

1.363 (13) Å, is in good agreement with the value of 1.369 (8) Å determined in 4-acetyl-2'-fluorobiphenyl (Young, Tollin & Sutherland, 1968). The distribution of bond angles around the C atom bonded to F is also similar in the two compounds. In the present structure C(2)–C(3)–C(4) is 124.3 (1.2), C(2)–C(3)–F is 117.2 (1.1) and C(4)–C(3)–F is 118.5 (1.1)° and these compare with 124.3 (0.6), 117.7 (0.7) and 118.0 (0.5)° for the comparable angles in 4-acetyl-2'-fluorobiphenyl.

The angle between the phenyl rings is 36.3 (0.6)° and in common with other halogen-substituted biphenyls the axis of the molecule defined by C(1), C(4), C(7), C(10) deviates significantly from collinearity. Not only is there a rotation by an angle ϕ_1 about the central C(1)–C(7) bond but also two other rotations: $\phi_2 = 1.6$ (0.5)° of the ring C(1)–C(6) about an axis in its plane, passing through C(1) perpendicular to C(1)–C(7); and $\phi_3 = 2.6$ (0.5)°, the corresponding angle of rotation for ring C(7)–C(12). Similar rotations have been found in a number of substituted biphenyls including 1.2 and 4.1° in 4-acetyl-3'-bromobiphenyl (Sutherland & Hoy, 1969), and 2.5 and 1.4° in 2,2'-dibromooctafluorobiphenyl (Hamor & Hamor, 1980).

The carboxyl group is rotated about the C(10)–C(13) bond through an angle ϕ_4 of 3.7 (0.5)°. Associated with this is a second rotation $\phi_5 = 3.1$ (0.5)° of the group C(10), C(13), O(1) and O(2)

about an axis in its plane passing through C(10) perpendicular to C(7)–C(10).

The various values of ϕ are larger than the corresponding values in 3'-iodobiphenyl-4-carboxylic acid (Sutherland & Mottram, 1972). These reductions are probably due to intermolecular forces since the molecules in that compound lie in a series of chains whereas they adopt a herring-bone configuration in the present structure (Fig. 1).

The O–H...O hydrogen bond of 2.623 (13) Å, the shortest intermolecular distance, is similar to the value of 2.61 Å quoted for 3'-iodobiphenyl-4-carboxylic acid.

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References

- HAMOR, M. J. & HAMOR, T. A. (1980). *Acta Cryst.* **B36**, 1402–1406.
International Tables for X-ray Crystallography (1974). Vol IV. Birmingham: Kynoch Press.
 SUTHERLAND, H. H. & HOY, T. G. (1969). *Acta Cryst.* **B25**, 2385–2391.
 SUTHERLAND, H. H. & MOTTRAM, M. J. (1972). *Acta Cryst.* **B28**, 2212–2217.
 YOUNG, D. W., TOLLIN, P. & SUTHERLAND, H. H. (1968). *Acta Cryst.* **B24**, 161–167.

Acta Cryst. (1983). **C39**, 1570–1572

Iopamidol, C₁₇H₂₂I₃N₃O₈

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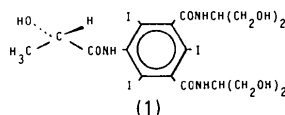
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Abstract. $M_r = 777.088$, triclinic, $P\bar{1}$, $a = 12.478$ (4), $b = 11.233$ (3), $c = 9.241$ (3) Å, $\alpha = 104.49$ (8), $\beta = 92.63$ (7), $\gamma = 108.63$ (8)°, $V = 1177$ (1) Å³, $Z = 2$, $D_x = 2.19$ Mg m⁻³, $\lambda(\text{Mo } K\alpha) = 0.71069$ Å, $\mu = 3.986$ mm⁻¹, $F(000) = 736$, $T = 295$ K. Final $R =$

0.0544 for 2381 observed reflections. The title compound, a new, non-ionic, hydrosoluble contrast medium, shows rotational disorder at the asymmetric C atom C(8). Two I atoms deviate slightly from the benzene ring plane due to steric hindrance. The molecules are packed together by hydrogen-bond interactions between amide O atoms of symmetry-related molecules and by van der Waals forces.

