.980	C5′′—O5′′	1.424 (8)
C3′—O3′′	1.349 (8)	C6—C6′	1.506 (9)
N1—H1A···O3′^{i}	155.7		
C6—N1—C2—C3	12.1 (13)	C3—C4—C5—C6	18.2 (9)
C2—N1—C6—C5	−11.2 (13)	C3—C4—C7—C8	−50.4 (7)
N1—C2—C3—C4	3.6 (12)	C4—C5—C6—N1	−5.5 (12)
C2—C3—C4—C5	−17.3 (9)		

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

Compound (III)

Crystal data

$C_{19}H_{20}N_2O_6$
M_r = 372.37
Monoclinic
$P2_1/c$
a = 12.018 (1) Å
b = 19.517 (2) Å
c = 8.606 (1) Å
β = 109.92 (1)°
V = 1897.8 (3) Å³
Z = 4
D_x = 1.303 Mg m^{-3}

Mo $K\alpha$ radiation
λ = 0.71073 Å
Cell parameters from 53 reflections
θ = 4.17–12.01°
μ = 0.098 mm^{-1}
T = 293 (2) K
Clear
0.4 × 0.2 × 0.2 mm
Plate

Data collection

Siemens $P4$ four-circle diffractometer
R_{int} = 0.0552
θ_{max} = 20.0°
$\theta/2\theta$ scans
Absorption correction: none
2402 measured reflections
1767 independent reflections
890 observed reflections [$I > 2\sigma(I)$]
$h = -11 \rightarrow 11$
$k = -18 \rightarrow 1$
$l = -1 \rightarrow 8$
3 standard reflections monitored every 97 reflections
intensity decay: 2.0%

Refinement

Refinement on F^2
$R(F)$ = 0.0587
$wR(F^2)$ = 0.1064
S = 1.134
1706 reflections
245 parameters
H-atom parameters not refined
$w = 1/[\sigma^2(F_o^2) + (0500P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = −0.003
$\Delta\rho_{max}$ = 0.137 e Å^{-3}
$\Delta\rho_{min}$ = −0.148 e Å^{-3}
Extinction correction: *SHELXL*93 (Sheldrick 1993)
Extinction coefficient: 0.0016 (11)
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)

Table 5. *Fractional atomic coordinates and equivalent isotropic displacement parameters (Å²) for (III)*

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

	x	y	z	U_{eq}
N1	0.8611 (6)	0.4858 (3)	0.1636 (8)	0.063 (2)
C2	0.8301 (6)	0.4265 (5)	0.0794 (9)	0.056 (2)
C2′	0.6999 (5)	0.4178 (4)	−0.0093 (8)	0.076 (2)
C3	0.9168 (6)	0.3799 (4)	0.0775 (8)	0.045 (2)
C3′	0.8852 (6)	0.3182 (4)	−0.0293 (9)	0.052 (2)
C3′′	0.7720 (6)	0.2170 (4)	−0.0896 (10)	0.084 (3)
C3′′′	0.6838 (7)	0.1807 (4)	−0.0432 (10)	0.104 (3)
O3′	0.9289 (4)	0.3041 (2)	−0.1301 (6)	0.069 (2)
O3′′	0.8055 (4)	0.2795 (2)	0.0063 (5)	0.0607 (14)
C4	1.0358 (6)	0.3953 (4)	0.1657 (8)	0.042 (2)
C5	1.0624 (6)	0.4570 (4)	0.2519 (8)	0.049 (2)
C5′	1.1870 (6)	0.4758 (4)	0.3504 (9)	0.049 (2)
C5′′	1.3485 (6)	0.4491 (4)	0.5981 (10)	0.098 (3)
C5′′′	1.4337 (7)	0.4160 (4)	0.5364 (11)	0.121 (3)
O5′′	1.2294 (4)	0.4347 (3)	0.4785 (6)	0.073 (2)
O5′	1.2399 (4)	0.5232 (2)	0.3211 (6)	0.079 (2)
C6	0.9733 (7)	0.5018 (4)	0.2481 (9)	0.056 (2)
C6′	0.9968 (6)	0.5685 (3)	0.3428 (9)	0.070 (2)
C7	1.1307 (5)	0.3458 (4)	0.1698 (8)	0.045 (2)
C8	1.1272 (6)	0.2780 (4)	0.2207 (8)	0.062 (2)
C9	1.2155 (8)	0.2323 (4)	0.2240 (10)	0.081 (3)
C10	1.3093 (7)	0.2527 (5)	0.1802 (10)	0.072 (2)
C11	1.3113 (6)	0.3186 (5)	0.1319 (9)	0.058 (2)
C12	1.2243 (6)	0.3654 (3)	0.1221 (7)	0.048 (2)
N2	1.4115 (6)	0.3410 (4)	0.0798 (9)	0.083 (2)
O1	1.4221 (6)	0.4009 (4)	0.0577 (11)	0.151 (4)
O2	1.4805 (5)	0.2976 (3)	0.0704 (8)	0.118 (2)

