

N2—N1—C7	115.0 (2)	O1—C8—N3	124.2 (2)
N1—N2—C8	120.8 (2)	N2—C8—N3	114.9 (2)
N4—N3—C8	119.3 (2)	N4—C9—C10	120.3 (2)
N3—N4—C9	115.8 (2)	C9—C10—C11	120.8 (2)
C2—C1—C6	119.4 (2)	C9—C10—C15	119.5 (2)
C2—C1—C7	122.0 (2)	C11—C10—C15	119.6 (2)
C6—C1—C7	118.6 (2)	C10—C11—C12	118.1 (2)
C1—C2—C3	118.0 (2)	F2—C12—C11	118.1 (3)
F1—C3—C2	117.9 (2)	F2—C12—C13	118.7 (3)
F1—C3—C4	118.5 (2)	C11—C12—C13	123.2 (3)
C2—C3—C4	123.6 (2)	C12—C13—C14	118.5 (3)
C3—C4—C5	117.9 (2)	C13—C14—C15	120.4 (3)
C4—C5—C6	120.8 (2)	C10—C15—C14	120.2 (3)
C1—C6—C5	120.3 (2)	N1—N2—H6	121 (2)
N1—C7—C1	122.1 (2)	C8—N2—H6	117 (2)
O1—C8—N2	120.9 (2)	N2—H6...O1 <sup>†</sup>	172 (2)

Symmetry code: (i)  $1 - x, 1 - y, 1 - z$ .

Weak reflections [ $I < 10\sigma(I)$ ] were rescanned (maximum of 3 rescans) and the counts accumulated to improve accuracy. The positional parameters of the non-aromatic H atoms were refined. The aromatic H atoms were placed at assumed positions (C,N—H = 0.95 Å,  $U = 1.2U_{eq}$  of the associated atom) and fixed.

Data collection: *MSC/AFC Diffractometer Control Software* (Molecular Structure Corporation, 1988). Cell refinement: *MSC/AFC Diffractometer Control Software*. Data reduction: *TEXSAN PROCESS* (Molecular Structure Corporation, 1985). Program(s) used to solve structure: *MITHRIL* (Gilmore, 1984). Program(s) used to refine structure: *TEXSAN LS*. Molecular graphics: *ORTEP* (Johnson, 1965). Software used to prepare material for publication: *TEXSAN FINISH*.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates, complete geometry, including bond distances and angles involving H atoms, and torsion angles have been deposited with the IUCr (Reference: CR1090). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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*Acta Cryst.* (1995). **C51**, 777–780

## 2-Methylthio-10,11-dihydro-11-(4-methylpiperazin-1-yl)dibenzo[*b,f*]thiepine Maleic Acid (Metitepine Maleate)<sup>†</sup>

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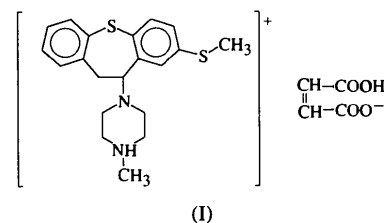
(Received 4 July 1994; accepted 13 October 1994)

## Abstract

The crystal structure of metitepine maleate, a mixed 5-HT<sub>1</sub>/5-HT<sub>2</sub> antagonist, has been determined from diffractometer data. The seven-membered ring has a boat–sofa conformation and folds about a line through the S atom and the opposite methylene group. The dihedral angle between the least-squares planes of the aromatic rings is 123.1 (1)°. The piperazine ring has the normal chair conformation and its mean plane is roughly parallel to the plane of one of the benzene rings.

## Comment

As part of our structural study on serotonin antagonists (ketanserine: Peeters, Blaton & De Ranter, 1982; cinanserin: Peeters, Blaton & De Ranter, 1986; pirenperone: Blaton, Peeters & De Ranter, 1985, 1995), we present here the crystal structure of metitepine, (I), a (6,7,6)-tricyclic dibenzo[*b,f*]thiepine derivative with mixed 5-HT<sub>1</sub>/5-HT<sub>2</sub> receptor antagonistic properties (Janssen, 1983). The conformation of the molecule and the atomic numbering are shown in Fig. 1.



