

## 10-Bromo-10,11-dihydroquinidine

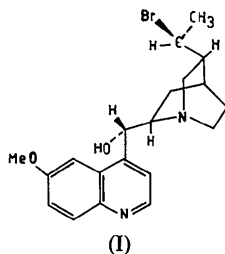
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(Received 9 October 1989; accepted 15 February 1990)

**Abstract.**  $C_{20}H_{25}BrN_2O_2$ ,  $M_r = 405.3$ , monoclinic,  $P2_1$ ,  $a = 7.236$  (2),  $b = 12.386$  (8),  $c = 10.909$  (3) Å,  $\beta = 95.89$  (2)°,  $V = 972.6$  (7) Å<sup>3</sup>,  $Z = 2$ ,  $D_m = 1.38$  (2),  $D_x = 1.384$  g cm<sup>-3</sup>, Mo  $K\alpha$ ,  $\lambda = 0.71069$  Å,  $\mu = 20.60$  cm<sup>-1</sup>,  $F(000) = 420$ ,  $T = 301$  K,  $R = 0.0493$ ,  $wR = 0.0384$  for 1723 reflections. The chirality of C(3), C(4), C(8) and C(9) is the same as that in quinidine; that at the new centre, C(10), is *S*. Molecules related by  $2_1$  axes form molecular chains with a hydrogen bond between the O atom of the hydroxyl group and the N atom in the quinoline ring with an N...O distance of 2.844 (7) Å.

**Introduction.** Quinidine, one of the basic *Cinchona* alkaloids, is well known as an antiarrhythmic agent. The crystal structures of quinidine and its derivatives have been reported as follows: quinidine (Kashino & Haisa, 1983), the quinidine salt of (–)-1,1'-dimethylferrocene-3-carboxylic acid (Carter, McPhail & Sim, 1967), quinidine ethanolate (Doherty, Benson, Maienthal & Stewart, 1978), the dihydrate sulfate of quinidine (Karle & Karle, 1981) and 10-hydroxy-10-methyl-10,11-dihydroquinidine (Suszko-Purzycka, Lipińska, Karczmarzyk & Pniewska, 1987). The molecule of the title compound (I) has an additional chirality centre [at C(10)] compared with the molecule of quinidine. The accepted absolute stereochemistry of the quinidine (Turner & Woodward, 1953) was confirmed by means of Bijvoet's anomalous-dispersion method for the quinidine salt of (–)-1,1'-dimethylferrocene-3-carboxylic acid (Carter *et al.*, 1967). Investigation of the crystal structure of 10-bromo-10,11-dihydroquinidine made it possible to fix the absolute configuration of the additional chirality centre and confirmed the stereochemistry of the parent alkaloid in the course of bromination.



**Experimental.** 10-Bromo-10,11-dihydroquinidine was obtained by addition of hydrogen bromide to the vinyl group of quinidine. This reaction gave a mixture of two diastereoisomers which differ in absolute configuration at the newly created chirality centre C(10) and have different values of  $R_f$  [0.48 and 0.53; thin-layer chromatography, silufol precoated plates, silica gel 60F<sub>254</sub> (Merck), developing solvent system toluene–methanol (1/4)]. The diastereoisomer with the lower value of  $R_f$  and arising in greater amount was isolated from anhydrous diethyl ether by repeated crystallization. Its colourless crystals were obtained from diethyl ether solution by slow evaporation. Their density was measured in aqueous KI solution by flotation. Space group and initial cell parameters were obtained from Weissenberg photographs (produced for [100] and [010] directions): systematic absence of the reflections  $0k0$  for  $k$  odd determined the space group as  $P2_1$  (No. 4). The crystal used for data collection had dimensions  $0.35 \times 0.19 \times 0.17$  mm. The intensities were collected on an Enraf–Nonius CAD-4 diffractometer, Mo  $K\alpha$ , graphite monochromator. The accurate unit-cell parameters were obtained by least-squares refinement of setting angles for 25 reflections with  $3.9 < \theta < 9.8^\circ$ . 2663 measured reflections,  $2 < \theta < 28^\circ$ ,  $\omega$ - $2\theta$  scan with  $\Delta\omega(\theta) = (1.3 + 0.34\tan\theta)^\circ$ . Three standard reflections (103, 121 and 310) were measured every 3600 s of exposure time. No significant change in the intensities of these reflections was found throughout the data collection. Index range:  $-9 \leq h \leq 9$ ,  $0 \leq k \leq 16$ ,  $0 \leq l \leq 14$ . 2425 unique reflections,  $R_{int} = 0.0200$ , 1723 reflections with  $|F| > 3\sigma(F)$  used in refinement. The structure was solved by direct methods. MULTAN80 (Main *et al.*, 1980) revealed the positions of 11 non-H atoms. The remaining non-H atoms were found from a difference Fourier map. Full-matrix least-squares refinement on  $F$  with SHELX76 (Sheldrick, 1976). Two refinements were performed. The refinement of the proper enantiomer with anisotropic thermal parameters and without H atoms gave  $R = 0.0684$ . The model with the opposite configuration [mirror image of the structure and thermal ellipsoids in the plane  $y = 0$  (Rogers, 1981)] and the same data set gave  $R = 0.0757$  and the ratio of the  $R$  values was 1.107, which is apparently