Table 6. *Selected geometric parameters (Å, °) for (III)*

N1—C6	1.333 (7)	C4—C5	1.393 (8)
N1—C2	1.348 (8)	C4—C7	1.486 (8)
C2—C3	1.388 (8)	C5—C6	1.375 (8)
C2—C2′	1.498 (8)	C5—C5′	1.493 (8)
C3—C4	1.405 (8)	C5′—O5′	1.197 (7)
C3—C3′	1.484 (9)	C5′—O5′′	1.318 (7)
C3′—O3′	1.190 (7)	C5′′—C5′′′	1.456 (9)
C3′—O3′′	1.335 (7)	C5′′—O5′′	1.478 (8)
C3′′—C3′′′	1.441 (8)	C6—C6′	1.510 (8)
C3′′—O3′′	1.451 (7)		
C6—N1—C2—C3	−0.6 (10)	C2—N1—C6—C5	−0.2 (10)
N1—C2—C3—C4	0.7 (9)	C4—C5—C6—N1	0.9 (10)
C2—C3—C4—C5	0.0 (9)	C3—C4—C7—C8	−54.4 (8)
C3—C4—C5—C6	−0.8 (9)		

Table 7. *Comparison of selected angles of parent 1,4-dihydropyridine compounds and their decomposition products*

Compound	Torsion angle SUM (°)	Deviation from bisection (°)	References
Nifedipine	52.1	13.5	*a*
A	11.9	0.6 (5)	*b*
B	90.2	2.2	*c*
(I)	12.6	31.6 (5)	*d*
(II)	67.9	9.6 (7)	*d*
(III)	5.19	35.6 (8)	*d*

References: (*a*) Triggle, Schefter & Triggle (1980); (*b*) Rowan & Holt (1995) [compound *A*: dimethyl 2,6-dimethyl-4-(2-nitrophenyl)pyridine-3,5-dicarboxylate($CuCl_2$)]; (*c*) Fossheim, Svarteng, Mostad, Romming, Shefter & Triggle (1982) [compound *B*: dimethyl 2,6-dimethyl-4-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarboxylate]; (*d*) this work.

For each compound, the scan width was 0.6° above $K_{\alpha 1}$ and 0.6° below $K_{\alpha 2}$, with a variable scan rate and background counts on each side of the scan.

For all compounds, data collection: *XSCANS* (Siemens, 1991); cell refinement: *XSCANS*; data reduction: *XSCANS*; program(s) used to solve structures: *SHELXS*86 (Sheldrick, 1990). Program(s) used to refine structures: *SHELXS*86 for (I) and (II); *SHELXL*93 (Sheldrick, 1993) for (III). For all compounds, molecular graphics: *XP* (Siemens, 1990)

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: FG1105). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

References

Arrowsmith, J. E., Campbell, S. F., Cross, P. E., Stubbs, J. K., Burges, R. A., Gardiner, D. G. & Blackburn, K. J. (1986). *J. Med. Chem.* **29**, 1696–1702.

