the C(20)—C(14) bond, not present in atisine itself, forces ring $E$ of unit ($A$) into a boat conformation. Also, the $C$ and $D$ rings of unit ($A$) have slightly different conformations from those in atisinium chloride and dihydroatisine, neither of which has a C(20)—C(14) bond (Pelletier, DeCamp & Mody, 1978). The $C$–$D$ ring fragments of the latter two structures have nearly the ideal conformation for bicyclo[2.2.2]octane, whereas in unit ($A$) of staphisine the dihedral angles for this fragment deviate from their ideal values of 0, 60, or $-60°$ by an average of $11\cdot5°$.

Fractional coordinates and temperature factors, bond distances, bond angles and torsion angles for the non-hydrogen atoms are listed in Tables 2, 3, 4, and 5. The anisotropic thermal parameters for the temperature factor exponentials defined by $T = -2\pi^2 \sum_i \sum_j U_{ij} \times h_i h_j a_i^* a_j^*$ are available.† None of the temperature factor coefficients was nonpositive-definite. The thermal parameters varied from a maximum of $0\cdot197\ (8)\ Å^2$ for $U_{11}$ of C(18$A$) to a minimum of $0\cdot023\ (1)\ Å^2$ for $U_{22}$ of C(9$B$). The $U$'s reported in Table 2 are the isotropic temperature factors equivalent to the components of the anisotropic temperature factor matrices, U (Hamilton, 1959).

The absolute configuration of staphisine was not determined from the X-ray data. The fractional coordinates reported correspond to the absolute configuration of atisine, but no relationship between the

two compounds is claimed. Intramolecular bond distances and angles include no remarkable values and there are no significantly short intermolecular distances.

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† Lists of structure factors, anisotropic thermal parameters and H atom coordinates have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 35538 (31 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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# The Structure of a Psychoactive Agent: 7-Chloro-3-hydroxy-1-methyl-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one (Temazepam)

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### Abstract

The structure of temazepam was solved by direct methods and then refined to $R = 0\cdot057$ ($R_w = 0\cdot040$) for 5108 intensities collected on a diffractometer. Crystals of $C_{16}H_{13}ClN_2O_2$ are monoclinic, space group $P2_1/c$, with $a = 19\cdot528\ (5)$, $b = 11\cdot328\ (3)$, $c = 20\cdot231\ (4)\ Å$, $\beta = 107\cdot0\ (1)°$ and twelve molecules in the unit cell; $D_m = 1\cdot40$ (by flotation), $D_x = 1\cdot400\ Mg\ m^{-3}$, $F(000) = 1872$. There are no distinct hydrogen bonds in the crystal as the shortest $H\cdots O$ distance is $2\cdot05\ Å$. The seven-membered ring is in a boat

conformation with $\Delta C_s^3 = 3\cdot5$, $3\cdot1$ and $3\cdot3°$ for the three independent molecules. The 3-hydroxy group is in an equatorial position and the angles between the planes of both the phenyl rings are $66\cdot0$, $66\cdot8$ and $58\cdot7°$ for the three molecules. The conformations and the bond lengths and angles in all three molecules are similar to each other and to those found in other 1,3-dihydro-2H-1,4-benzodiazepin-2-ones.

