

Di-2-pyridyl ketone 4-methyl-4-phenyl-
thiosemicarbazoneVarughese Philip, V. Suni and M. R. Prathapachandra
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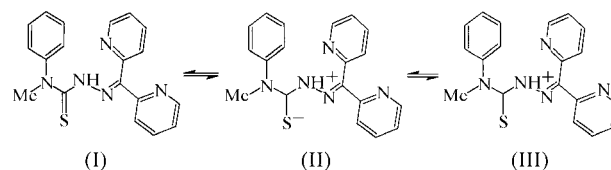
The molecule of the title compound, $C_{19}H_{17}N_5S$, adopts a *Z* configuration about the azomethine bond and exists as the thione tautomer. The overall structure of the molecule is distributed in four different planes. An intramolecular hydrogen bond involving the pyridyl N atom and the H atom attached to the hydrazine N atom leads to the formation of a six-membered ring.

Comment

Thiosemicarbazones are an important group of multidentate ligands with potential binding sites available for a wide variety of metal ions. These thiourea derivatives find substantial applications in different facets of contemporary scientific research. Their biological activity depends on the parent aldehyde or ketone (Padhye & Kauffman, 1985; Lukevics *et al.*, 1995), and their potential use as antimalarial agents was first recognized with N^4 -substituted 2-acetylpyridine thiosemicarbazones (Klayman *et al.*, 1979). The versatile antimicrobial nature of thiosemicarbazones and their metal complexes has been the focus of our research for the past decade, with successful single-crystal X-ray diffraction studies having been conducted for many of these compounds (John *et al.*, 2002; Sreekanth & Kurup, 2003; Sreekanth *et al.*, 2004; Philip *et al.*, 2004).

The title compound, (I), is the first reported di-2-pyridyl ketone thiosemicarbazone in which the N^4 -position of the thiosemicarbazone moiety is disubstituted. The compound is also found to exist in the *cis* conformation, *ZZ*. There is only one previous report of a similar di-2-pyridyl ketone N^4 -methylthiosemicarbazone, which is monosubstituted at the N^4 -position (Swearingen & West, 2001) and exists in a *ZE* conformation. Previously, we have reported a di-2-pyridyl ketone thiosemicarbazone that was also found to exist in the *ZZ* conformation (Usman *et al.*, 2002), and in which the N^4 -position forms part of a pentamethyleneimine five-membered ring. Similar conformations are also observed when a piperidyl or hexamethyleneiminyl ring occupies the

N^4 -position (Swearingen *et al.*, 2002). However, there are no previous reports of a *ZZ* conformation in mono/disubstituted thiosemicarbazones of di-2-pyridyl ketone.



A perspective view of the molecular structure of (I), along with the atom-labeling scheme, is given in Fig. 1. A *ZZ* conformation is exhibited by the molecule, since *cis* configurations are adopted with respect to the $C6=N3$ and $C12-N4$ bonds. The $S1=C12-N4-N3$ torsion-angle value [$-5.8(3)^\circ$] indicates that thionyl atom S1 is positioned *cis* to hydrazine atom N3. The deviation between the planes of the thiosemicarbazone moiety and the coordinating pyridyl ring (Cg2, comprising atoms $C7-C11$ and $N2$) is smaller in (I) than in other di-2-pyridyl ketone and benzoylpyridine thiosemicarbazones; the dihedral angle between these planes is $16.98(5)^\circ$ for (I), and $23.56(9)$ and $28.14(8)^\circ$ for di-2-pyridyl ketone N^4,N^4 -(butane-1,4-diyl)thiosemicarbazone (Usman *et al.*, 2002) and 2-benzoylpyridine N^4,N^4 -(butane-1,4-diyl)thiosemicarbazone (Sreekanth & Kurup, 2004).

