

# The thiosemicarbazone ligand *bis*(4-*N*-ethyl-thiosemicarbazone)-1,4-diacetylbenzene as building block for supramolecular species

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## ABSTRACT

We report herein the synthesis and the characterization of the tetradentate thiosemicarbazone ligand *bis*(4-*N*-ethyl-thiosemicarbazone)-1,4-diacetylbenzene. Its crystal structure has been analysed together with the possible coordination modes that could feature in its derived metal complexes.

## KEYWORDS

Thiosemicarbazone, ligand, metal complex

## INTRODUCTION

The chemistry of thiosemicarbazones has been receiving considerable attention because of their broad therapeutic activity, for instance antibacterial, antimicrobial, anti-fungal and antiHIV,<sup>1</sup> as well as their versatility as ligands.<sup>2,3</sup> The  $\pi$ -delocalisation of charge and the configurational flexibility of their molecular chain can give rise to a great variety of coordination modes.

As continuation of our successful studies with the series of tetradentate ligands *bis*(4-*N*-R-thiosemicarbazone)-1,3-diacetylbenzene)<sup>4</sup> we have designed and synthesised the analogous 1,4-functionalised *bis*(4-*N*-R-thiosemicarbazone)-1,4-diacetylbenzene), named H<sub>2</sub>pDABEt (Figure 1). Our aim is checking if the *trans* arrangement of the thiosemicarbazone arms modifies the structure of the ligand and its coordinative behaviour towards different metal ions.

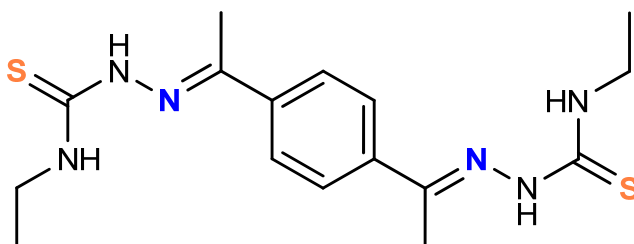


Figure 1

## EXPERIMENTAL

The [N<sub>2</sub>S<sub>2</sub>] tetradentate thiosemicarbazone ligand H<sub>2</sub>pDABEt has been prepared by treatment of 1,4-diacetylbenzene (0.73 g, 0.9 mmol) with 4-*N*-ethyl-3-thiosemicarbazide (0.99 g, 9 mmol) in a 1:2 molar ratio, under standard reflux conditions during 24 hours in ethanol. The removal of the solvent with a Dean-Stark trap gives rise to a yellow powdery solid that was satisfactorily characterised as it is shown below. Recrystallization of H<sub>2</sub>pDABEt in acetonitrile allows us to obtain crystals of the ligand, which were crystallographically studied.

Ligand H<sub>2</sub>pDABEt: M.p. 285 °C. Yield 1.21 g (80%) Elemental analysis, Calc. for C<sub>16</sub>H<sub>24</sub>N<sub>6</sub>S<sub>2</sub>: C, 52.7; H, 6.6; N, 23.1; S, 17.6. Found: C, 52.5; H, 6.8; N, 23.0; S, 17.5 %. MS ESI<sup>-</sup> (m/z): 363.2 ([H<sub>2</sub>pDABEt-H]<sup>-</sup>); IR (KBr, cm<sup>-1</sup>): ν(N-H) 3336, 3234, ν(C=N + C-N) 1527, 1493, 1452, ν(C=S) 1113, 841; ν(N-N) 1041. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>, ppm), δ (m, nH): 10.21 (s, 2H), 8.53 (t, 2H), 7.94 (s, 4H), 3.61 (m, 4H, J = 6.6 Hz), 2.30 (s, 6H), 1.15 (t, 6H, J = 6.6 Hz).

## RESULTS AND DISCUSSION

The crystal structure of H<sub>2</sub>pDABEt·CH<sub>3</sub>CN is shown in Figure 2 with the atom-labelling scheme. Main crystallographic data are summarised in Table 1. Bond lengths and angles are shown in Table 2, while the hydrogen bond parameters are listed in Table 3.

The crystal structure of H<sub>2</sub>pDABEt consists of discrete molecules with the two thiosemicarbazone arms adopting an *anti*-arrangement and an *E* conformation in relation to the two imine bonds (Figure 2). The ligand is additionally solvated by an acetonitrile molecule. As expected, this *E* conformation is mainly determined by the existence of both intra- and intermolecular hydrogen bonds (Figure 2, Table 3).

The imine nitrogen atom and the NH thioamide group of each ligand arm are involved in the intramolecular hydrogen bonds giving rise to two five-membered chelate rings *per* ligand arm. Besides, the ligand features a non-classic interaction involving the H3 aromatic protons.