## Introduction

Many benzodiazepines and benzoxazepines show biological activity. They are used as psychoactive agents; in particular, benzodiazepines are used as anticonvulsant drugs. Camerman & Camerman (1970, 1972) have suggested that the biological activity of many anticonvulsant agents is related to their structure. They based their hypothesis on the structural similarity of 7-chloro-1-methyl-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one [common name diazepam, (IV)] (see Fig. 1) with the most widely employed anticonvulsant drug against grand mal epilepsy, diphenylhydantoin (Camerman & Camerman, 1972). Further X-ray investigations of structures of benzodiazepines showed the hypothesis to be probable but some examples did not agree with it. The structures of 7-chloro-5-(2-chlorophenyl)-3-hydroxy-1,3-dihydro-2H-1,4-benzodiazepin-2-one [lorazepam, (III) (Bandoli & Clemente, 1976)], 7-nitro-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one [nitrazepam, (V) (Gilli, Bertolasi, Sacerdoti & Borea, 1977)], 5-(2-chlorophenyl)-7-nitro-1,3-dihydro-2H-1,4-benzodiazepin-2-one [clonazepam, (VI) (Chananont, Hamor & Martin, 1979)], and 7-chloro-3-hydroxy-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one [oxazepam, (II) (Gilli, Bertolasi, Sacerdoti & Borea, 1978a)] have been determined by X-ray methods and are very similar in conformation and stereochemical arrangement to the structure of diazepam. All five compounds are biologically active. On the other hand, two other compounds [7-chloro-5-(2-fluorophenyl)-1-methyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one (2'-fluorodiazepam) and 1-methyl-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one (7-dechlorodiazepam)] were found by Sternbach, Sancilio & Blount (1974) to have very similar structures and no biological activity. Of course, determination of the crystal structure gives only one conformation and this is not necessarily the same as that which acts at the receptor sites. Furthermore the 'active' conformation is probably one of those with higher energy. In fact, the problem of the relation between the structure and biological activity of benzodiazepines has not been elucidated. To increase the experimental basis as much as possible, we have determined the crystal and molecular structure of a new benzodiazepine which is used as a psychoactive agent:
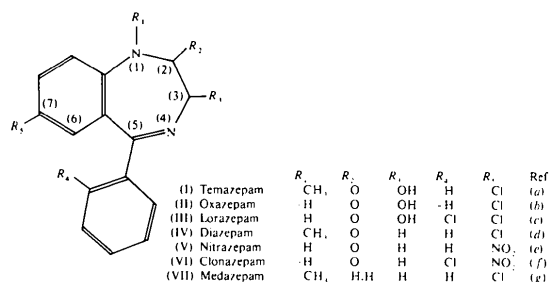


| | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ | Ref |
|---|---|---|---|---|---|---|
| (I) Temazepam | CH₃ | O | OH | H | Cl | (a) |
| (II) Oxazepam | H | O | OH | H | Cl | (b) |
| (III) Lorazepam | H | O | OH | Cl | Cl | (c) |
| (IV) Diazepam | CH₃ | O | H | H | Cl | (d) |
| (V) Nitrazepam | H | O | H | H | NO₂ | (e) |
| (VI) Clonazepam | H | O | H | Cl | NO₂ | (f) |
| (VII) Medazepam | CH₃ | H,H | H | H | Cl | (g) |

Fig. 1. 1,4-Benzodiazepines, the structures of which are known. References: (a) present work; (b) Gilli, Bertolasi, Sacerdoti & Borea (1978a); (c) Bandoli & Clemente (1976); (d) Camerman & Camerman (1972); (e) Gilli, Bertolasi, Sacerdoti & Borea (1977); (f) Chananont, Hamor & Martin (1979); (g) Gilli, Bertolasi, Sacerdoti & Borea (1978b).

7-chloro-3-hydroxy-1-methyl-5-phenyl-1,3-dihydro-2H-1,4-benzodiazepin-2-one [temazepam, (I)]. The space group of crystals of this compound is $P2_1/c$, with three independent molecules in the asymmetric unit; this provides material in the search for structural relationships. A preliminary communication giving the crystal data was published earlier (Gałdecki, Główka, Kozłowska & Werfel, 1976).

## Experimental

Colourless crystals of the title compound were obtained by the slow cooling of a saturated solution in ethanol. Preliminary Weissenberg photographs showed the crystals to be monoclinic and the accurate unit-cell parameters were determined on a diffractometer.

The intensities were collected on a Syntex $P2_1$ diffractometer with graphite-monochromated Cu radiation from a spherical crystal of diameter ~0·3 mm. Measurements were carried out in the $\theta$–$2\theta$ mode ($\theta \leq 57\cdot6°$). From 5108 recorded reflections, 4356 had $F > 2\sigma(F)$ and were included in the refinement. The structure was solved by means of MULTAN (Germain, Main & Woolfson, 1971).