The molecule of (I) consists of four fragments, *viz.* two planar pyridine rings (Cg1, comprising atoms $C1-C5$ and $N1$, and Cg2), the phenyl ring (Cg3) and the thiosemicarbazone moiety. The four different planes associated with the structure of (I) are shown in Figs. 1 and 2. The thiosemicarbazone (TSC) moiety, comprising atoms $N3, N4, C12, S1$ and $N5$, is almost planar, the maximum deviation being $0.0449(15)$ Å for atom $N4$, and the view along the TSC axis substantiates the non-planar nature of the molecule. The two pyridyl rings, Cg1 and Cg2, are also planar, with maximum deviations of $-0.0097(19)$ and $-0.012(3)$ Å for atoms $C5$ and $C10$, respectively, and are inclined at a dihedral angle of $46.09(7)^\circ$. The benzene ring is planar, having an r.m.s. deviation from the mean plane of $0.006(2)$ Å, while the value of the

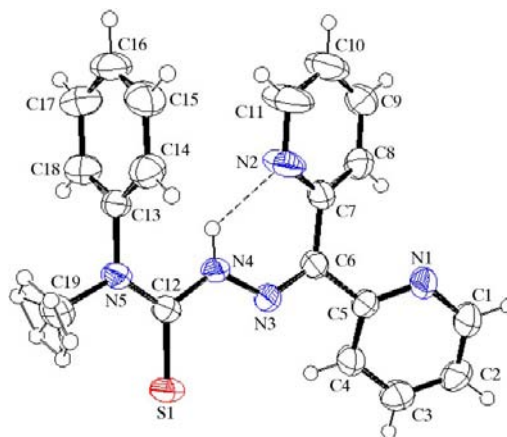


Figure 1

A view of the molecule of (I), with displacement ellipsoids drawn at the 50% probability level. H atoms attached to atom $C19$ have an occupancy of 0.5.

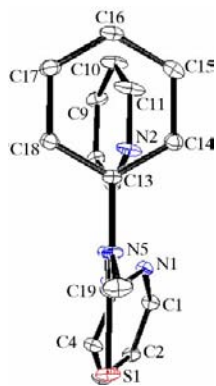


Figure 2

A view of the molecule of (I) along the thiosemicarbazone axis, with displacement ellipsoids drawn at the 10% probability level.

C13–N5–C12=S1 torsion angle [-178.90 (15°)] implies a *trans* alignment of the benzene ring with respect to the thiosemicarbazone moiety. The phenyl ring is twisted significantly from the thiosemicarbazone plane, with a dihedral angle of 81.74 (5°) between the least-squares planes.

The thiosemicarbazone moiety adopts an extended conjugation, with electron delocalization throughout the N5/C12/S1/N4/N3 group. The fact that the compound exists in the thione form is confirmed by the N3–N4, N4–C12 and C12=S1 bond distances (Table 1); the C12=S1 bond distance is close to that expected for a C=S double bond (1.60 Å; Huheey *et al.*, 1993). The potential resonance forms of the structure as a result of the extended conjugation are depicted in the scheme above. The N3–N4 bond distance in (I) is shorter than the corresponding distance of 1.44 Å in unsubstituted thiosemicarbazides (Palenik *et al.*, 1974). The resonance form involving pyridine ring Cg1 would account for the shortening of the N–N distance through extensive electron delocalization, which suggests that canonical form (III) might exist. The net result would be a small negative charge residing on pyridine atom N1, which is reported to be important in terms of biological activity (Restivo & Palenik, 1970; Gabe *et al.*, 1969).

An intramolecular N4–H4···N2 hydrogen bond leads to the formation of a six-membered ring comprising atoms N2, C7, C6, N3, N4 and H4. Some weak C–H··· π interactions are also observed (Table 2). The packing arrangement of adjacent molecules in an offset fashion contributes towards minimizing any repulsive interactions of the bulky pyridyl groups.

Experimental

A solution of di-2-pyridyl ketone (10 mmol, 1.84 g) in methanol (5 ml) was treated with a solution of *N*⁴-methyl-*N*⁴-phenylthiosemicarbazide (1.81 g, 10 mmol) in methanol (25 ml) and refluxed for 2 h. On slow evaporation at room temperature, bright-yellow crystals of the title compound separated out. These crystals were collected, washed with methanol and dried over P₄O₁₀ *in vacuo*. Single crystals of (I) suitable for X-ray analysis were obtained by slow evaporation from a methanol solution. Analysis found: C 66.11, H 4.98, N 19.94%; calculated: C 65.70, H 4.89, N 20.17%.