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Introduction. Iopamidol (1) [(*S*)-*N,N'*-bis(1,3-dihydroxy-2-propyl)-5-(2-hydroxypropionamido)-2,4,6-triiodo-1,3-benzenedicarboxamide] is a non-ionic, hydro-soluble contrast medium used in myelography and angiography. Its synthesis (Felder & Pitrè, 1977) and physico-chemical behaviour (Felder, Pitrè & Tirone, 1977; Clerici, Traldi, Grandi & Pitrè, 1982) have already been reported. In view of the interest of this class of compounds, we have now carried out a single-crystal X-ray investigation of the title compound:



Experimental. Colorless, prismatic crystals of (1) obtained with great difficulty from an aqueous solution; single crystal of approximate dimensions $0.6 \times 0.4 \times 0.5$ mm. Philips PW 1100 diffractometer. Cell constants determined from least-squares fit of 20 high-angle reflections ($16.0 \leq 2\theta \leq 34.0$). $\omega/2\theta$ scan, Mo $K\alpha$ graphite-monochromated radiation, scan speed $0.06^\circ \text{ s}^{-1}$, scan width 1.2° , background measured for 5 s on each side of the peaks, $2\theta_{\text{max}} = 50.0^\circ$. Two standard reflections ($2\bar{2}0$ and 220) measured every 90 min (no significant variation detected). 4100 independent reflections collected ($h \pm 14, k \pm 12, l 0-10$), 2381 considered observed having $I \geq 2.5\sigma(I)$. Empirical absorption correction applied using azimuthal (ψ) scans of reflections $01\bar{3}$, $02\bar{8}$, $0,2,1\bar{0}$; range of transmission factors 0.85–0.51. Structure solved by Patterson and Fourier methods, refined by blocked full-matrix least squares (anisotropic thermal factors for I atoms) using *SHELX* (Sheldrick, 1976). H atoms, found on a difference Fourier map, not refined, but their contribution taken into account. Function minimized $\sum w(F_o - F_c)^2$, $w = [\sigma^2(F_o) + 0.006882F_o^2]^{-1}$ (optimized). Final $R = 0.0544$, $R_w = 0.0788$, $S = 2.1$. $\Delta/\sigma = 0.3$; final $\Delta\rho$ excursions $\leq |0.5| \text{ e } \text{Å}^{-3}$. Atomic scattering factors from *International Tables for X-ray Crystallography* (1974), and correction for real part of anomalous dispersion for I atoms applied. Geometrical calculations performed using *PARST* (Nardelli, 1982*a,b*).

During the last stage of the refinement the distances C(8)–C(9) and C(8)–O(2) tended to be outside the expected range. This fact and residual electron density in the Fourier map gave an indication of disorder around the asymmetric C atom C(8). The most satisfactory model was obtained assuming a threefold disorder of atoms O(2), C(9) and H bound to C(8). Moreover, this model allows this chiral molecule to be described in the centrosymmetric space group $P\bar{1}$. A refinement in the non-centrosymmetric group $P1$ failed to give either improved agreement factors or satisfactory bond distances. Therefore space group $P\bar{1}$ was

retained refining atoms C(9) and O(2) with site occupancy equal to 0.3333. Convergence was obtained without the necessity of constraining the bond lengths involved.

Due to the presence of disorder and the poor quality of the crystal the precision of this structural determination is somewhat low.

Discussion. Refined atomic coordinates with equivalent or isotropic thermal factors are given in Table 1; bond lengths and angles are in Table 2.* An *ORTEP* view of the molecule is given in Fig. 1.

The C–C and C–O distances and related angles fall in the expected range. The average for the C–I distances [$2.10(1) \pm 0.01 \text{ Å}$]† is similar to values reported in the literature (e.g. Sindt & Mackay, 1980).

* Lists of structure factors, anisotropic thermal parameters, H-atom coordinates and relevant least-squares planes (Table 3) have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 38698 (19 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

† The sign \pm refers to the mean square deviation from the mean.

