Stark, R. E., Haberkorn, R. A. & Griffin, R. G. (1978). *J. Chem. Phys.* **68**, 1996–2001.
Stark, R. E., Jelinski, L. E., Ruben, D. J., Torchia, D. A. & Griffin, R. G. (1983). *J. Magn. Reson.* **55**, 266–272.
Stewart, P. L., Tycko, R. & Opella, S. J. (1988). *J. Chem. Soc. Faraday Trans.* 1, **84**, 3803–3819.
Tycko, R., Stewart, P. L. & Opella, S. J. (1986). *J. Am. Chem. Soc.* **108**, 5419–5425.

Acta Cryst. (1990). C**46**, 246–248

Structure of 9-Chloro-7-(2-fluorophenyl)-5*H*-pyrimido[5,4-*d*][2]benzazepine*

By Helen J. Kemmish and Thomas A. Hamor

*Department of Chemistry, University of Birmingham, Birmingham B*15 2*TT, England*

(*Received* 10 *February* 1989; *accepted* 8 *May* 1989)

Abstract. $C_{18}H_{11}ClFN_3$, $M_r = 323{\cdot}8$, monoclinic, $P2_1/n$, $a = 8{\cdot}651\ (2)$, $b = 10{\cdot}336\ (3)$, $c = 16{\cdot}855\ (3)$ Å, $\beta = 90{\cdot}39\ (2)°$, $V = 1507{\cdot}1$ Å^3, $Z = 4$, $D_x = 1{\cdot}427$ g cm^{-3}, $\lambda(\text{Mo } K\alpha) = 0{\cdot}71069$ Å, $\mu = 2{\cdot}20$ cm^{-1}, $F(000) = 664$, $T = 293$ K, $R = 0{\cdot}036$ for 2425 observed reflections. The angle between the mean planes of the fluorophenyl ring and the fused benzo moiety is 71·7 (3)°. The seven-membered heterocyclic ring adopts a cycloheptatriene-like boat conformation with bow and stern angles of 59·3 (4) and 32·4 (4)°. The pyrimidine ring and the two benzene rings are each planar to within ±0·025 Å. Bond lengths and angles are normal.

Introduction. The title compound (Trybulski, Benjamin, Earley, Fryer, Gilman, Reeder, Walser, Davidson, Horst, Sepinwall, O'Brien & Dairman, 1983) is related to the classical psychoactive 5-phenyl-1,4-benzodiazepin-2-ones such as diazepam,† but differs from these in having the N atom at the 1-position of the seven-membered ring replaced by a C atom. Further, a six-membered hetero-ring is fused across the C1—C4A bond (corresponding to the N1—C2 bond of the benzodiazepine system). Such compounds have been found to have similar pharmacological profiles to the benzodiazepines and have a high affinity for the benzodiazepine receptor *in vitro*. In the present case the affinity is similar to that of diazepam. We now report the crystal structure of the title compound as part of a continuing study of structure–activity relationships for this class of compounds.

Experimental. Crystal size 0·65 × 0·5 × 0·3 mm. X-ray measurements were made on an Enraf–Nonius CAD-4 diffractometer; cell dimensions were determined from the setting angles of 24 reflections in the range $17 < \theta < 25°$; graphite-monochromated Mo $K\alpha$ radiation was used; 5969 reflections were scanned by $\omega/2\theta$ scans up to $\theta = 26°$, 2982 unique, $R_{\text{int}} = 0{\cdot}021$, 2425 $[I > 2{\cdot}5\sigma(I)]$ reflections were considered observed and used in the analysis, index range h −10 to 10, k 0 to 12, l 0 to 20. Two standard reflections measured every 2 h showed no significant variation in intensity. No absorption corrections were applied. The structure was determined by direct methods and refined on F by full-matrix least-squares calculations using anisotropic thermal parameters for the non-H atoms. The H atoms were located in a subsequent difference synthesis and refined isotropically. Weights $w = 1/[\sigma^2(F) + 0{\cdot}005 \times F^2]$ were used in the least-squares refinement. The refinement converged to $R = 0{\cdot}036$, $wR = 0{\cdot}067$, with maximum shift/e.s.d. ratio of 0·3. The residual electron density in a final difference map was within ±0·3 e Å^{-3}. No correction for secondary extinction was applied.

Atomic scattering factors were taken from *International Tables for X-ray Crystallography* (1974). Computations were carried out on the University of Birmingham Honeywell DPS 8/70 computer and on the CDC 7600 at the University of Manchester Regional Computer Centre with the *SHELX*76 (Sheldrick, 1976) and *PLUTO* (Motherwell & Clegg, 1978) programs.