The solution described by the best figures of merit ($M_{abs} = 1\cdot191$, $R_{Karle} = 29\cdot69\%$) gave an $E$ map (400 $E \geq 1\cdot75$) which revealed 50 of the 63 independent non-hydrogen atoms. The remaining atoms were found from the Fourier synthesis ($R = 50\%$). The structure was then refined by the block-diagonal least-squares method. Six cycles of refinement with isotropic thermal parameters followed by four cycles of anisotropic refinement resulted in an $R$ of 0·148. At this stage, all the H atoms were found with some trouble from difference Fourier maps. Further block-diagonal refinement of all atoms (H with isotropic, others with anisotropic temperature factors) decreased $R$ to 0·122; the parameters did not show good

Table 1. *Atomic coordinates* $(\times 10^4)$ *and isotropic temperature factors for non-hydrogen atoms*

| | Molecule | $x$ | $y$ | $z$ | $B_{iso}$ (Å²) |
|---|---|---|---|---|---|
| Cl | A | 6545 (1) | 8024 (1) | 6606 (1) | 5·39 (3) |
| | B | 2179 (1) | 5944 (1) | 8274 (1) | 5·61 (3) |
| | C | 7466 (1) | 4330 (1) | 9955 (1) | 5·95 (3) |
| O(2) | A | 9363 (1) | 4222 (2) | 5293 (1) | 4·1 (1) |
| | B | 1041 (2) | 10968 (2) | 5418 (1) | 4·6 (1) |
| | C | 3914 (2) | 8188 (3) | 9326 (2) | 6·0 (1) |
| O(3) | A | 9141 (1) | 6219 (2) | 4529 (1) | 3·5 (1) |
| | B | 1496 (1) | 12032 (2) | 6613 (1) | 3·9 (1) |
| | C | 4890 (2) | 8825 (3) | 10555 (2) | 5·7 (1) |
| N(1) | A | 8563 (2) | 4730 (3) | 5863 (2) | 2·8 (1) |
| | B | 1258 (2) | 9129 (3) | 5860 (2) | 3·1 (1) |
| | C | 4686 (2) | 6826 (3) | 9115 (2) | 4·1 (1) |
| N(4) | A | 9247 (1) | 6986 (3) | 5631 (1) | 2·8 (1) |
| | B | 2437 (2) | 10629 (3) | 6753 (2) | 3·1 (1) |
| | C | 5603 (2) | 8808 (3) | 9806 (2) | 4·3 (1) |
| C(2) | A | 8955 (2) | 4950 (3) | 5410 (2) | 3·1 (1) |
| | B | 1293 (2) | 10333 (3) | 5906 (2) | 3·4 (1) |
| | C | 4514 (2) | 7729 (4) | 9490 (2) | 5·6 (1) |
| C(3) | A | 8858 (2) | 6178 (3) | 5088 (2) | 2·8 (1) |
| | B | 1667 (2) | 10817 (3) | 6620 (2) | 3·5 (1) |
| | C | 5130 (2) | 8140 (4) | 10108 (2) | 4·6 (1) |
| C(5) | A | 8945 (2) | 7266 (3) | 6096 (2) | 2·4 (1) |
| | B | 2643 (2) | 9566 (3) | 6908 (2) | 3·2 (1) |
| | C | 5997 (2) | 8216 (4) | 9526 (2) | 3·0 (1) |
| C(6) | A | 7781 (2) | 7508 (3) | 6331 (2) | 3·2 (1) |
| | B | 2367 (2) | 7802 (3) | 7511 (2) | 3·2 (1) |
| | C | 6653 (2) | 6286 (4) | 9703 (2) | 4·1 (1) |
| C(7) | A | 7143 (2) | 7057 (4) | 6386 (2) | 3·5 (1) |
| | B | 1932 (2) | 6867 (3) | 7556 (2) | 3·6 (1) |
| | C | 6645 (2) | 5072 (4) | 9709 (2) | 3·9 (1) |
| C(8) | A | 6965 (2) | 5883 (4) | 6279 (2) | 3·8 (1) |
| | B | 1298 (2) | 6648 (4) | 7051 (2) | 4·2 (1) |
| | C | 6022 (2) | 4425 (4) | 9529 (2) | 4·1 (1) |
| C(9) | A | 7445 (2) | 5137 (4) | 6108 (2) | 4·0 (1) |
| | B | 1087 (2) | 7396 (4) | 6495 (2) | 3·6 (1) |
| | C | 5382 (2) | 5028 (4) | 9334 (2) | 4·5 (1) |
| C(10) | A | 8093 (2) | 5560 (3) | 6027 (2) | 2·6 (1) |
| | B | 1507 (2) | 8377 (3) | 6438 (2) | 3·0 (1) |
| | C | 5368 (2) | 6251 (3) | 9330 (2) | 4·1 (1) |
| C(11) | A | 8571 (2) | 3505 (4) | 6126 (2) | 4·3 (1) |
| | B | 864 (2) | 8600 (4) | 5186 (2) | 4·2 (1) |
| | C | 4121 (2) | 6309 (5) | 8545 (3) | 6·1 (1) |
| C(12) | A | 8266 (2) | 6756 (3) | 6143 (2) | 2·4 (1) |
| | B | 2163 (2) | 8567 (3) | 6947 (2) | 3·4 (1) |
| | C | 6002 (2) | 6900 (3) | 9512 (2) | 3·1 (1) |
| C(51) | A | 9302 (2) | 8184 (3) | 6607 (2) | 2·6 (1) |
| | B | 3427 (2) | 9292 (3) | 7081 (2) | 3·4 (1) |
| | C | 6502 (2) | 8874 (4) | 9233 (2) | 4·0 (1) |
| C(52) | A | 9616 (2) | 9146 (3) | 6378 (2) | 3·2 (1) |
| | B | 3653 (2) | 8220 (4) | 6887 (2) | 5·0 (1) |
| | C | 6789 (2) | 8370 (4) | 8734 (2) | 4·0 (1) |
| C(53) | A | 9962 (2) | 10010 (4) | 6839 (2) | 4·2 (1) |
| | B | 4382 (2) | 7977 (4) | 7035 (3) | 5·2 (1) |
| | C | 7270 (2) | 9019 (4) | 8483 (2) | 5·1 (1) |
| C(54) | A | 10009 (2) | 9914 (4) | 7532 (2) | 4·1 (1) |
| | B | 4878 (3) | 8758 (5) | 7410 (3) | 6·5 (2) |
| | C | 7453 (2) | 10147 (4) | 8726 (2) | 6·0 (1) |
| C(55) | A | 9688 (2) | 8960 (4) | 7763 (2) | 3·7 (1) |
| | B | 4666 (2) | 9826 (5) | 7613 (3) | 6·4 (2) |
| | C | 7171 (2) | 10652 (4) | 9205 (2) | 5·4 (1) |
| C(56) | A | 9327 (3) | 8112 (3) | 7297 (2) | 3·0 (1) |
| | B | 3931 (2) | 10108 (4) | 7427 (2) | 4·7 (1) |
| | C | 6697 (2) | 10027 (4) | 9465 (2) | 4·6 (1) |