The intermolecular hydrogen bonds are established between the imine and the thioamide nitrogen atoms that are bonded to the sulfur atom of neighbour molecule. These interactions give rise to parallel chains of ligands (Figure 3) that features open-channels along the crystal cell (Figure 4).

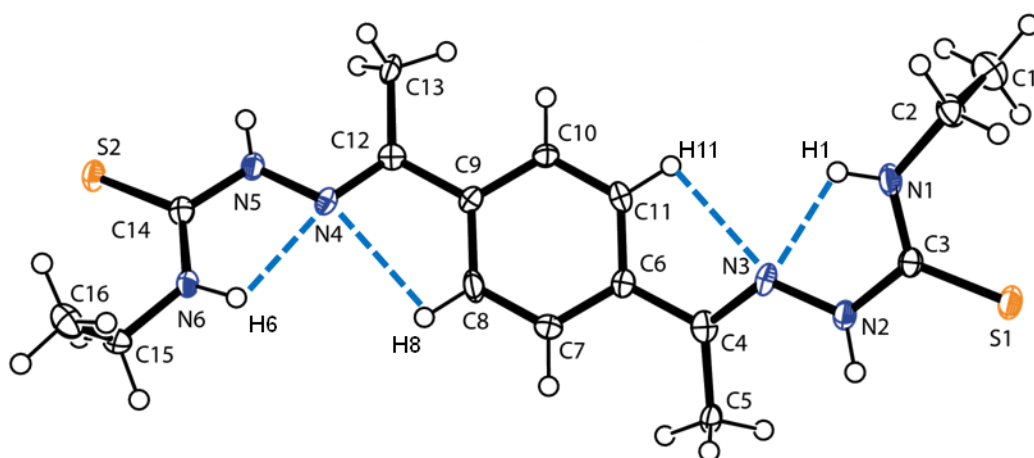
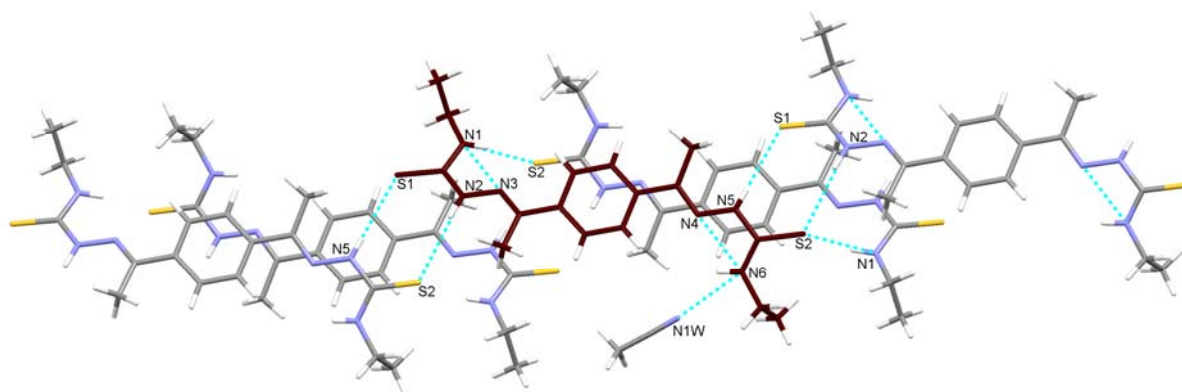
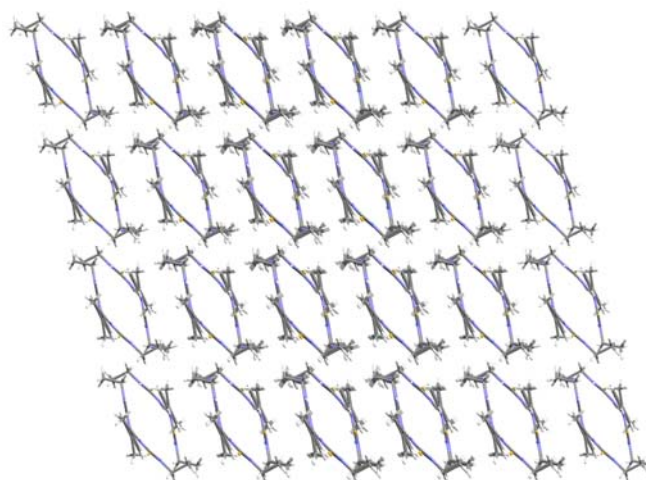


Figure 2



**Figure 3**



**Figure 4**

The imine bond distances are in the interval 1.285-1.290 Å, slightly higher to those expected for conjugated imine bonds (1.279 Å). The charge delocalization give rise to some double bond character for the C9-C12, C6-C4, N4-N5 and N3-N2 bonds as they have smaller values than those usual for the corresponding single bonds, C-C (1.530 Å) and N-N (1.420 Å). In the case of the thiourea groups the bond distances C-N and C-S are in the expected range [C-N (1.346 Å) and C=S thiourea (1.681 Å)].<sup>5</sup>

Regarding to the H<sub>2</sub>pDABEt arrangement it must be noted that the N/S donor atoms for the ligand arms are oriented to opposite directions. For that reason the coordination of these two donor atoms to the same metal ion would need a conformational rotation that places the imine nitrogen and the thioamide sulfur atoms pointing to the same metal centre.