Discussion. Fig. 1 illustrates the atomic numbering scheme. Atomic coordinates are listed in Table 1.‡ Bond lengths, bond angles and selected torsion angles are in Table 2.

---

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

† 7-Chloro-1,3-dihydro-1-methyl-5-phenyl-2*H*-1,4-benzodiazepin-2-one. Marketed as Valium (Roche).

‡ Lists of structure factors, anisotropic thermal parameters and H-atom parameters have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 52208 (15 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

0108-2701/90/020246-03$03.00

The bond lengths and angles are generally similar to those found in benzodiazepines (Hamor & Martin, 1983). Whereas benzodiazepines possess an N(1)—C(2) bond of *ca* 1·37 Å, with a near-planar disposition of valencies due to delocalization effects, the corresponding bond in the title compound, C(1)—C(4A), is an aromatic bond of length 1·392 (3) Å. C(1), C(4A) and the four atoms bonded to them are coplanar to within ±0·025 Å. The ring angle, C(12)—C(1)—C(4A), at 121·8 (2)° is similar in magnitude to those in benzodiazepines methylated at N(1) (Chananont, Hamor & Martin, 1981), but is some 1 to 3° smaller than the angle at N(1) when there is an extra ring fused across the N(1)—C(2) bond (see *e.g.* Butcher & Hamor, 1984; Kemmish & Hamor, 1988). In the crystal structure of the very closely related 9-chloro-7-(2-chlorophenyl)-5*H*-pyrimido[5,4-*d*][2]benzazepine 3-oxide, the C(1)—C(4A) bond length is 1·393 Å and the angle at C(1) is 122·6° (Trybulski, Fryer, Reeder, Walser & Blount, 1983).

As in the benzodiazepines, the seven-membered ring in the title compound adopts a cycloheptatriene-like boat conformation, with bow and stern angles of 59·3 (4) and 32·4 (4)° falling within the ranges commonly found in benzodiazepines, 58–64 and 32–40°, respectively (Hamor & Martin, 1983). The deviation parameter (Hamor & Martin, 1983), which is a measure of the deviation of the seven-membered ring from mirror symmetry and zero torsion angles about the three double bonds of the ideal cycloheptatriene boat conformation, is 6·1°, similar to values found in benzodiazepines.

The angle between the mean planes of the 7-(2-fluorophenyl) ring and the fused benzene ring is 71·7 (3)° which is slightly smaller than that in benzodiazepines containing an *ortho* halo-substituted phenyl ring (range 73–86°). The angle, however, falls near the upper end of the range for benzodiazepines containing an unsubstituted phenyl ring. The overall geometrical similarity between the title compound and the classical benzodiazepine diazepam is illustrated in Fig. 2.

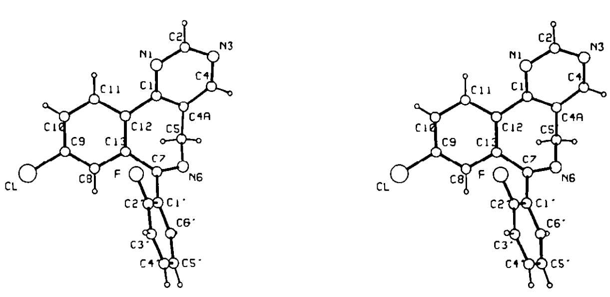

Fig. 1. Stereoscopic view of the title compound in a direction perpendicular to the mean plane of atoms C(8)—C(13) drawn with *PLUTO* (Motherwell & Clegg, 1978).

Table 1. *Fractional atomic coordinates* (× 10^5 *for* Cl; × 10^4 *for other atoms*) *with e.s.d.'s in parentheses and equivalent isotropic temperature factors* (Å^2 × 10^3)

$$U_{eq} = (U_{11} + U_{22} + U_{33} + 2U_{13}\cos\beta)/3.$$

	x	*y*	*z*	U_{eq}
Cl	55588 (6)	53104 (5)	24051 (3)	54
F	5755 (1)	1686 (1)	373 (1)	64
N(1)	1709 (2)	4203 (2)	−980 (1)	48
N(3)	−314 (2)	2929 (2)	−1560 (1)	59
N(6)	1322 (2)	1167 (2)	791 (1)	46
C(1)	1511 (2)	3589 (2)	−286 (1)	36
C(2)	782 (3)	3843 (2)	−1571 (1)	56
C(4)	−514 (2)	2367 (2)	−860 (1)	55
C(4A)	346 (2)	2674 (2)	−193 (1)	42
C(5)	65 (2)	2078 (2)	602 (1)	54
C(7)	2646 (2)	1666 (2)	955 (1)	37
C(8)	3983 (2)	3513 (2)	1585 (1)	37
C(9)	4451 (2)	4782 (2)	1605 (1)	38
C(10)	4069 (2)	5640 (2)	1006 (1)	44
C(11)	3131 (2)	5218 (2)	397 (1)	41
C(12)	2554 (2)	3953 (2)	375 (1)	34
C(13)	3024 (2)	3077 (2)	969 (1)	34
C(1′)	3866 (2)	732 (2)	1193 (1)	37
C(2′)	5356 (2)	747 (2)	899 (1)	46
C(3′)	6446 (3)	−172 (2)	1090 (2)	57
C(4′)	6053 (3)	−1144 (2)	1606 (2)	59
C(5′)	4585 (3)	−1196 (2)	1927 (1)	53
C(6′)	3509 (2)	−270 (2)	1714 (1)	44