The structure is similar to those of octoclotheptin (Jaunin, Petcher & Weber, 1977) and oxyprothepine (Koch & Evrard, 1974). Least-squares-planes calculations through the aromatic rings show that benzo ring *A* is more planar than the benzo ring *B* [maximum deviations 0.009 (4) and 0.030 (4) Å, respectively]. The dihedral angle between these planes is 123.1 (1)° and

<sup>†</sup> Internal code of the Janssen Research Foundation: R27199.

falls in the range 104–156° observed for related (6,7,6)-tricyclic compounds (Bandoli, Nicolini & Tollenaere, 1984, and references therein). The distances of the atoms S13, C9 and C10 to the mean planes of the fused benzene rings are 0.074 (1), 0.044 (4) and 0.145 (4) Å, respectively, for ring A, and 0.040 (1), 1.266 (4) and 0.094 (4) Å, respectively, for ring B. This shows that, unlike the nearly symmetrical folding about a line through the hetero atom and the center of the opposite double bond in dibenzo[*b,f*]heteroepines (Wagner, 1980; Reboul, Cristau, Soyfer & Estienne, 1980; Drake & Jones, 1982; Bandoli & Nicolini, 1982), the title compound folds asymmetrically about a line through S13 and C10. The major differences in the two halves of the tricyclic moiety, apart from the torsion angles, are in the endocyclic angles of the seven-membered ring. Whereas the angles facing ring B are close to the normal  $sp^2$  and  $sp^3$  values, those facing ring A are markedly enlarged. This enlarging and the asymmetric folding is common to almost all crystal structures of dihydrodibenzo[*b,f*]heteroepines (Bandoli *et al.*, 1984).

The conformation of the central ring in (6,7,6)-tricyclic compounds is generally described as a boat with the atoms common to the benzene rings as the basal plane, the hetero atom as the bow and the saturated or unsaturated bridge as the stern. The atoms C5, C6, C12 and C11 show a zigzag shape with deviations of 0.051 (3), -0.059 (3), 0.068 (3) and -0.095 (4) Å, respectively, from the least-squares plane. S13, C9 and C10 are displaced from the base by -0.728 (1), -0.248 (4) and -0.963 (4) Å, respectively. The bow angle is 137.6 (2) and the stern angle 152.5 (2)°. From the puckering parameters (Cremer & Pople, 1975) [ $q_2 = 0.886$  (3),  $q_3 = 0.398$  Å,  $\varphi_2 = -28.2$  (2),  $\varphi_3 = 47.9$  (5)°] and asymmetry parameters (Nardelli, 1983*a*) [ $\Delta(C5) = 0.037$  (1)], and according to Boessenkool & Boeyens (1980), the conformation is better described as a distorted boat-sofa with a mirror plane through C5 and the center of the C11—C12 bond.

The piperazine ring has the chair conformation. The distances to N21 reflect the protonation of this atom. A noticeable feature of the piperazine ring in the crystal structures of the title compound, octoclothepein and oxyprothepine is the common relative position of this ring. The N18—C19 and N18—C23 bonds are both *gauche* to the C9—C10 bond, and the lone pair on N18 is therefore directed towards the H4 atom on C4, resulting in a possible intramolecular C—H...N hydrogen bond; the H4...N18 distance (2.45 Å) is 0.30 Å shorter than the sum of the van der Waals radii (Taylor & Kennard, 1980).

The maleate molecule has a cyclic structure because of the strong intramolecular O—H...O hydrogen bond [O31—H31 = 0.820, O31...O25 = 2.446 (4), H31...O25 = 1.637 Å, O31—H31...O25 = 168.8°] and is linked to the metitepine molecule by an N—H...O hydrogen bond [N21—H21 = 0.910, N21...O27

= 2.680 (4), H21...O27 = 1.772 Å, N21—H21...O27 = 176.1°]. Weak intermolecular C—H...O contacts join the molecules in the *b* direction [C1—H1A = 0.960, C1...O27<sup>i</sup> = 3.425 (5), H1A...O27<sup>i</sup> = 2.504 Å, C1—H1A...O27<sup>i</sup> = 160.8°; C22—H22A = 0.970, C22...O32<sup>ii</sup> = 3.328 (5), H22A...O32<sup>ii</sup> = 2.484 Å, C22—H22A...O32<sup>ii</sup> = 145.4°; symmetry codes: (i)  $x, -y + \frac{3}{2}, z - \frac{1}{2}$ ; (ii)  $x, y - 1, z$ ].