convergence. In this situation we decided to divide the structure into four parts and refine them independently in two cycles of full-matrix least squares. Three parts were the 7-chloro-3-hydroxy-1-methyl-2*H*-1,4-benzo-diazepin-2-one system of each molecule and the fourth was three 5-phenyl substituents. Eventually, three cycles of block-diagonal refinement of all atoms resulted in an $R$ of 0·057 ($R_w = 0·040$).[*]

Scattering factors for P, O and C were taken from Doyle & Turner (1968) and for H from *International Tables for X-ray Crystallography* (1962). The calculations were processed on ODRA-1305 (*MULTAN* only) and IBM 370/145 computers using the XRAY 70 system of Stewart, Kundell & Baldwin (1970).

## Discussion

The atomic coordinates are given in Table 1. The atom numbering system (partly consistent with the chemical name) and the general conformations of the three symmetrically independent molecules are shown in Fig. 2. The conformations of the molecules are very similar, as are interatomic distances and valency angles (Tables 2, 3 and 4). More marked differences, >0·03 Å for the distances and >3° for the angles, occur for bonds C(2)=O(2), C(3)—O(3) and angles O(3)—C(3)—C(2), N(4)—C(3)—C(2), C(5)—C(51)—C(52), and these are comparable with the differences observed in structures of various derivatives of 1,3-dihydro-2*H*-1,4-benzo-diazepine. Molecule *C* shows the largest deviations from the expected bond lengths and angles; this correlates with the values of the temperature factors, which are the highest for the atoms of this molecule.

