

5-Methyl-2-thiouracil

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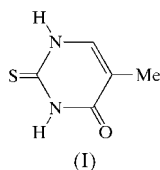
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The molecular structure of the title compound, also known as 2-thiothymine [systematic name: 2,3-dihydro-5-methyl-2-thioxopyrimidin-4(1*H*)-one], C₅H₆N₂OS, is similar to that of thymine, with only small changes in the ring structure, apart from a significant difference at the substitution site [S=C = 1.674 (1) Å]. The molecules are connected by hydrogen bonds, with N—H...O = 2.755 (2) Å and N—H...S = 3.352 (1) Å. The hydrogen-bond network is different from that in thymine, since it involves all the donor and acceptor atoms.

Comment

Thio-nucleobases have been used as intrinsic photolabels to probe the structure and organization of RNA molecules in solution (Favre *et al.*, 1998; Favre, 1990), and to identify the contacts between nucleic acids and proteins in nucleoprotein complexes (Meisenheimer & Koch, 1997). The thio-analogues of nucleic acid bases absorb light at long wavelengths and can be selectively photoactivated into the electronic triplet state, which leads to their high affinity for crosslinking to other nucleic acid bases and amino acid residues with which they are in contact. It has also been shown that the thio-analogues of nucleic acid bases behave as good traps for the excess energy emitted by ionizing radiation (Sanković *et al.*, 1991; Herak & Hüttermann, 1991; Herak *et al.*, 1999, 2000).



In a study of the trapping properties of thio-nucleobases, it was observed that 5-methyl-2-thiouracil, (I), behaves differently from other thio-nucleobases and all naturally occurring bases. In irradiated nucleic acids and their constituents, as well as in the crystals of thiocytosine and thioguanine, only radicals of the π -type were observed. In contrast, in irradiated crystals of (I), the electron-loss radicals are of the σ -type (Bešić *et al.*,

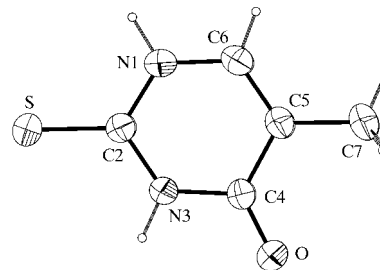


Figure 1

A view of (I) with the atom-labelling scheme. Displacement ellipsoids are drawn at the 50% probability level and H atoms are shown as small spheres of arbitrary radii.

2001). In order to learn more about the radicals formed and the relation of the observed electron paramagnetic resonance parameters to the radical molecular skeleton, the molecular structure is required (Matković-Čalogović & Sanković, 1999). Therefore, the detailed analysis of the crystal structure of (I) is reported here.

The crystal structures of thymine (Ozeki *et al.*, 1969) and thymine monohydrate (Gerdil, 1961) have been known for many years, yet no structural data have been available for 2-thiothymine, (I), until now. The structural differences between (I) (Fig. 1) and thymine were derived by comparison with the recently redetermined structure of thymine (Portalone *et al.*, 1999), and the same numbering scheme is used here.

The replacement of O by the S atom on C2 results in a significant bond-length change only at the substitution site [S=C2 = 1.674 (1) Å, instead of O=C2 = 1.244 (4) Å], and in only a small change in the ring structure, namely an increase of the C4—C5—C6 angle by 1.5°. The other angle alterations are of only marginal significance, being a decrease of C4—C5—C6 and an increase of C2—N1—C6 by 0.9°. Therefore, the thio-keto derivative, (I), has a similar electron distribution to thymine.

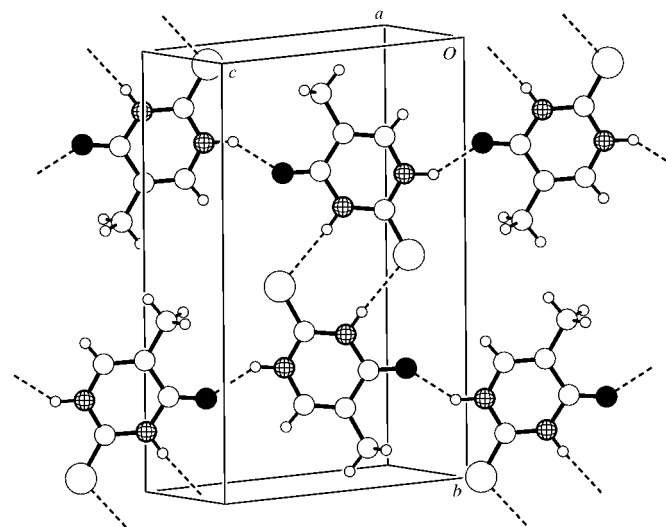


Figure 2

The packing of the molecules in the unit cell of (I). Hydrogen bonds are indicated by dashed lines.