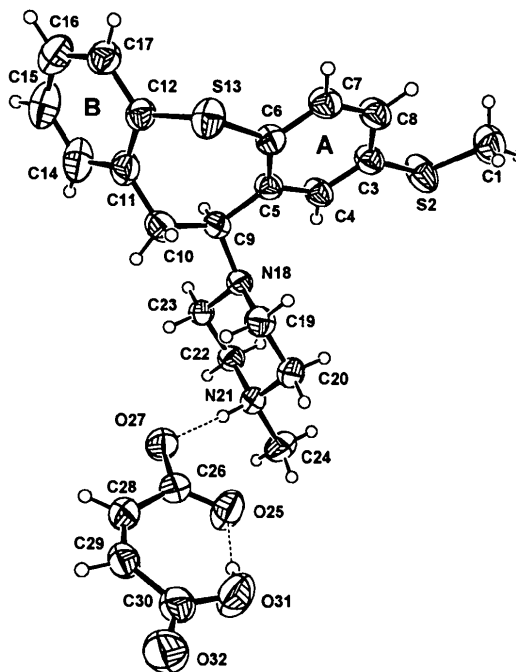


Fig. 1. ORTEX (McArdle, 1994) diagram of the molecule showing the atomic numbering scheme. Displacement ellipsoids are plotted at the 40% probability level.

## Experimental

### Crystal data

$C_{20}H_{25}N_2S_2 \cdot C_4H_3O_4^-$

$M_r = 472.61$

Monoclinic

$P2_1/c$

$a = 10.206$  (2) Å

$b = 9.692$  (1) Å

$c = 24.498$  (1) Å

$\beta = 91.91$  (2)°

$V = 2421.9$  (5) Å<sup>3</sup>

$Z = 4$

$D_x = 1.296$  Mg m<sup>-3</sup>

$D_m = 1.299$  Mg m<sup>-3</sup>

$D_m$  measured by flotation in *n*-heptane/CCl<sub>4</sub>

Cu  $K\alpha$  radiation

$\lambda = 1.54184$  Å

Cell parameters from 16 reflections

$\theta = 13$ –30°

$\mu = 2.260$  mm<sup>-1</sup>

$T = 293$  K

Prism

0.26 × 0.26 × 0.16 mm

Colourless

Crystal source: Janssen Research Foundation, Beerse, Belgium

### Data collection

Hilger & Watts four-circle diffractometer

$\omega/2\theta$  scans (1.2° min<sup>-1</sup>, width 1.2°)

2816 observed reflections [ $F^2 > 3\sigma(F^2)$ ]

$R_{int} = 0.0140$

$\theta_{max} = 65.00^\circ$

Absorption correction:  $h = -11 \rightarrow 11$   
 North, Phillips & Mathews (1968)  $k = -11 \rightarrow 0$   
 $T_{\min} = 0.797$ ,  $T_{\max} = 0.996$   $l = 0 \rightarrow 28$   
 4223 measured reflections 3 standard reflections  
 3867 independent reflections monitored every 50 reflections  
 intensity decay: <1.0%

### Refinement

Refinement on  $F^2$   $\Delta\rho_{\max} = 0.41 \text{ e } \text{\AA}^{-3}$   
 $R[F^2 > 2\sigma(F^2)] = 0.0478$   $\Delta\rho_{\min} = -0.29 \text{ e } \text{\AA}^{-3}$   
 $wR(F^2) = 0.1492$  Extinction correction: *SHELXL93* (Sheldrick, 1993)  
 $S = 1.066$  Extinction coefficient: 0.0021 (3)  
 3867 reflections Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C)  
 293 parameters  
 H-atom parameters not refined  
 $w = 1/[\sigma^2(F_o^2) + (0.1025P)^2 + 0.8810P]$   
 where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} < 0.001$

Table 1. Fractional atomic coordinates and equivalent isotropic displacement parameters ( $\text{\AA}^2$ )

$$U_{eq} = (1/3)\sum_i \sum_j U_{ij} a_i^* a_j^* \mathbf{a}_i \cdot \mathbf{a}_j.$$