Table 1. Fractional atomic coordinates and equivalent isotropic temperature factors

$U_{eq}$  is defined as one third of the trace of the orthogonalized  $U_{ij}$  tensor.

	x	y	z	$U_{eq}(\text{\AA}^2)$
Br(1)	0.0611 (1)	0.1210	0.6229 (1)	0.0918 (3)
N(1)	0.4573 (6)	0.2305 (4)	0.3319 (4)	0.035 (2)
N(2)	0.0558 (7)	0.5590 (4)	-0.0639 (5)	0.045 (2)
O(1)	0.0520 (6)	0.2377 (4)	0.2188 (4)	0.046 (2)
O(2)	0.6844 (6)	0.3412 (4)	-0.1643 (4)	0.057 (2)
C(2)	0.3534 (9)	0.1842 (5)	0.4280 (6)	0.040 (2)
C(3)	0.3169 (8)	0.2681 (5)	0.5289 (5)	0.038 (2)
C(4)	0.3785 (8)	0.3782 (5)	0.4851 (6)	0.037 (2)
C(5)	0.5880 (11)	0.3715 (9)	0.4775 (8)	0.055 (3)
C(6)	0.6302 (9)	0.2767 (7)	0.3952 (7)	0.051 (3)
C(7)	0.2837 (9)	0.4007 (5)	0.3564 (5)	0.035 (2)
C(8)	0.3562 (7)	0.3196 (4)	0.2656 (5)	0.030 (2)
C(9)	0.2078 (7)	0.2794 (5)	0.1643 (5)	0.032 (2)
C(10)	0.1161 (8)	0.2665 (5)	0.5589 (6)	0.047 (2)
C(11)	0.0707 (12)	0.3466 (8)	0.6580 (8)	0.056 (3)
C(22)	-0.0494 (8)	0.5209 (6)	0.0162 (7)	0.051 (2)
C(23)	-0.0073 (9)	0.4303 (6)	0.0901 (6)	0.047 (2)
C(24)	0.1507 (7)	0.3735 (5)	0.0787 (5)	0.033 (2)
C(25)	0.4305 (8)	0.3525 (5)	-0.0382 (5)	0.036 (2)
C(26)	0.5325 (8)	0.3908 (5)	-0.1262 (5)	0.040 (2)
C(27)	0.4871 (9)	0.4914 (5)	-0.1844 (6)	0.043 (2)
C(28)	0.3354 (9)	0.5452 (5)	-0.1615 (5)	0.042 (2)
C(29)	0.2153 (7)	0.5040 (5)	-0.0787 (5)	0.036 (2)
C(30)	0.2671 (7)	0.4092 (4)	-0.0109 (5)	0.031 (2)
C(31)	0.7347 (12)	0.2386 (8)	-0.1153 (9)	0.071 (3)

significant, since the theoretical ratio at the 0.005 level is 1.003. For the proper enantiomer all H atoms were successively located from a difference Fourier map and refined isotropically; the refinement converged at  $R = 0.0493$ ,  $wR = 0.0384$ ,  $w = 3.8805/\sigma^2(F)$ . 325 refined parameters; max.  $\Delta/\sigma = -0.060$  (non-H atoms) and  $-0.093$  (H atoms); maximum difference peak  $+0.51$  (at a position  $1.20 \text{ \AA}$  from the Br atom), minimum difference peak  $-0.65 e \text{ \AA}^{-3}$ ; no corrections for absorption or secondary extinction. Atomic scattering factors from *SHELX76*. The geometrical calculations were carried out using *PARST* (Nardelli, 1983).

**Discussion.** Final atomic coordinates and equivalent isotropic thermal parameters are given in Table 1,\* bond distances, valence angles and selected torsion angles in Table 2. The numbering of the atoms and a view of the molecule are shown in the *PLUTO78* (Motherwell & Clegg, 1978) drawing in Fig. 1.

