to the involvement of the ring N in hydrogen-bond formation. The two phenyl rings are inclined to one another at an angle of 67·2°.

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Structure of 8-Chloro-1-[(dimethylamino)methyl]-6-phenyl-4*H*-imidazo-[1,2-*a*][1,4]benzodiazepine, $C_{20}H_{19}ClN_4$*

BY HELEN J. BUTCHER AND THOMAS A. HAMOR

Department of Chemistry, University of Birmingham, Birmingham B15 2TT, England

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Abstract. $M_r = 350·8$, triclinic, $P\bar{1}$, $a = 9·036$ (4), $b = 9·888$ (3), $c = 11·035$ (7) Å, $\alpha = 94·62$ (4), $\beta = 100·40$ (5), $\gamma = 106·75$ (3)°, $U = 919·4$ Å^3, $Z = 2$, $D_x = 1·267$ Mg m^{-3}, μ(Mo $K\alpha$, $\lambda = 0·71069$ Å) = 0·18 mm^{-1}, $F(000) = 368$, room temperature, $R = 0·042$ for 1361 observed reflections. The seven-membered ring adopts a boat conformation and the angle between the phenyl ring and the fused benzene moiety is 66·5 (5)°. Bond lengths and angles agree with those found in other 1,4-benzodiazepines. The benzo and imidazo rings are effectively planar.

Introduction. Many 5-phenyl-1,4-benzodiazepines exhibit a broad range of psychotherapeutic properties. The title compound (Gall & Kamdar, 1981) is of the type possessing a five-membered hetero-ring fused across the N(1)—C(2) bond of the parent system. It has a rather low affinity for the benzodiazepine receptor *in vitro* in comparison with the analogous triazolobenzodiazepines triazolam† (Hester, Rudzik & Kamdar, 1971) and estazolam‡ (Meguro & Kuwada, 1970) which bind considerably better, approximately 100 times more strongly in the case of estazolam (Braestrup & Squires, 1978). The structure of the title compound is reported as part of a study of structure–activity relationships for benzodiazepines.

Experimental. Crystal size 0·025 × 0·15 × 0·5 mm, Enraf–Nonius CAD-4 diffractometer, cell dimensions from setting angles of 25 reflections, graphite-monochromated Mo $K\alpha$ radiation, no absorption correction, 3237 reflections scanned by ω–2θ scans up to $\theta = 25°$, 1361 reflections considered observed [$I > 2·5\sigma(I)$], index range h −10 to 9, k −11 to 11, l 0 to 12. Two standard reflections, measured every 2 h; no significant intensity variation. Structure solved by direct methods; H atoms apart from those of methyl groups located from Fourier difference map; least-squares refinement, $\sum w(\Delta F)^2$ minimized, methyl groups refined as rigid groups, other H atoms refined isotropically and non-H anisotropically; final calculated shifts all $<0·1\sigma$; $R = 0·042$, $wR = 0·052$; weighting scheme, $w = 1/[\sigma^2(F) + 0·0015F^2]$; residual electron density in final difference map within ±0·2 e Å^{-3}; no correction for secondary extinction.

Computations were carried out with *SHELX* (Sheldrick, 1978) using complex neutral-atom scattering factors (*International Tables for X-ray Crystallography*, 1974) and *PLUTO* (Motherwell & Clegg, 1978).

* Contribution from the Crystallography Unit, Universities of Aston and Birmingham.

† 8-Chloro-6-(2-chlorophenyl)-1-methyl-4*H*-*s*-triazolo[4,3-*a*][1,4]benzodiazepine. Marketed as Halcion (Upjohn).

‡ 8-Chloro-6-phenyl-4*H*-*s*-triazolo[4,3-*a*][1,4]benzodiazepine.