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{eq}$
C1	0.3431 (4)	0.7079 (5)	0.0712 (2)	0.084 (2)
S2	0.3196 (1)	0.6274 (1)	0.13483 (4)	0.0883 (4)
C3	0.1681 (3)	0.6912 (4)	0.1560 (1)	0.057 (1)
C4	0.1431 (3)	0.6806 (4)	0.2105 (1)	0.055 (1)
C5	0.0261 (3)	0.7243 (3)	0.2333 (1)	0.049 (1)
C6	-0.0698 (3)	0.7773 (3)	0.1971 (1)	0.050 (1)
C7	-0.0446 (3)	0.7870 (4)	0.1418 (1)	0.059 (1)
C8	0.0720 (3)	0.7460 (4)	0.1209 (1)	0.063 (1)
C9	0.0153 (3)	0.7003 (4)	0.2946 (1)	0.056 (1)
C10	-0.1024 (4)	0.7618 (5)	0.3220 (2)	0.070 (1)
C11	-0.2279 (3)	0.6892 (4)	0.3066 (2)	0.068 (1)
C12	-0.2930 (3)	0.7222 (3)	0.2573 (1)	0.055 (1)
S13	-0.22549 (9)	0.8466 (1)	0.21355 (4)	0.0672 (3)
C14	-0.2833 (4)	0.5869 (5)	0.3383 (2)	0.092 (2)
C15	-0.4025 (4)	0.5262 (5)	0.3226 (2)	0.094 (2)
C16	-0.4675 (4)	0.5689 (5)	0.2760 (2)	0.086 (2)
C17	-0.4129 (3)	0.6648 (4)	0.2435 (2)	0.067 (1)
N18	0.1428 (3)	0.7341 (3)	0.32206 (9)	0.0489 (8)
C19	0.1764 (4)	0.8797 (4)	0.3242 (1)	0.062 (1)
C20	0.3175 (4)	0.8975 (4)	0.3437 (1)	0.067 (1)
N21	0.3412 (3)	0.8306 (3)	0.3978 (1)	0.0560 (8)
C22	0.2994 (3)	0.6833 (4)	0.3959 (1)	0.056 (1)
C23	0.1587 (3)	0.6743 (3)	0.3765 (1)	0.052 (1)
C24	0.4796 (4)	0.8443 (5)	0.4180 (2)	0.081 (2)
O25	0.3171 (3)	1.1342 (3)	0.4533 (1)	0.090 (1)
C26	0.2146 (3)	1.0839 (4)	0.4722 (1)	0.063 (1)
O27	0.1824 (3)	0.9608 (3)	0.4660 (1)	0.075 (1)
C28	0.1223 (4)	1.1727 (4)	0.5022 (2)	0.069 (1)
C29	0.1241 (4)	1.3069 (4)	0.5112 (2)	0.068 (1)
C30	0.2171 (4)	1.4156 (4)	0.4963 (2)	0.073 (1)
O31	0.3188 (3)	1.3839 (3)	0.4680 (2)	0.099 (1)
O32	0.1952 (4)	1.5343 (3)	0.5089 (2)	0.111 (2)
C1—S2—C3—C4	-160.5 (3)	C10—C9—N18—C19	-62.0 (4)	
C1—S2—C3—C8	21.9 (4)	C10—C9—N18—C23	65.7 (3)	
C6—C5—C9—C10	-11.3 (5)	C9—C10—C11—C12	-81.5 (4)	
C9—C5—C6—S13	6.5 (5)	C10—C11—C12—S13	1.0 (5)	
C5—C6—S13—C12	-48.8 (3)	C11—C12—S13—C6	60.3 (3)	
C5—C9—C10—C11	71.2 (4)			

The structure was solved by Patterson and direct methods on the difference structure. H atoms were calculated at geometrical positions and refined as riding on their parent atom.

Data collection: Hilger & Watts Y290 software. Cell refinement: *XRAY76 PARAM* (Stewart *et al.*, 1976). Data reduction: *REDU4* (Stoe & Cie, 1992). Program(s) used to solve structure: *DIRDIF* (Beurskens *et al.*, 1981). Program(s) used to refine structure: *SHELXL93* (Sheldrick, 1993). Molecular graphics: *ORTEX2.1b* (McArdle, 1994). Software used to prepare material for publication: *PARST* (Nardelli, 1983b).