The absolute configuration of the molecule, *S*, is consistent with the absolute configuration of quinidine (Carter *et al.*, 1967; Turner & Woodward, 1953), except for the new chirality centre at C(10) which has an *S* configuration.

\* Lists of structure factors, anisotropic thermal parameters, H-atom parameters, least-squares planes and torsion angles have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 53066 (19 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

Table 2. Bond distances ( $\text{\AA}$ ), angles ( $^\circ$ ) and selected torsion angles ( $^\circ$ ) with e.s.d.'s in parentheses

Br(1)—C(10)	1.988 (6)	C(5)—C(6)	1.529 (11)
N(1)—C(2)	1.469 (7)	C(7)—C(8)	1.541 (7)
N(1)—C(6)	1.480 (8)	C(8)—C(9)	1.543 (7)
N(1)—C(8)	1.472 (7)	C(9)—C(24)	1.524 (8)
N(2)—C(22)	1.305 (7)	C(10)—C(11)	1.528 (10)
N(2)—C(29)	1.364 (7)	C(22)—C(23)	1.397 (9)
O(1)—C(9)	1.424 (6)	C(23)—C(24)	1.359 (8)
O(2)—C(26)	1.361 (6)	C(24)—C(30)	1.425 (7)
O(2)—C(31)	1.412 (9)	C(25)—C(26)	1.355 (7)
C(2)—C(3)	1.555 (8)	C(25)—C(30)	1.433 (7)
C(3)—C(4)	1.526 (9)	C(26)—C(27)	1.422 (8)
C(3)—C(10)	1.522 (7)	C(27)—C(28)	1.330 (8)
C(4)—C(5)	1.529 (8)	C(28)—C(29)	1.411 (7)
C(4)—C(7)	1.524 (9)	C(29)—C(30)	1.417 (8)
C(2)—N(1)—C(6)	106.7 (5)	O(1)—C(9)—C(24)	110.9 (5)
C(2)—N(1)—C(8)	112.2 (4)	C(8)—C(9)—C(24)	108.5 (4)
C(6)—N(1)—C(8)	107.0 (5)	Br(1)—C(10)—C(3)	108.5 (4)
C(22)—N(2)—C(29)	117.2 (5)	Br(1)—C(10)—C(11)	105.9 (5)
C(26)—O(2)—C(31)	118.4 (5)	C(3)—C(10)—C(11)	115.0 (6)
N(1)—C(2)—C(3)	112.4 (5)	N(2)—C(22)—C(23)	124.7 (6)
C(2)—C(3)—C(4)	107.4 (5)	C(22)—C(23)—C(24)	119.9 (6)
C(2)—C(3)—C(10)	112.2 (5)	C(9)—C(24)—C(23)	121.2 (5)
C(4)—C(3)—C(10)	113.3 (5)	C(9)—C(24)—C(30)	121.0 (5)
C(3)—C(4)—C(5)	107.0 (6)	C(23)—C(24)—C(30)	117.7 (5)
C(3)—C(4)—C(7)	109.5 (5)	C(26)—C(25)—C(30)	119.8 (5)
C(5)—C(4)—C(7)	108.3 (5)	O(2)—C(26)—C(25)	125.0 (5)
C(4)—C(5)—C(6)	109.4 (6)	O(2)—C(26)—C(27)	114.6 (5)
N(1)—C(6)—C(5)	111.2 (5)	C(25)—C(26)—C(27)	120.4 (6)
C(4)—C(7)—C(8)	108.8 (5)	C(26)—C(27)—C(28)	120.8 (5)
N(1)—C(8)—C(7)	111.0 (4)	C(27)—C(28)—C(29)	120.9 (5)
N(1)—C(8)—C(9)	112.6 (5)	N(2)—C(29)—C(28)	118.6 (5)
C(7)—C(8)—C(9)	114.4 (5)	N(2)—C(29)—C(30)	122.3 (5)
O(1)—C(9)—C(8)	109.9 (4)	C(28)—C(29)—C(30)	119.1 (5)
C(24)—C(30)—C(25)	123.3 (5)	C(25)—C(30)—C(29)	118.5 (5)
C(24)—C(30)—C(29)	118.1 (5)	N(1)—C(8)—C(9)—C(24)	-164.1 (4)
C(7)—C(8)—C(9)—C(24)	67.9 (6)	C(8)—C(9)—C(24)—C(30)	76.5 (6)
C(7)—C(8)—C(9)—O(1)	-53.5 (6)	C(8)—C(9)—C(24)—C(23)	-99.6 (6)
N(1)—C(8)—C(9)—O(1)	74.4 (6)	C(2)—N(1)—C(4)—C(3)	4.8 (4)
O(1)—C(9)—C(24)—C(30)	-162.6 (5)	C(6)—N(1)—C(4)—C(5)	5.3 (5)
O(1)—C(9)—C(24)—C(23)	21.2 (7)	C(8)—N(1)—C(4)—C(7)	8.1 (4)