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Table 1. *Fractional atomic coordinates* ($\times 10^4$) *with e.s.d.'s in parentheses and equivalent isotropic temperature factors* ($Å^2 \times 10^3$) *for non-hydrogen atoms*

$U_{eq} = \frac{1}{3}(U_{11} + U_{22} + U_{33} + 2U_{23}\cos\alpha + 2U_{13}\cos\beta + 2U_{12}\cos\gamma)$.

	x	y	z	U_{eq}
Cl	2133 (2)	−705 (1)	3815 (1)	57
N(1)	7313 (4)	4708 (3)	4469 (3)	32
N(3)	8748 (5)	6702 (4)	3938 (4)	49
N(5)	7112 (4)	3733 (4)	1766 (3)	42
N(14)	7518 (5)	5261 (4)	7561 (4)	49
C(1)	8390 (5)	5461 (4)	5559 (4)	38
C(2)	9222 (6)	6651 (5)	5181 (6)	49
C(3)	7592 (5)	5512 (5)	3538 (5)	37
C(4)	6674 (7)	4961 (5)	2262 (5)	46
C(6)	6716 (5)	2586 (4)	2251 (4)	34
C(7)	4599 (5)	1101 (5)	3153 (5)	38
C(8)	3685 (5)	857 (4)	4029 (5)	38
C(9)	3986 (6)	1871 (5)	5042 (5)	41
C(10)	5177 (5)	3118 (5)	5190 (5)	37
C(11)	6098 (5)	3392 (4)	4307 (4)	32
C(12)	5818 (5)	2382 (4)	3257 (4)	31
C(13)	8543 (6)	4928 (5)	6773 (5)	46
C(15)	8018 (7)	6790 (6)	8000 (6)	66
C(16)	7540 (9)	4449 (7)	8606 (6)	85
C(1′)	7207 (5)	1367 (4)	1773 (4)	35
C(2′)	7595 (6)	432 (5)	2533 (5)	41
C(3′)	8141 (7)	−637 (6)	2117 (6)	52
C(4′)	8307 (7)	−791 (7)	918 (6)	62
C(5′)	7912 (7)	121 (7)	126 (6)	61
C(6′)	7366 (6)	1201 (6)	549 (5)	50

Discussion. Final atomic parameters are listed in Table 1;* bond lengths, bond angles and selected torsion angles are in Table 2. The atomic numbering scheme is illustrated in Fig. 1.

Bond lengths and angles agree with those found in estazolam (Kamiya, Wada & Nishikawa, 1973) and other 1,4-benzodiazepines (Hamor & Martin, 1983). The N(1)–C(3) formal single bond is shortened to 1·364 (5) Å and the disposition of bonds about N(1) is planar; thus the geometry of this bond resembles a double bond, as has been found for benzodiazepin-2-ones. The angle C(3)–N(1)–C(11) is 123·8 (4)° which is very similar to the corresponding angle in N(1)–Me substituted benzodiazepines (Chananont, Hamor & Martin, 1981).

The conformation of the seven-membered ring only deviates slightly from an ideal cycloheptatriene-like boat. The stern angle of 35·3 (6)° is similar to that found in N(1)–Me substituted molecules and to that in estazolam (32°), whilst the bow angle of 56·5 (6)° is also close to the angle of 54° in estazolam (Kamiya *et al.*, 1973); 1,4-benzodiazepin-2-ones, however, have a somewhat steeper bow angle (58–64°) (Hamor & Martin, 1983).

The benzene and imidazo rings are planar to within the limits of experimental error. The angle between the

* Lists of structure factors, anisotropic thermal parameters, coordinates of H atoms and the results of mean-plane calculations have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 39179 (12 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

Table 2. *Bond lengths* (Å), *bond angles* (°) *and selected torsion angles* (°)