Fossheim, R., Svarteng, K., Mostad, A., Romming, C., Shefter, E. & Triggle, D. J. (1982). *J. Med. Chem.* **25**, 126–131.

Hantzsch, A. (1882). *Justus Liebigs Ann. Chem.* **215**, 1–81.

Hayase, N., Itagaki, Y., Ogawa, S., Akutsu, S., Inagaki, S. & Abiko, Y. (1994). *J. Pharm. Sci.* **83**, 532–538.

Hurwitz, L., Partridge, L. D. & Leach, J. K. (1991). In *Calcium Channels: Their Properties, Functions, Regulation, and Clinical Relevance*. Boca Raton, FL, USA: CRC Press.

Janis, R. A., Silver, P. J. & Triggle, D. J. (1987). *Adv. Drug Res.* **16**, 309–591.

Loev, B., Goodman, M. M., Snader, K. M., Tedeschi, R. & Macko, E. (1974). *J. Med. Chem.* **17**, 956–965.

Morad, M., Goldmann, Y. E. & Trentham, D. R. (1983). *Nature (London)*, **304**, 635–638.

Núnez-Vergara, L. J., Sunkel, C. & Squella, J. A. (1994). *J. Pharm. Sci.* **83**, 502–507.

Rowan, K. R. & Holt, E. M. (1995). *Acta Cryst.* C**51**, 2554–2559.

Sadana, G. S. & Ghogare, A. B. (1991). *J. Indian Chem. Soc.* **68**, 237–239.

Sheldrick, G. M. (1990). *Acta Cryst.* A**46**, 467–473.

Sheldrick, G. M. (1993). *SHELXL*93. *Program for the Refinement of Crystal Structures*. University of Göttingen, Germany.

Siemens (1990). *XP. Interactive Molecular Graphics Program*. Version 4.1. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.

Siemens (1991). *XSCANS Users Manual*. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.

Suzuki, K., Shiratori, K., Murayama, B., Harada, N., Miyano, T. & Takeya, K. (1989). *J. Pharmacobio-Dyn.* **12**, 293–298.

Triggle, D. J., Langs, D. A. & Janis, R. A. (1989). *Med. Res. Rev.* **9**, 123–180.

Triggle, A. M., Schefter, E. & Triggle, D. J. (1980). *J. Med. Chem.* **23**, 1442–1445.

Acta Cryst. (1996). C**52**, 1570–1572

(Tosyliminoiodo)benzene at 298 K

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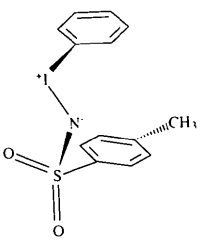
Abstract

The structure of (tosyliminoiodo)benzene (PhINTs), $C_{13}H_{12}INO_2S$, has been determined at 298 K and is compared with the structure previously determined at 130 K.

Comment

We are currently studying the primary nitrene transfer reagents ArINTs (Ts = *para*-toluenesulfonyl) (Cicero, Zhao & Protasiewicz, 1996) and have determined the structure of (tosyliminoiodo)benzene, PhINTs, (I), at room temperature. During the course of our work, the structure of the same compound at 130 K was reported by Power and co-workers (Mishra, Olmstead, Ellison & Power, 1995).



(I)

The compound at both temperatures exists as a zigzag polymer in the solid state utilizing N···I contacts to bridge the monomers in an asymmetric fashion. Intramolecular bond distances in (I) have nearly the same values as those obtained by Power and co-workers at 130 K. For example, the I—N bond distance is 2.027 (3) at 298 K *versus* 2.039 (2) Å at 130 K. Aromatic C—C distances range from 1.368 (8) to 1.390 (7) Å with an observed average value of 1.379 (7) Å. H atoms were located and their positions refined [C—H = 0.79 (6)–