## CONCLUSIONS

The novel thiosemicarbazone ligand H<sub>2</sub>pDABEt could be obtained with high purity and yield. Its crystal structure reveals that donor atoms (nitrogen and sulfur) are oriented to opposite directions in the ligand arms. This fact indicates a necessary conformational rotation in order to bind a metal center. Thus, considering the optimal conformation taken by the free ligand, supramolecular metal assemblies of the type [M<sub>2</sub>L<sub>2</sub>] are expected.

Table 1

	<b>H<sub>2</sub>pDABEt-CH<sub>3</sub>CN</b>
<b>Formula</b>	C <sub>18</sub> H <sub>27</sub> N <sub>7</sub> S <sub>2</sub>
<b>Molecular weight</b>	405.59
<b>Crystal system</b>	Triclinic
<b>Crystal size /mm</b>	0.13 x 0.06 x 0.02
<b>Volume /Å<sup>3</sup></b>	1042.53(11)
<b>Space group</b>	P -1
<b>Z</b>	2
<b>a/Å</b>	10.0961(6)
<b>b/Å</b>	10.2402(6)
<b>c/Å</b>	10.4225(6)
<b>α/°</b>	85.747(3)
<b>β/°</b>	80.660(4)
<b>γ/°</b>	78.954(3)
<b>D/g cm<sup>-3</sup></b>	1.292
<b>μ/mm<sup>-1</sup></b>	0.273
<b>F(000)</b>	432
<b>Interval θ/°</b>	1.98- 26.71
<b>Measured reflexions</b>	15301
<b>Independent reflexions [R<sub>int</sub>]</b>	4308 [0.0913]
<b>Residues/e-Å<sup>-3</sup></b>	0.318 and -0.338
<b>R Final index [ &gt;2σ(I)]</b>	0.0607 [0.1078]
<b>R index [all data]</b>	0.1381 [0.1273]

**Table 2**

<b>Bond distances (Å)</b>					
C2-N1	1.464(4)	C4-C5	1.499(5)	C14-S2	1.690(3)
C3-N1	1.329(4)	C9-C12	1.481(4)	C15-N6	1.461(4)
C3-N2	1.365(4)	C12-N4	1.290(4)	C15-C16	1.519(4)
C3-S1	1.673(3)	C12-C13	1.494(4)	N2-N3	1.375(4)
C4-N3	1.285(4)	C14-N6	1.327(4)	N4-N5	1.373(4)
C4-C6	1.485(4)	C14-N5	1.365(4)		
<b>Bond angles (°)</b>					
N1-C3-N2	115.6(3)	N4-C12-C9	115.5(3)	C3-N1-C2	125.3(3)
N1-C3-S1	124.5(3)	N4-C12-C13	123.4(3)	C3-N2-N3	117.8(3)
N2-C3-S1	119.9(3)	C9-C12-C13	121.1(3)	C4-N3-N2	119.4(3)
N3-C4-C6	115.6(3)	N6-C14-N5	116.3(3)	C12-N4-N5	117.8(3)
N3-C4-C5	124.5(3)	N6-C14-S2	123.7(3)	C14-N5-N4	118.8(3)
C6-C4-C5	119.8(3)	N5-C14-S2	120.0(3)	C14-N6-C15	124.8(3)

**Table 3**

<b>Ligand</b>	<b>D-H...A</b>	<b>D...A (Å)</b>	<b>D-H...A (°)</b>	<b>Symmetry operations</b>
H <sub>2</sub> pDABEt	C8-H8...N4	2.763(4)	95.43	
	C11-H11...N3	2.761(4)	95.25	
	N1-H1...N3	2.581(4)	109.97	
	N6-H6...N4	2.617(4)	105.70	
	N5-H5...S1	3.553(3)	173.41	x, +y-1, +z+1
	N6-H6...N1W	3.098(4)	126.50	-x+1, -y+1, -z+1
	N1-H1...S2	3.361(3)	122.18	-x+2, -y+1, -z+2
	N2-H2...S2	3.554(3)	163.91	x, +y+1, +z-1

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