N(1)–C(1)	1·401 (5)	C(8)–Cl	1·727 (4)
N(1)–C(3)	1·364 (5)	C(8)–C(9)	1·372 (6)
N(1)–C(11)	1·415 (5)	C(9)–C(10)	1·358 (6)
C(1)–C(2)	1·344 (6)	C(10)–C(11)	1·385 (6)
C(1)–C(13)	1·476 (7)	C(11)–C(12)	1·402 (5)
C(2)–N(3)	1·370 (7)	C(13)–N(14)	1·464 (6)
N(3)–C(3)	1·308 (5)	N(14)–C(15)	1·461 (6)
C(3)–C(4)	1·471 (7)	N(14)–C(16)	1·457 (7)
C(4)–N(5)	1·476 (6)	C(1′)–C(2′)	1·374 (6)
N(5)–C(6)	1·279 (5)	C(2′)–C(3′)	1·370 (7)
C(6)–C(1′)	1·489 (6)	C(3′)–C(4′)	1·360 (8)
C(6)–C(12)	1·482 (6)	C(4′)–C(5′)	1·380 (8)
C(7)–C(12)	1·399 (6)	C(5′)–C(6′)	1·381 (7)
C(7)–C(8)	1·373 (6)	C(6′)–C(1′)	1·386 (6)
C(1)–N(1)–C(3)	107·2 (3)	C(8)–C(9)–C(10)	120·8 (5)
C(1)–N(1)–C(11)	128·9 (4)	C(9)–C(10)–C(11)	120·3 (5)
C(3)–N(1)–C(11)	123·8 (4)	N(1)–C(11)–C(10)	119·3 (4)
N(1)–C(1)–C(2)	103·4 (4)	N(1)–C(11)–C(12)	120·3 (4)
N(1)–C(1)–C(13)	124·7 (4)	C(10)–C(11)–C(12)	120·5 (4)
C(2)–C(1)–C(13)	131·9 (5)	C(6)–C(12)–C(7)	118·1 (4)
C(1)–C(2)–N(3)	113·3 (4)	C(6)–C(12)–C(11)	124·5 (4)
C(2)–N(3)–C(3)	104·3 (4)	C(7)–C(12)–C(11)	117·4 (4)
N(1)–C(3)–N(3)	111·8 (4)	C(1)–C(13)–N(14)	115·0 (4)
N(1)–C(3)–C(4)	119·5 (4)	C(13)–N(14)–C(15)	110·6 (4)
N(3)–C(3)–C(4)	128·6 (5)	C(13)–N(14)–C(16)	109·7 (4)
C(3)–C(4)–N(5)	109·8 (4)	C(15)–N(14)–C(16)	110·8 (5)
C(4)–N(5)–C(6)	117·6 (4)	C(6)–C(1′)–C(2′)	121·7 (4)
N(5)–C(6)–C(1′)	117·3 (4)	C(6)–C(1′)–C(6′)	119·9 (4)
N(5)–C(6)–C(12)	125·0 (4)	C(2′)–C(1′)–C(6′)	118·3 (5)
C(1′)–C(6)–C(12)	117·7 (4)	C(1′)–C(2′)–C(3′)	121·9 (5)
C(8)–C(7)–C(12)	121·3 (4)	C(2′)–C(3′)–C(4′)	119·7 (6)
C(7)–C(8)–C(9)	119·8 (4)	C(3′)–C(4′)–C(5′)	119·8 (6)
C(7)–C(8)–Cl	119·4 (4)	C(4′)–C(5′)–C(6′)	120·3 (6)
C(9)–C(8)–Cl	120·9 (4)	C(5′)–C(6′)–C(1′)	119·9 (6)
C(11)–N(1)–C(3)–C(4)	−4·7*	C(12)–C(6)–C(1′)–C(2′)	−33·2
N(1)–C(3)–C(4)–N(5)	−68·3	N(5)–C(6)–C(1′)–C(2′)	146·3
C(3)–C(4)–N(5)–C(6)	68·4	N(1)–C(1)–C(13)–N(14)	−88·8
C(4)–N(5)–C(6)–C(12)	1·4	C(2)–C(1)–C(13)–N(14)	95·7
N(5)–C(6)–C(12)–C(11)	−43·0	C(1)–C(13)–N(14)–C(15)	−68·8
C(6)–C(12)–C(11)–N(1)	−0·5	C(1)–C(13)–N(14)–C(16)	168·7
C(12)–C(11)–N(1)–C(3)	43·4		

* E.s.d.'s ~ 0·6°.