Table 1. Final positional and isotropic thermal parameters with e.s.d.'s on last significant digit in parentheses

U_{eq} (for I atoms only) is defined as $U_{\text{eq}} = \frac{1}{3} \sum_i \sum_j U_{ij} a_i^* a_j^* (\mathbf{a}_i, \mathbf{a}_j)$.

	x	y	z	$U_{\text{iso}}(U_{\text{eq}})$ (Å ²)
I(1)	0.42234 (8)	0.27362 (8)	0.07128 (12)	0.0366 (6)
I(2)	0.48274 (9)	0.82433 (11)	0.42312 (15)	0.0521 (8)
I(3)	0.89710 (8)	0.66430 (10)	0.31299 (14)	0.0445 (7)
C(1)	0.5295 (10)	0.4622 (12)	0.1923 (15)	0.026 (3)
C(2)	0.4810 (10)	0.5584 (12)	0.2475 (14)	0.024 (3)
C(3)	0.5557 (11)	0.6831 (13)	0.3313 (15)	0.027 (3)
C(4)	0.6718 (11)	0.7117 (12)	0.3494 (14)	0.024 (3)
C(5)	0.7183 (11)	0.6193 (12)	0.2923 (15)	0.026 (3)
C(6)	0.6478 (10)	0.4893 (12)	0.2102 (14)	0.024 (3)
C(7)	0.2867 (16)	0.4796 (19)	0.2918 (22)	0.064 (5)
C(8)	0.1622 (18)	0.4731 (22)	0.2555 (26)	0.081 (6)
C(9A)	0.1519 (67)	0.5792 (77)	0.2711 (88)	0.115 (24)
C(9B)	0.1168 (59)	0.3422 (68)	0.1445 (79)	0.121 (21)
C(9C)	0.1038 (65)	0.5124 (76)	0.3650 (89)	0.089 (23)
C(10)	0.7478 (10)	0.8531 (12)	0.4378 (14)	0.026 (3)
C(11)	0.8474 (11)	1.0041 (13)	0.6809 (15)	0.030 (3)
C(12)	0.7622 (12)	1.0688 (14)	0.7460 (17)	0.041 (4)
C(13)	0.9289 (14)	0.9914 (16)	0.8025 (19)	0.051 (4)
C(14)	0.6983 (10)	0.3865 (12)	0.1476 (14)	0.024 (3)
C(15)	0.7760 (11)	0.2282 (13)	0.2098 (15)	0.030 (3)
C(16)	0.8597 (12)	0.2419 (14)	0.3408 (17)	0.040 (4)
C(17)	0.6811 (12)	0.0915 (14)	0.1533 (17)	0.040 (4)
N(1)	0.3624 (9)	0.5315 (10)	0.2147 (12)	0.028 (3)
N(2)	0.7795 (9)	0.8716 (10)	0.5815 (12)	0.030 (3)
N(3)	0.7220 (9)	0.3263 (11)	0.2471 (12)	0.032 (3)
O(1)	0.3091 (15)	0.4232 (17)	0.3851 (20)	0.114 (6)
O(2A)	0.1598 (50)	0.5774 (57)	0.2690 (67)	0.120 (20)
O(2B)	0.1112 (37)	0.3824 (42)	0.1219 (48)	0.061 (13)
O(2C)	0.1095 (40)	0.4808 (47)	0.3734 (54)	0.100 (14)
O(3)	0.7778 (9)	0.9404 (10)	0.3719 (12)	0.049 (3)
O(4)	0.8368 (12)	1.2048 (14)	0.8320 (17)	0.081 (4)
O(5)	0.8678 (11)	0.9092 (12)	0.8834 (14)	0.069 (4)
O(6)	0.7125 (8)	0.3606 (9)	0.0155 (11)	0.035 (2)
O(7)	0.8068 (11)	0.2168 (13)	0.4613 (15)	0.076 (4)
O(8)	0.7376 (8)	−0.0070 (10)	0.1082 (11)	0.044 (3)

The letters A, B, C distinguish the three disordered positions of C(9) and O(2).

The benzene ring is planar, while the small deviations of two I atoms may be accounted for by steric hindrance (see Table 3*).