Table 2. *Bond lengths* (Å) *and bond angles* (°) *with e.s.d.'s in parentheses and selected torsion angles* (°, *e.s.d.'s* 0·3°)

Cl—C(9)	1·736 (2)	C(7)—C(1′)	1·483 (2)
F—C(2′)	1·361 (2)	C(8)—C(9)	1·374 (2)
N(1)—C(1)	1·342 (2)	C(8)—C(13)	1·399 (2)
N(1)—C(2)	1·329 (3)	C(9)—C(10)	1·384 (3)
N(3)—C(2)	1·339 (3)	C(10)—C(11)	1·375 (3)
N(3)—C(4)	1·328 (3)	C(11)—C(12)	1·400 (2)
N(6)—C(5)	1·472 (3)	C(12)—C(13)	1·408 (2)
N(6)—C(7)	1·285 (2)	C(1′)—C(2′)	1·384 (3)
C(1)—C(4A)	1·392 (3)	C(1′)—C(6′)	1·394 (2)
C(1)—C(12)	1·478 (2)	C(2′)—C(3′)	1·375 (3)
C(4)—C(4A)	1·380 (3)	C(3′)—C(4′)	1·374 (3)
C(4A)—C(5)	1·496 (3)	C(4′)—C(5′)	1·384 (4)
C(7)—C(13)	1·495 (2)	C(5′)—C(6′)	1·380 (3)
C(1)—N(1)—C(2)	116·2 (2)	C(9)—C(10)—C(11)	118·6 (2)
C(2)—N(3)—C(4)	114·7 (2)	C(10)—C(11)—C(12)	121·6 (2)
C(5)—N(6)—C(7)	116·5 (2)	C(1)—C(12)—C(11)	118·2 (1)
N(1)—C(1)—C(4A)	121·1 (2)	C(1)—C(12)—C(13)	123·0 (1)
N(1)—C(1)—C(12)	117·1 (1)	C(11)—C(12)—C(13)	118·7 (1)
C(4A)—C(1)—C(12)	121·8 (2)	C(7)—C(13)—C(8)	117·0 (1)
N(1)—C(2)—N(3)	127·7 (2)	C(7)—C(13)—C(12)	123·7 (1)
N(3)—C(4)—C(4A)	123·4 (2)	C(8)—C(13)—C(12)	119·2 (1)
C(1)—C(4A)—C(4)	116·8 (2)	C(7)—C(1′)—C(2′)	124·0 (2)
C(1)—C(4A)—C(5)	120·2 (2)	C(7)—C(1′)—C(6′)	119·6 (2)
C(4)—C(4A)—C(5)	123·0 (2)	C(2′)—C(1′)—C(6′)	116·4 (2)
N(6)—C(5)—C(4A)	109·5 (2)	F—C(2′)—C(1′)	118·9 (2)
N(6)—C(7)—C(13)	126·1 (2)	F—C(2′)—C(3′)	117·9 (2)
N(6)—C(7)—C(1′)	115·4 (1)	C(1′)—C(2′)—C(3′)	123·2 (2)
C(13)—C(7)—C(1′)	118·4 (1)	C(2′)—C(3′)—C(4′)	118·7 (2)
C(9)—C(8)—C(13)	120·0 (2)	C(3′)—C(4′)—C(5′)	120·5 (2)
Cl—C(9)—C(8)	118·8 (1)	C(4)′—C(5′)—C(6′	119·4 (2)
Cl—C(9)—C(10)	119·6 (1)	C(1′)—C(6′)—C(5′)	121·8 (2)
C(8)—C(9)—C(10)	121·7 (2)		
C(12)—C(1)—C(4A)—C(5)	3·2	C(7)—C(13)—C(12)—C(1)	5·9
C(1)—C(4A)—C(5)—N(6)	−72·7	C(13)—C(12)—C(1)—C(4A)	33·0
C(4A)—C(5)—N(6)—C(7)	71·4	C(13)—C(7)—C(1′)—C(2′)	−49·4
C(5)—N(6)—C(7)—C(13)	−0·3	N(6)—C(7)—C(1′)—C(2′)	133·7
N(6)—C(7)—C(13)—C(12)	−44·9		