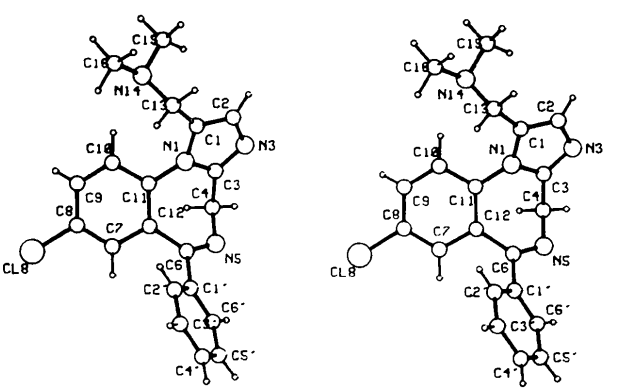

Fig. 1. Stereoscopic view of the molecule in a direction perpendicular to the mean plane through atoms C(7)–(12).

two benzene rings is 66·5 (5)°, which is in the expected range for molecules with an unsubstituted phenyl ring (Hamor & Martin, 1983).

All intermolecular contact distances correspond to normal van der Waals interactions.

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Stereochemical Aspects of Narcotic Action. II.* 9-(*m*-Hydroxyphenyl)-9α-methoxy-3-methyl-3-azoniabicyclo[3.3.1]nonane *p*-Toluenesulfonate Monohydrate, $C_{16}H_{24}NO_2^+.C_7H_7O_3S^-.H_2O$

BY G. HITE,† P. SALVA, J. B. ANDERSON, M. RAPPOSCH AND M. MANGION

Section of Medicinal Chemistry and Pharmacognosy, School of Pharmacy and Institute of Materials Science, University of Connecticut, Storrs, CT 06268, *USA*

AND M. FROIMOWITZ

Ralph Lowell Laboratories, Mailman Research Center, McLean Hospital and Harvard Medical School, 115 *Mill Street, Belmont, MA* 02178, *USA*

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Abstract. $M_r = 451·6$, monoclinic, $P2_1/c$, $a = 10·006$ (3), $b = 28·597$ (5), $c = 8·352$ (2) Å, $\beta = 106·29$ (2)°, $V = 2293·8$ (3) Å^3, $Z = 4$, $D_m = 1·305$ (3), $D_x = 1·307$ (3) Mg m^{-3}, λ(Cu $K\alpha_1$) = 1·5405 Å, $\mu = 1·55$ mm^{-1}, $F(000) = 968$, $T = 293$ K, $R = 0·065$, 2224 reflections. The crystal contains enantiomeric conformations [angles C(5)–C(9)–C(10)–C(11) ±19·5 (6); C(16)–O(1)–C(9)–C(10) ±54·6 (5)°] but not the diastereomeric conformers generated by 180° rotation around the C(9)–C(10) bonds. The chair–chair conformation of the bicyclic nucleus is flattened [N to C(7), 3·080 (7) Å]. Independently calculated, energy-minimized conformations for the non-phenolic analog are consistent with the solid-state conformations.

Introduction. Analogs and diastereoisomers (9α,9β) of (1) are strong narcotic analgetics (Ohki, Oida, Ohashi, Takagi & Iwai, 1970) offering a unique opportunity to determine the relative orientations of the aromatic rings, N atoms and N substituents at the narcotic receptor through a series of linear free-energy correlations (Portoghese, 1965). Before embarking on that study it was necessary to compare the conformations of two representative, diastereomeric analogs, the first of which, the 9α isomer (1), is the subject of this report. The conformation of the bicyclic nucleus and the torsion angle around the C(9)–C(10) bond are of particular interest. These define the distances between the pharmacophoric groups (N, phenyl, OH). In addition, the potencies of some narcotic analgetics have been correlated with the torsion angles of the aromatic rings (Froimowitz, 1982; Portoghese, 1978; Fries, Dodge, Hope & Portoghese, 1982).

* Part I: Tecle & Hite (1976).

† To whom correspondence should be addressed.

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