The conformation of the other substituents is such that the two C=O groups of the benzenecarboxamide

* See deposition footnote.

Table 2. Bond lengths (Å) and angles (°)

E.s.d.'s on last significant digit are given in parentheses.

I(1)—C(1)	2.10 (1)	C(8)—O(2)*	1.26 (10)
I(2)—C(3)	2.09 (2)	C(10)—N(2)	1.31 (2)
I(3)—C(5)	2.11 (1)	C(10)—O(3)	1.25 (2)
C(1)—C(2)	1.40 (2)	C(11)—C(12)	1.53 (2)
C(1)—C(6)	1.40 (2)	C(11)—C(13)	1.54 (2)
C(2)—C(3)	1.41 (2)	C(11)—N(2)	1.49 (1)
C(2)—N(1)	1.41 (2)	C(12)—O(4)	1.50 (2)
C(3)—C(4)	1.37 (2)	C(13)—O(5)	1.39 (2)
C(4)—C(5)	1.35 (2)	C(14)—N(3)	1.34 (2)
C(4)—C(10)	1.55 (2)	C(14)—O(6)	1.22 (2)
C(5)—C(6)	1.43 (2)	C(15)—C(16)	1.51 (2)
C(4)—C(14)	1.49 (2)	C(15)—C(17)	1.55 (2)
C(7)—C(8)	1.55 (3)	C(15)—N(3)	1.45 (2)
C(7)—N(1)	1.29 (2)	C(16)—O(7)	1.37 (2)
C(7)—O(1)	1.26 (3)	C(17)—O(8)	1.48 (2)
C(8)—C(9)*	1.34 (10)		
I(1)—C(1)—C(2)	119 (1)	C(7)—C(8)—C(9C)	121 (4)
I(1)—C(1)—C(6)	119 (1)	C(7)—C(8)—O(2A)	110 (4)
C(2)—C(1)—C(6)	122 (1)	C(7)—C(8)—O(2B)	111 (3)
C(1)—C(2)—C(3)	117 (1)	C(7)—C(8)—O(2C)	113 (3)
C(1)—C(2)—N(1)	121 (1)	C(4)—C(10)—N(2)	116 (1)
C(3)—C(2)—N(1)	122 (1)	C(4)—C(10)—O(3)	120 (1)
I(2)—C(3)—C(2)	117 (1)	N(2)—C(10)—O(3)	124 (1)
I(2)—C(3)—C(4)	121 (1)	C(12)—C(11)—C(13)	114 (1)
C(2)—C(3)—C(4)	121 (1)	C(12)—C(11)—N(2)	107 (1)
C(3)—C(4)—C(5)	121 (1)	C(13)—C(11)—N(2)	109 (1)
C(3)—C(4)—C(10)	118 (1)	C(11)—C(12)—O(4)	104 (1)
C(5)—C(4)—C(10)	121 (1)	C(11)—C(13)—O(5)	110 (1)
I(3)—C(5)—C(4)	121 (1)	C(6)—C(14)—N(3)	114 (1)
I(3)—C(5)—C(6)	118 (1)	C(6)—C(14)—O(6)	120 (1)
C(4)—C(5)—C(6)	121 (1)	N(3)—C(14)—O(6)	125 (1)
C(1)—C(6)—C(5)	117 (1)	C(16)—C(15)—C(17)	114 (1)
C(1)—C(6)—C(14)	121 (1)	C(16)—C(15)—N(3)	111 (1)
C(5)—C(6)—C(14)	121 (1)	C(17)—C(15)—N(3)	108 (1)
C(8)—C(7)—N(1)	119 (2)	C(15)—C(16)—O(7)	112 (1)
C(8)—C(7)—O(1)	119 (2)	C(15)—C(17)—O(8)	108 (1)
N(1)—C(7)—O(1)	121 (2)	C(2)—N(1)—C(7)	125 (1)
C(7)—C(8)—C(9A)	114 (4)	C(10)—N(2)—C(11)	121 (1)
C(7)—C(8)—C(9B)	99 (3)	C(14)—N(3)—C(15)	123 (1)

* Average values for the three disordered positions.