The authors thank Dr Jan Tollenaere of Janssen Research Foundation, Beerse, Belgium, for providing the metitepine maleate sample.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCR (Reference: NA1122). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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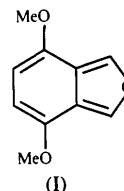
Table 2. Selected geometric parameters ( $\text{\AA}$ ,  $^\circ$ )

C1—S2	1.767 (4)	C14—C15	1.394 (6)
S2—C3	1.759 (4)	C15—C16	1.365 (7)
C3—C4	1.371 (4)	C16—C17	1.357 (6)
C3—C8	1.388 (5)	N18—C19	1.453 (4)
C4—C5	1.400 (4)	N18—C23	1.459 (4)
C5—C6	1.396 (4)	C19—C20	1.512 (5)
C5—C9	1.529 (4)	C20—N21	1.489 (4)
C6—C7	1.389 (4)	N21—C22	1.490 (4)
C6—S13	1.784 (3)	N21—C24	1.486 (5)
C7—C8	1.370 (5)	C22—C23	1.499 (5)

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## Comment

Benzo[*c*]furans represent an important class of highly reactive derivatives and have received intensive investigation with respect to both their synthetic applications and the theoretical aspects of their chemistry (Fredrichsen, 1980; Rodrigo, 1988). The parent compound has been characterized previously and undergoes rapid polymerization at room temperature (Warrener, 1971; Wege, 1971). The reported benzo[*c*]furan derivatives that exhibit increased stability incorporate substituents at the 1 and 3 positions and/or a benzenoid ring at the quinoid oxidation level. The single-crystal X-ray structures of three such compounds have been determined (Ahad, Banham, Whalley, Ferguson & Siew, 1980; Grove & Hitchcock, 1986; Rodrigo, Knabe, Taylor, Rajapaksa & Chernishenko, 1986). In this paper, the crystal structure of 4,7-dimethoxybenzo[*c*]furan, (I), is presented, the first example of a symmetrical benzo[*c*]furan derivative that is both stable at room temperature and unsubstituted at the 1 and 3 positions.



*Acta Cryst.* (1995). **C51**, 780–782

## 4,7-Dimethoxybenzo[*c*]furan

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### Abstract

The title compound, C<sub>10</sub>H<sub>10</sub>O<sub>3</sub>, is nearly planar with a maximum deviation from planarity of 0.140(2) Å for methoxy atom C11. The geometry of the benzo[*c*]furan moiety is indicative of a non-aromatic ring system. The bond lengths more closely resemble those of two non-interacting diene systems than those of an aromatic one. There are alternating long and short bond lengths around the ring skeleton with the long and short C—C bonds averaging 1.437(2) and 1.354(2) Å, respectively. There are close C—H···O intermolecular contacts which may help stabilize the molecule in the solid state.

As expected from the substitution pattern, the molecule has approximate mirror symmetry with the mirror lying perpendicular to the ring system and passing through the furan atom O2. The benzo[*c*]furan ring system is planar [maximum deviation of 0.011(2) Å for C7].

The geometry of (I) is very much like that calculated for the parent compound (Dewar, Harget, Trinajstić & Worley, 1970), with alternating long and short bond lengths. A similar pattern is observed for 1-cyano-5,6-(methylenedioxy)benzo[*c*]furan (Rodrigo *et al.*, 1986). In the isomeric benzo[*b*]furan, which is commercially available, the benzene ring is calculated to be aromatic with six essentially equivalent bonds (Dewar *et al.*, 1970).

In the lattice, molecules are connected by short C—H···O contacts across crystallographic inversion centers (Fig. 2). The geometry of the contacts is consistent with the hydrogen-bonding interactions seen in amino acids and carboxylic acids where hydrogen bonding is known to play an important role in crystal packing. The role of C—H···O and C—H···N hydrogen bonding in crystal packing has been discussed extensively (Berkovitch-Yellin & Leiserowitz, 1984; Desiraju, 1991; Jeffrey & Saenger, 1991).