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[*] Lists of structure factors, anisotropic thermal parameters and H-atom coordinates have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 35542 (30 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)

The values listed in Table 4 have been omitted.

| | Molecule *A* | Molecule *B* | Molecule *C* |
|---|---|---|---|
| Cl—C(7) | 1·752 (5) | 1·739 (4) | 1·748 (4) |
| N(1)—C(11) | 1·484 (5) | 1·483 (5) | 1·464 (5) |
| C(5)—C(51) | 1·489 (5) | 1·500 (5) | 1·490 (6) |
| C(6)—C(7) | 1·382 (6) | 1·378 (6) | 1·376 (6) |
| C(6)—C(12) | 1·404 (6) | 1·395 (5) | 1·399 (5) |
| C(7)—C(8) | 1·375 (6) | 1·379 (5) | 1·374 (6) |
| C(8)—C(9) | 1·378 (6) | 1·372 (6) | 1·377 (6) |
| C(9)—C(10) | 1·408 (6) | 1·406 (6) | 1·386 (6) |
| C(51)—C(52) | 1·395 (6) | 1·387 (6) | 1·410 (7) |
| C(52)—C(53) | 1·383 (5) | 1·393 (6) | 1·399 (7) |
| C(53)—C(54) | 1·384 (7) | 1·367 (7) | 1·378 (7) |
| C(54)—C(55) | 1·395 (6) | 1·381 (8) | 1·372 (7) |
| C(55)—C(56) | 1·385 (5) | 1·409 (6) | 1·386 (7) |
| C(56)—C(51) | 1·386 (6) | 1·382 (6) | 1·403 (6) |

There is conjugation of a lone pair of N(1) with the $\pi$ electrons of the C(2)=O(2) bond so that N(1)—C(2) is 1·36–1·37 Å, which is similar to that found in all 1,4-benzodiazepin-2-ones (Table 4), compared with a value of about 1·46 Å in 1,4-benzodiazepines without a ketone O at C(2) (Gilli, Bertolasi, Sacerdoti & Borea, 1978b). This conjugation imposes a boat conformation [in medazepam (VII) such a conjugation is not possible and the 1,4-diazepine ring adopts the less strained conformation of a skew boat]. Asymmetry parameters (Duax & Norton, 1975) for mirror-plane symmetry $(\Delta C_s^2)$ are 3·5 (5), 3·1 (5) and 3·3 (6)° for molecules $A$, $B$ and $C$ respectively. The bow angles between the plane defined by atoms C(2), C(3), N(4) and the least-

squares basis plane through N(1), C(2), N(4), C(5) are 63·1, 63·6 and 62·7°, while the stern angles between the least-squares plane through C(5), C(12), C(10), N(1) and the basis plane are 33·9, 33·6 and 39·9° for molecules $A$, $B$ and $C$ respectively.

Shortening of the C(5)—C(51) bond suggests that there is some electron delocalization between the chlorophenyl ring and the adjacent C=N system, and there is a reason for the tendency of the 5-phenyl ring to be planar with that system whereas the N(4)··· H(52) [or N(4)···H(56)] repulsive interaction tends to disturb the planarity. These N(4)···H distances are 2·66, 2·60 and 2·64 Å. The angles between the mean planes of both phenyl rings are 66·0, 66·8 and 58·7° for molecules $A$, $B$ and $C$. Similar values were reported for other structures with an o-unsubstituted 5-phenyl ring, e.g. 61·8° in nitrazepam (Gilli, Bertolasi, Sacerdoti & Borea, 1977) and 54·7° in diazepam (Camerman & Camerman, 1972), while for 5-(2-chlorophenyl)-substituted 1,3-dihydro-2H-1,4-benzo-diazepines values of 73·4 and 81·0° (lorazepam) and

Table 3. *Valency angles* (°)

The values listed in Table 4 have been omitted.