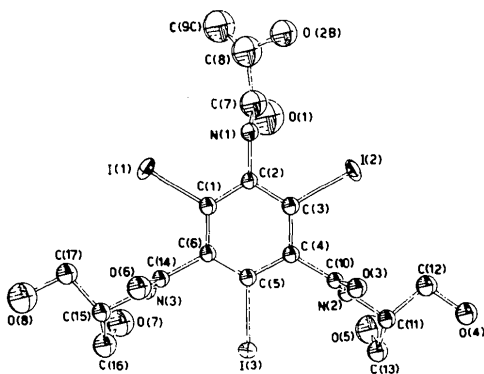


Fig. 1. An ORTEP view (Johnson, 1971) showing the numbering scheme. The positions of the disordered atoms have been omitted for clarity.

Table 4. Intermolecular contacts (Å)

E.s.d.'s on last significant digit are given in parentheses.

I(1)...O(8 ⁱ)	3.016 (9)	O(5)...O(8 ^v)	2.85 (2)
I(2)...I(2 ⁱⁱ)	3.719 (3)	O(5)—H(O5)...O(8 ^v)	1.96
N(1)...O(6 ⁱⁱⁱ)	2.95 (2)	O(7)...O(3 ^{vi})	2.90 (2)
N(1)—H(N1)...O(6 ⁱⁱⁱ)	2.08	O(8)...O(3 ^{vi})	2.71 (2)
N(2)...O(1 ^v)	3.24 (2)	O(8)—H(O8)...O(3 ^{vi})	1.62

Symmetry operations: (i) $\bar{x} + 1, \bar{y}, \bar{z}$; (ii) $\bar{x} + 1, \bar{y} + 2, \bar{z} + 1$; (iii) $\bar{x} + 1, \bar{y} + 1, \bar{z}$; (iv) $\bar{x} + 1, \bar{y} + 1, \bar{z} + 1$; (v) $x, y + 1, z + 1$; (vi) $x, y + 1, z$.

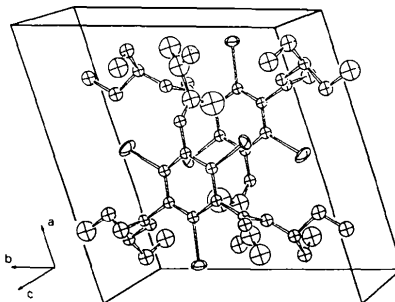


Fig. 2. Packing of the molecules in the unit cell.

groups are pointing in directions opposite to that of the CO group of the hydroxypropionamido moiety.

Intermolecular contacts are given in Table 4. The presence of packing distances in the range 2.70–2.95 Å [distances shorter than the sum of van der Waals radii (Bondi, 1964)] is suggestive of hydrogen-bond interactions among amide O atoms [e.g. O(3), O(5), O(6), O(8)] of symmetry-related molecules, which, together with van der Waals forces, dictate the molecular packing (Fig. 2).

References

- BONDI, A. (1964). *J. Phys. Chem.* **68**, 441–451.
 CLERICI, A., TRALDI, P., GRANDI, M. & PITRÈ, D. (1982). *Biomed. Mass Spectrom.* **9**, 257–264.
 FELDER, E. & PITRÈ, D. (1977). US Patent 4001323.
 FELDER, E., PITRÈ, D. & TIRONE, P. (1977). *Farmaco Ed. Sci.* **32**, 835–841.
International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press.
 JOHNSON, C. K. (1971). *ORTEP*. Report ORNL-3794, revised. Oak Ridge National Laboratory, Tennessee.
 NARDELLI, M. (1982a). *PARST*. A system of computer routines for calculating molecular parameters from results of crystal structure analysis. Univ. of Parma, Italy.
 NARDELLI, M. (1982b). *Comput. Chem.* **6**, 139–152.
 SHELDRICK, G. M. (1976). *SHELX*. Program for crystal structure determination. Univ. of Cambridge, England.
 SINDT, A. C. & MACKAY, M. F. (1980). *Cryst. Struct. Commun.* **9**, 1063–1067.