Crystal data

C₁₉H₁₇N₅S
*M*_r = 347.44
 Triclinic, *P* $\bar{1}$
a = 9.3059 (10) Å
b = 9.4966 (10) Å
c = 10.5689 (10) Å
 α = 92.544 (1)°
 β = 99.256 (1)°
 γ = 104.917 (1)°
V = 887.18 (16) Å³

Z = 2
*D*_x = 1.301 Mg m⁻³
 Mo K α radiation
 Cell parameters from 25 reflections
 θ = 2.0–25.0°
 μ = 0.19 mm⁻¹
T = 293 (2) K
 Block, bright yellow
 0.28 × 0.23 × 0.23 mm

Data collection

Enraf–Nonius CAD-4 diffractometer
 ω/θ scans
 3316 measured reflections
 3111 independent reflections
 2251 reflections with $I > 2\sigma(I)$
*R*_{int} = 0.011

θ_{\max} = 25.0°
h = $-11 \rightarrow 10$
k = $0 \rightarrow 11$
l = $-12 \rightarrow 12$
 3 standard reflections
 frequency: 3600 min
 intensity decay: 2%

Refinement

Refinement on *F*²
R [*F*² > 2 σ (*F*²)] = 0.037
wR(*F*²) = 0.104
S = 1.02
 3111 reflections
 228 parameters
 H-atom parameters constrained

$w = 1/[\sigma^2(F_o^2) + (0.0496P)^2 + 0.2064P]$
 where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\max} < 0.001$
 $\Delta\rho_{\max} = 0.16$ e Å⁻³
 $\Delta\rho_{\min} = -0.20$ e Å⁻³
 Extinction correction: *SHELXL97*
 Extinction coefficient: 0.012 (2)

Table 1

Selected geometric parameters (Å, °).

S1–C12	1.6685 (18)	N4–C12	1.377 (2)
N1–C5	1.335 (2)	N5–C13	1.446 (2)
N2–C7	1.340 (2)	N5–C19	1.468 (2)
N3–C6	1.295 (2)	C5–C6	1.499 (2)
N3–N4	1.361 (2)	C6–C7	1.487 (2)
C6–N3–N4	120.87 (15)	N3–C6–C7	127.07 (16)
N3–N4–C12	118.72 (14)	N3–C6–C5	112.18 (16)
C12–N5–C13	123.01 (14)	C7–C6–C5	120.73 (15)
C12–N5–C19	121.59 (15)	N5–C12–N4	113.74 (15)
C13–N5–C19	115.39 (15)	N5–C12–S1	123.48 (13)
N1–C5–C6	117.68 (16)	N4–C12–S1	122.77 (14)
C6–N3–N4–C12	-174.50 (17)	C13–N5–C12–S1	-178.90 (15)
N4–N3–C6–C5	177.49 (16)	N3–N4–C12–S1	-5.8 (3)

Table 2

Hydrogen-bonding geometry and C–H··· π interactions (Å, °) in (I) (for definitions, see *Comment* text).

<i>D</i> –H··· <i>A</i>	<i>D</i> –H	H··· <i>A</i>	<i>D</i> ··· <i>A</i>	<i>D</i> –H··· <i>A</i>
N4–H4···N2	0.86	2.03	2.642 (2)	128
C4–H4A···Cg2 ⁱ	0.93	2.87	3.487 (2)	125
C11–H11···Cg3	0.93	3.32	3.871 (4)	120

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

H atoms were located in a difference Fourier map and refined using a riding model, with *U*_{iso}(H) values of 1.2*U*_{eq} of the parent atom (C–H = 0.93 and 0.96 Å, and N–H = 0.86 Å). The H atoms of the methyl group (C19), being disordered, were constrained geometrically over six sites (each with an occupancy factor of 0.5).

Data collection: *CAD-4 Software* (Nonius, 1996); cell refinement: *CAD-4 Software*; data reduction: *CAD-4 Software*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEP-3* (Farrugia, 1997); 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: GA1079). Services for accessing these data are described at the back of the journal.

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