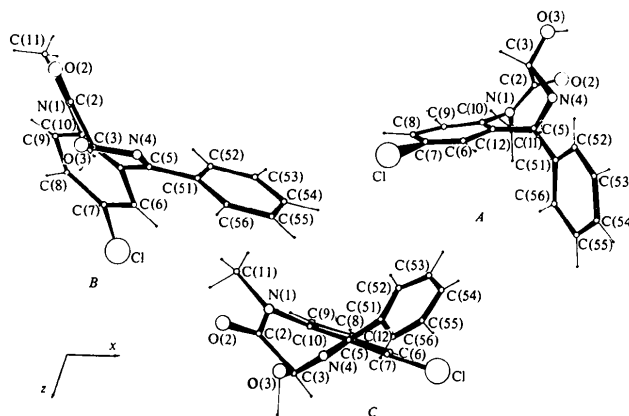| | Molecule $A$ | Molecule $B$ | Molecule $C$ |
|---|---|---|---|
| C(2)—N(1)—C(11) | 117·3 (3) | 117·9 (3) | 118·9 (3) |
| C(10)—N(1)—C(11) | 118·4 (3) | 118·6 (3) | 118·5 (3) |
| N(4)—C(5)—C(51) | 117·3 (3) | 118·5 (3) | 118·1 (4) |
| C(12)—C(5)—C(51) | 118·4 (4) | 116·6 (3) | 118·9 (4) |
| C(7)—C(6)—C(12) | 119·5 (4) | 119·8 (3) | 119·2 (4) |
| Cl—C(7)—C(6) | 118·3 (3) | 119·5 (3) | 118·1 (3) |
| Cl—C(7)—C(8) | 119·3 (3) | 118·7 (3) | 119·1 (3) |
| C(6)—C(7)—C(8) | 122·4 (4) | 121·8 (4) | 122·8 (4) |
| C(7)—C(8)—C(9) | 118·3 (4) | 119·1 (4) | 118·1 (4) |
| C(8)—C(9)—C(10) | 121·4 (4) | 120·9 (4) | 120·8 (4) |
| N(1)—C(10)—C(9) | 117·9 (3) | 118·5 (3) | 118·2 (3) |
| C(9)—C(10)—C(12) | 119·3 (4) | 119·3 (3) | 120·7 (4) |
| C(5)—C(12)—C(6) | 118·0 (3) | 118·8 (3) | 120·1 (3) |
| C(6)—C(12)—C(10) | 119·0 (4) | 119·1 (3) | 118·4 (4) |
| C(5)—C(51)—C(52) | 118·5 (3) | 120·2 (3) | 122·0 (4) |
| C(5)—C(51)—C(56) | 122·1 (3) | 120·5 (4) | 118·6 (4) |
| C(52)—C(51)—C(56) | 119·4 (3) | 119·3 (4) | 119·4 (4) |
| C(51)—C(52)—C(53) | 120·3 (4) | 120·1 (4) | 119·8 (4) |
| C(52)—C(53)—C(54) | 120·2 (4) | 120·4 (5) | 119·3 (5) |
| C(53)—C(54)—C(55) | 119·8 (4) | 120·5 (4) | 121·5 (5) |
| C(54)—C(55)—C(56) | 119·9 (4) | 119·3 (4) | 120·4 (4) |
| C(55)—C(56)—C(51) | 120·4 (4) | 120·2 (4) | 119·6 (4) |



Fig. 2. The numbering system of the atoms and a general view of the independent molecules of temazepam in the crystal viewed in the [010] direction.

Table 4. *Comparison of bond lengths* (Å) *and angles* (°) *for* 1,3-*dihydro*-2H-1,4-*benzodiazepines*