However, the impact of the 2-thio substitution on the hydrogen-bond network is great, resulting in a different packing of the molecules in the unit cell of (I) (Fig. 2) compared with thymine. A strong N1—H \cdots O=C4 hydrogen bond of 2.755 (2) Å is formed in (I), yet the same O atom in thymine only forms a contact with atom C6 of the neighbouring molecule at 3.387 (4) Å. In thymine, both N—H groups form hydrogen bonds with O=C2 of two adjacent molecules [2.827 (3) and 2.833 (3) Å], forming endless ribbons of planar molecules, whereas in (I), the less electronegative S atom is involved in only a weaker N3—H3 \cdots S=C2 bond of 3.352 (1) Å. Therefore, in (I), all the donor and acceptor atoms are involved in the hydrogen-bond network, which connects molecules in planes parallel to (10 $\bar{2}$).

As in thymine, the methyl group in (I) has a conformation such that one of its H atoms is eclipsed with regard to the ring C=C bond.

Experimental

Single crystals of (I) were grown from an aqueous saturated solution of 2-thiothymine (Aldrich) by slow evaporation in a thermostatic oven (Memmert) at 310 K. The beaker containing the solution was covered with aluminium foil to reduce evaporation. Crystals of good quality were obtained after two weeks, and these were stable for months when exposed to the atmosphere.

Crystal data

C ₅ H ₆ N ₂ OS	$D_x = 1.490 \text{ Mg m}^{-3}$
$M_r = 142.19$	Mo $K\alpha$ radiation
Monoclinic, $P2_1/c$	Cell parameters from 46 reflections
$a = 4.2626 (6) \text{ \AA}$	$\theta = 10.6\text{--}18.2^\circ$
$b = 14.512 (2) \text{ \AA}$	$\mu = 0.42 \text{ mm}^{-1}$
$c = 10.255 (2) \text{ \AA}$	$T = 295 (2) \text{ K}$
$\beta = 92.272 (11)^\circ$	Block, colourless
$V = 633.86 (18) \text{ \AA}^3$	$0.57 \times 0.18 \times 0.17 \text{ mm}$
$Z = 4$	

Data collection

Philips PW1100 diffractometer updated by Stoe	$R_{\text{int}} = 0.048$
ω scans	$\theta_{\text{max}} = 30^\circ$
Absorption correction: ψ scan (X-RED; Stoe & Cie, 1995)	$h = -5 \rightarrow 3$
$T_{\text{min}} = 0.801$, $T_{\text{max}} = 0.931$	$k = 0 \rightarrow 20$
1888 measured reflections	$l = 0 \rightarrow 13$
1801 independent reflections	4 standard reflections
1339 reflections with $I > 2\sigma(I)$	frequency: 90 min
	intensity decay: 4.0%

Refinement

Refinement on F^2	All H-atom parameters refined
$R[F^2 > 2\sigma(F^2)] = 0.035$	$w = 1/[\sigma^2(F_o^2) + (0.0724P)^2]$
$wR(F^2) = 0.106$	where $P = (F_o^2 + 2F_c^2)/3$
$S = 1.04$	$(\Delta/\sigma)_{\text{max}} < 0.001$
1801 reflections	$\Delta\rho_{\text{max}} = 0.27 \text{ e \AA}^{-3}$
106 parameters	$\Delta\rho_{\text{min}} = -0.31 \text{ e \AA}^{-3}$

H atoms were found in the difference Fourier map and refined isotropically, giving C—H distances in the range 0.92 (2)–0.99 (3) Å and N—H distances of 0.93 (2) and 0.97 (2) Å.

Data collection: *STADIA* (Stoe & Cie, 1995); cell refinement: *X-RED* (Stoe & Cie, 1995); data reduction: *X-RED*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1990); program(s) used to

Table 1

Selected geometric parameters (Å, °).

S—C2	1.6735 (13)	C4—O	1.2269 (15)
N1—C2	1.3521 (16)	C4—C5	1.4486 (16)
N1—C6	1.3717 (16)	C5—C6	1.3483 (19)
C2—N3	1.3579 (16)	C5—C7	1.4987 (18)
N3—C4	1.3879 (15)		
C2—N1—C6	123.37 (10)	O—C4—C5	125.09 (11)
N1—C2—N3	114.63 (10)	N3—C4—C5	115.80 (11)
N1—C2—S	122.57 (9)	C6—C5—C4	117.40 (11)
N3—C2—S	122.80 (9)	C6—C5—C7	123.74 (12)
C2—N3—C4	126.53 (10)	C4—C5—C7	118.86 (12)
O—C4—N3	119.11 (11)	C5—C6—N1	122.25 (11)

Table 2

Hydrogen-bonding geometry (Å, °).

$D\text{—}H\cdots A$	$D\text{—}H$	$H\cdots A$	$D\cdots A$	$D\text{—}H\cdots A$
N1—H1 \cdots O ⁱ	0.97 (2)	1.91 (2)	2.7551 (17)	145 (2)
N3—H3 \cdots S ⁱⁱ	0.93 (2)	2.43 (3)	3.3523 (13)	170.7 (17)

Symmetry codes: (i) $1 + x, \frac{3}{2} - y, \frac{1}{2} + z$; (ii) $-x, 1 - y, 1 - z$.

refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *PLATON98* (Spek, 1990); software used to prepare material for publication: *SHELXL97*.

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: SK1576). Services for accessing these data are described at the back of the journal.

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