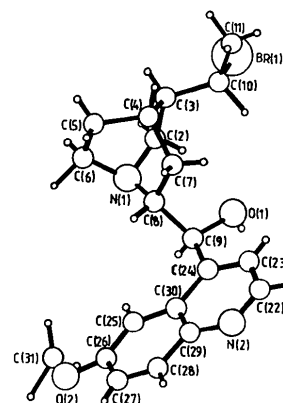


Fig. 1. A view of the molecule with the atomic labelling.

Bond lengths, valence angles and torsion angles are comparable with equivalent values for the hydroxy derivative of quinidine (Suszko-Purzycka *et al.*, 1987) and the quinidine base (Kashino & Haisa, 1983).

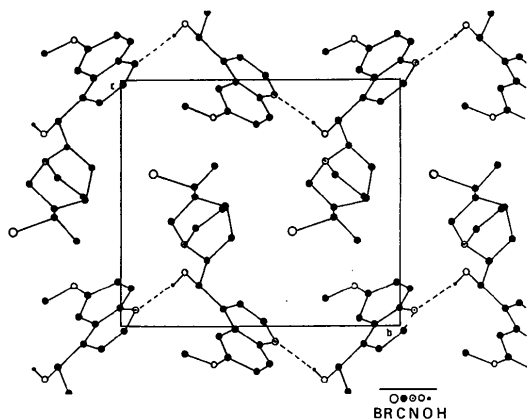


Fig. 2. Projection of the structure along *a*. The hydrogen bonds are indicated by broken lines. The H atoms are omitted except that belonging to the hydroxyl group.

The C—Br distance [1.988 (6) Å] is typical of C<sub>sp<sup>3</sup></sub>—Br bonds in similar substructures (Allen, Kennard, Watson, Brammer, Orpen & Taylor, 1987).

The least-squares plane of the quinoline ring shows that the largest deviation from the plane is 0.072 (6) Å for the C(26) atom connected to the O atom of the methoxy group; the methoxy O(2) and C(31) atoms are located at 0.188 (5) and 0.359 (9) Å from this plane.

Packing of the molecules and the hydrogen-bonding scheme is shown in Fig. 2. Molecules related by 2<sub>1</sub> axes are linked together by hydrogen bonds between O(1) of the hydroxyl group and N(2) of the quinoline ring with the distances: O(1<sup>i</sup>)...N(2<sup>ii</sup>) 2.844 (7), H(O1<sup>i</sup>)...N(2<sup>ii</sup>) 2.14 (5) Å and the angle O(1<sup>i</sup>)—H(O1<sup>i</sup>)...N(2<sup>ii</sup>) 174 (6)°, where (i) = *x*, *y*, *z* and

(ii) =  $-x, y - 1/2, -z$ . In other *Cinchona* alkaloids and their derivatives hydrogen bonds are formed either by the more basic N(1) quinuclidine N atom or by both N(1) and N(2) quinuclidine and quinoline N atoms.

Measurements of the intensities were carried out at the Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw. This research was supported by Project RP.II.10 from the Polish Ministry of Education.

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*Acta Cryst.* (1990). **C46**, 2126–2128

## Structure of 1,4-Bis(3-quinoly)-1,3-butadiyne

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(Received 31 May 1989; accepted 10 January 1990)

**Abstract.** C<sub>22</sub>H<sub>12</sub>N<sub>2</sub>, *M<sub>r</sub>* = 304.47, monoclinic, *P*2<sub>1</sub>/*c*, *a* = 4.807 (3), *b* = 13.687 (4), *c* = 11.909 (2) Å, β =

95.34 (3)°, *V* = 780.59 Å<sup>3</sup>, *Z* = 2, *D<sub>x</sub>* = 1.295 Mg m<sup>-3</sup>, λ(Mo *K*α) = 0.7107 Å, μ = 0.083 mm<sup>-1</sup>, *F*(000) = 316, *T* = 295 K, final *R* = 0.0636 for 528 reflections with *F* > 5.0σ(*F*). The

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