| | (I) | | | (II) | | (III) | | (IV) | (V) | (VI) | | (VII) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N(1)—C(2) | 1·377 (6) | 1·367 (5) | 1·373 (6) | 1·358 (5) | 1·365 (5) | 1·35 (2) | 1·31 (2) | 1·365 (2) | 1·362 (4) | 1·357 (4) | 1·362 (3) | 1·461 (6) | 1·456 (6) |
| C(2)—C(3) | 1·524 (5) | 1·518 (5) | 1·532 (6) | 1·523 (5) | 1·522 (5) | 1·52 (3) | 1·50 (2) | 1·506 (2) | 1·499 (5) | 1·504 (3) | 1·506 (4) | 1·493 (6) | 1·498 (6) |
| C(3)—N(4) | 1·461 (4) | 1·464 (5) | 1·459 (6) | 1·465 (5) | 1·460 (5) | 1·47 (2) | 1·45 (3) | 1·460 (2) | 1·460 (5) | 1·458 (3) | 1·471 (4) | 1·478 (6) | 1·466 (6) |
| N(4)=C(5) | 1·286 (5) | 1·280 (5) | 1·272 (6) | 1·278 (5) | 1·280 (5) | 1·28 (3) | 1·27 (2) | 1·286 (2) | 1·289 (4) | 1·284 (4) | 1·280 (3) | 1·281 (4) | 1·268 (4) |
| C(5)—C(12) | 1·475 (5) | 1·486 (5) | 1·492 (6) | 1·496 (5) | 1·484 (5) | 1·48 (2) | 1·47 (2) | 1·482 (2) | 1·480 (4) | 1·485 (4) | 1·485 (3) | 1·492 (5) | 1·479 (5) |
| C(10)=C(12) | 1·400 (6) | 1·405 (5) | 1·394 (5) | 1·393 (5) | 1·407 (5) | 1·41 (2) | 1·38 (3) | 1·407 (2) | 1·399 (6) | 1·408 (3) | 1·407 (3) | 1·422 (5) | 1·416 (5) |
| C(10)—N(1) | 1·419 (5) | 1·412 (5) | 1·431 (5) | 1·404 (5) | 1·403 (5) | 1·40 (2) | 1·41 (2) | 1·422 (2) | 1·406 (5) | 1·410 (3) | 1·400 (3) | 1·388 (5) | 1·398 (5) |
| C(2)=O(2) | 1·217 (5) | 1·204 (5) | 1·235 (5) | 1·211 (5) | 1·216 (5) | 1·24 (2) | 1·24 (1) | 1·218 (2) | 1·222 (4) | 1·233 (3) | 1·230 (3) | | |
| C(3)—O(3) | 1·398 (5) | 1·416 (5) | 1·375 (6) | 1·403 (5) | 1·398 (5) | 1·38 (2) | 1·40 (2) | | | | | | |
| C(2)—N(1)—C(10) | 123·9 (3) | 123·2 (3) | 121·8 (3) | 127·0 (3) | 126·3 (3) | 125·0 (7) | 125·8 (8) | 123·1 (2) | 126·1 (3) | 126·4 (2) | 126·8 (2) | 120·6 (3) | 118·9 (3) |
| C(3)—N(4)—C(5) | 117·1 (3) | 114·4 (3) | 116·9 (3) | 118·2 (3) | 118·3 (3) | 117·0 (8) | 118·0 (7) | 118·1 (2) | 117·6 (3) | 118·2 (2) | 117·7 (2) | 115·8 (3) | 116·6 (3) |
| O(2)—C(2)—N(1) | 122·0 (3) | 122·7 (3) | 122·1 (4) | 123·3 (3) | 122·6 (3) | 122·1 (7) | 122·3 (7) | 121·8 (2) | 120·9 (3) | 121·5 (2) | 121·3 (2) | | |
| O(2)—C(2)—C(3) | 122·8 (4) | 122·1 (3) | 123·2 (4) | 123·8 (3) | 123·5 (3) | 122·5 (9) | 119·7 (9) | 122·9 (2) | 123·4 (3) | 122·8 (2) | 123·2 (2) | | |
| N(1)—C(2)—C(3) | 115·2 (3) | 115·2 (3) | 114·6 (3) | 112·9 (3) | 113·9 (3) | 115·2 (8) | 118·0 (9) | 115·3 (2) | 115·7 (3) | 115·7 (2) | 115·6 (2) | 113·0 (3) | 113·4 (3) |
| O(3)—C(3)—N(4) | 110·2 (3) | 111·7 (3) | 111·2 (3) | 111·3 (3) | 111·4 (3) | 110·8 (6) | 110·2 (7) | | | | | | |
| O(3)—C(3)—C(2) | 110·3 (3) | 107·2 (3) | 111·8 (4) | 111·3 (3) | 111·0 (3) | 111·3 (12) | 110·3 (9) | | | | | | |
| N(4)—C(3)—C(2) | 106·1 (3) | 107·8 (3) | 105·0 (3) | 107·7 (3) | 106·4 (3) | 105·8 (9) | 108·1 (8) | 110·5 (2) | 109·3 (3) | 111·0 (2) | 110·5 (3) | 111·6 (4) | 111·3 (4) |
| N(4)—C(5)—C(12) | 124·4 (4) | 124·9 (3) | 122·9 (4) | 123·6 (3) | 123·9 (3) | 124·2 (7) | 125·6 (6) | 123·6 (2) | 125·3 (3) | 125·4 (2) | 125·7 (2) | 123·9 (3) | 123·2 (3) |
| N(1)—C(10)—C(12) | 122·8 (4) | 122·3 (3) | 121·1 (3) | 123·6 (3) | 122·3 (3) | 122·9 (6) | 122·5 (8) | 122·0 (2) | 122·7 (3) | 123·0 (2) | 122·7 (2) | 119·7 (3) | 119·7 (3) |
| C(5)—C(12)—C(10) | 123·0 (4) | 122·1 (3) | 121·5 (3) | 122·0 (3) | 122·7 (3) | 121·1 (7) | 122·0 (5) | 122·2 (2) | 122·8 (3) | 121·4 (2) | 122·3 (2) | 119·3 (3) | 119·1 (3) |