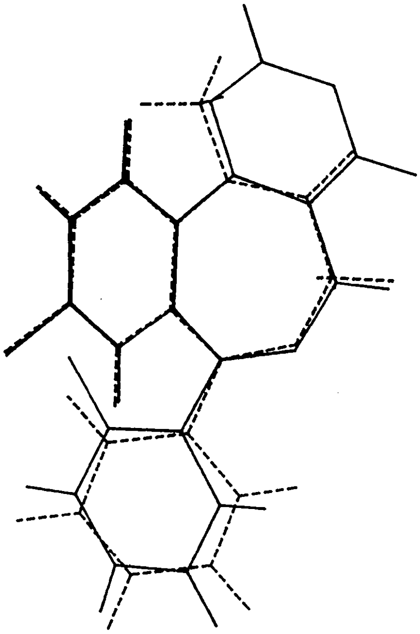

Fig. 2. Superposition of drawings of the title compound (full lines) and diazepam (dashed lines).

The C(7)—C(1′) bond length of 1·483 (2) Å corresponds to that of a single bond between trigonally hybridized C atoms and the C(7)—N(6) bond length of 1·285 (2) Å to that of a C=N double bond.

All intermolecular contacts are of the normal van der Waals type.

We thank Dr R. I. Fryer, Hoffmann-LaRoche for materials, Dr I. L. Martin, Medical Research Council Centre, Cambridge, for affinity measurements and the SERC for financial support to HJK.

References

Butcher, H. J. & Hamor, T. A. (1984). *Acta Cryst.* **C40**, 848–850.

Chananont, P., Hamor, T. A. & Martin, I. L. (1981). *Acta Cryst.* **B37**, 1371–1375.

Hamor, T. A. & Martin, I. L. (1983). *Progress in Medicinal Chemistry*, Vol. 20, edited by G. P. Ellis & G. B. West, pp. 157–223. Amsterdam: Elsevier.

International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press. (Present distributor Kluwer Academic Publishers, Dordrecht.)

Kemmish, H. J. & Hamor, T. A. (1988). *Acta Cryst.* **C44**, 1823–1825.

Motherwell, W. D. S. & Clegg, W. (1978). *PLUTO*. Program for plotting molecular and crystal structures. Univ. of Cambridge, England.

Sheldrick, G. M. (1976). *SHELX76*. Program for crystal structure determination. Univ. of Cambridge, England.

Trybulski, E. J., Benjamin, L. E., Earley, J. V., Fryer, R. I., Gilman, N. W., Reeder, E., Walser, A., Davidson, A. B., Horst, W. D., Sepinwall, J., O'Brien, R. A. & Dairman, W. (1983). *J. Med. Chem.* **26**, 1589–1596.

Trybulski, E. J., Fryer, R. I., Reeder, E., Walser, A. & Blount, J. (1983). *J. Med. Chem.* **26**, 1596–1601.

Acta Cryst. (1990). C**46**, 248–251

Structure of an Unexpected Dibenz[*d,f*]azonine from the HBr Elimination of *N*-Formyl-*N*-norbromocodide

By H. van Koningsveld

Laboratory of Applied Physics, Delft University of Technology, Lorentzweg 1, 2628 *CJ Delft, The Netherlands*

and J. T. M. Linders, R. J. Booth, T. S. Lie and L. Maat

Department of Organic Chemistry, Delft University of Technology, Julianalaan 136, 2628 *BL Delft, The Netherlands*

(*Received* 5 *March* 1989; *accepted* 12 *May* 1989)

Abstract. (+)-(*R*)-(*Z*)-7-Formyl-8,9-dihydro-2-methoxy-7*H*-dibenz[*d,f*]azonin-1-ol, $C_{18}H_{17}NO_3$, M_r = 295·34, orthorhombic, $P2_12_12_1$, a = 9·966 (2), b = 14·025 (3), c = 10·595 (2) Å, V = 1480·9 Å^3, Z = 4, D_x = 1·33 g cm^{-3}, λ(Cu $K\alpha$) = 1·54180 Å, μ = 7·44 cm^{-1}, F(000) = 608, T = 293 K, R = 0·036 for 1773 observed reflections. The title compound is formed *via* an acid-catalyzed rearrangement of 6-demethoxy-*N*-formyl-*N*-northebaine, the HBr elimination product from *N*-formyl-*N*-norbromocodide. The dibenzazonine consists of two phenyl rings, which are almost perpendicular to each other. The nine-membered ring is in a boat-like conformation with the *N*-formyl moiety practically planar.

0108-2701/90/020248-04$03.00