85·7 and 77·8° (clonazepam) have been found (Bandoli & Clemente, 1976; Chananont, Hamor & Martin, 1979).

Temazepam molecules are not too densely packed in the crystal. The shortest intermolecular distances are 2·88 for $O(3^A) \cdots O(2^A)$ [the second atom at $2 - x, 1 - y, 1 - z$], 2·87 Å for $N(4^C) \cdots O(3^C)$ [$1 - x, 2 - y, 2 - z$], and for transformation [$1 - x, 2 - y, 1 - z$] 3·21 Å for $O(3^A) \cdots O(2^B)$, 3·02 Å for $O(3^B) \cdots O(3^A)$ and 3·08 Å for $O(2^B) \cdots N(4^A)$. Although some lengths suggest the presence of hydrogen bonds, a detailed analysis of the O—H bond directions and hydrogen-proton-acceptor distances brings doubt to the suggestion. Even if an O—H bond length of about 1 Å is assumed [0·54 (4), 0·52 (4) and 0·61 (4) Å were obtained after refinement for molecules $A$, $B$ and $C$, while the mean C—H bond lengths are 1·00 ($A$), 1·01 ($B$) and 1·02 Å ($C$)], the presence of hydrogen bonds, both inter- and intramolecular, is questionable. Thus, in the case of molecule $A$, $O(3) \cdots O(2)$ and $O(3) \cdots N(4)$ intramolecular distances are 2·702 (4) and 2·346 (4) Å, whereas $H(1) \cdots O(2)$ and $H(1) \cdots N(4)$ are 2·60 (4) and 2·51 (5) Å; and after 'lengthening' of the O—H bond, the distances are 2·54 Å for both possible acceptors. For molecule $B$ analogous distances are 2·614 (4) and 2·384 (4), 2·91 (4) and 2·16 (4) [$H \cdots X$], and 3·20 and 2·13 Å after 'correcting' the O—H distance; for molecule $C$ 2·751 (4) and 2·340 (5) [$X \cdots X$], 3·35 (4) and 2·56 (5) [$H \cdots X$], and 3·73 and 2·36 Å. The shortest intermolecular $H \cdots X(O,N)$ distance involves $O(3^A) \cdots O(2^A)$ with $H(1) \cdots O(2)$ distances of 2·05 and 2·35 (4) Å (with and without correction of the H-atom position).

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# The Structure of 1-Phenyl-4,5-(1,2-D-glucofurano)imidazolidin-2-one

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## Abstract

The crystal structure of $C_{13}H_{16}N_2O_5$ has been solved by direct methods. Crystal data are $a = 9·033$ (1), $b = 10·097$ (1), $c = 7·155$ (1) Å, $\beta = 105·92$ (1)°, $Z = 2$, space group $P2_1$ (from statistics). The final $R$ value for 1246 independent reflexions was 0·068. The glucofurano-imidazolidine group adopts a *cis* form of coupling with a dihedral angle of 70·2 (6)°. The phenyl substituent forms a dihedral angle of 15·1 (6)° with the imidazolidine ring plane. Intermolecular hydrogen bonds link molecules related by a screw axis to give helical chains parallel to $b$.

## Introduction

The crystal structure of 1-phenyl-4,5-(1,2-D-glucofurano)imidazolidin-2-one