Synthesis and X-ray crystal structure of the thiosemicarbazone ligand *bis*(4-*N*-methyl-thiosemicarbazone)-4,4'-diacetylphenylmethane

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Abstract: We report herein the synthesis of the tetradentate thiosemicarbazone ligand *bis*(4-*N*-methyl-thiosemicarbazone)-4,4'-diacetylphenylmethane, which is a suitable precursor in supramolecular chemistry for the preparation of helical metal complexes. This molecule has been characterized by microanalysis, mass spectrometry, IR and ^{1}H and ^{13}C NMR spectroscopies. Its crystal structure has also been analysed.

Keywords: thiosemicarbazone, ligand, helical, metal complex

Introduction

Thiosemicarbazones represent one class of versatile multidonor ligands,[1] which have been demonstrated to possess a wide biological activity.[2,3] Our group has recently reported that tetradentate [SNNS] thiosemicarbazones derived from 1,3-diacetylbencene can act as useful building blocks for generating novel supramolecular motifs.[4-6] On the other hand, the ligands containing the large spacer *bis*phenylmethane employed by Hannon *et al* give rise to supramolecular structures with interesting properties.[7]

Taking into account the versatility of tetradentate tiosemicarbazones and the supramolecular structures derived from ligands containing the spacer *bis*phenylmethane, in this work we try to combine both structural factors. With this objective in mind we have synthesized and characterized the new ligand *bis*(4-*N*-methyl-thiosemicarbazone)-4,4'-diacetylphenylmethane **1** (Figure 1), which is a potential precursor of helical metal complexes.

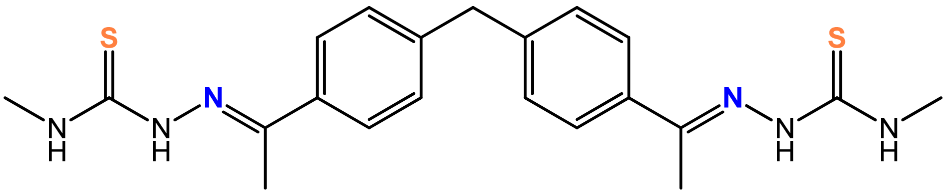
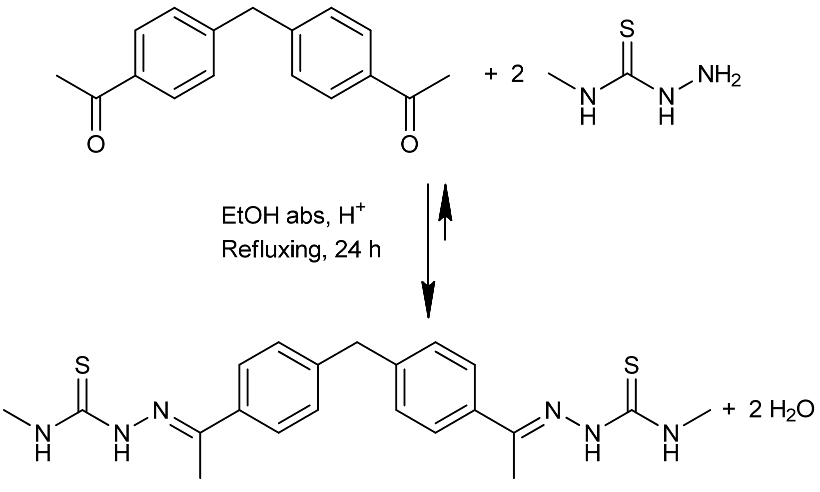


Figure 1

Experimental

The [N_2S_2] tetradentate tiosemicarbazone ligand **1** has been prepared by treatment of 4,4'-diacetylphenylmethane (1.00 g, 3.96 mmol) with 4-*N*-methyl-3-thiosemicarbazide (0.83 g, 7.92 mmol) in a 1:2 molar ratio, under standard reflux conditions during 24 hours in absolute ethanol, in presence of a catalytic quantity of p-toluenesulfonic acid (Scheme 1). 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 **1** in acetonitrile allows us to obtain crystals of the ligand, which were crystallographically studied.

Ligand **1**: M.p. 205 ºC. Yield 1.57 g (93%) Elemental analysis, Calc. for $C_{21}H_{26}N_6S_2$: C, 59.13; H, 19.70; N, 6.14; S, 15.03. Found: C, 59.11; H, 19.25; N, 5.80; S, 14.70 %. MS ESI$^-$ (m/z): 426.59 ([1]$^+$); IR (KBr, cm^{-1}): ν(N-H) 3365, 3284, 3225, ν(C=N + C-N) 1545, 1493, ν(C=S) 1105, 818. ^{1}H NMR (DMSO-d_6, ppm), δ (m, nH): 10.17 (s, 2H), 8.41 (s, 2H), 7.83 (d, 4H), 7.25 (d, 4H), 3.99 (s, 2H), 3.02 (d, 6H), 2.24 (s, 6H).



Scheme 1

Results and discussion

This ligand molecule has been obtained with high purity and yield. The crystal structure of **1** 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 **1** consists of discrete molecules with the two thiosemicarbazone arms adopting an *E* conformation in relation to the two imine bonds (Figure 2). As expected, this *E* conformation is mainly determined by the existence of both intra- and intermolecular hydrogen bonds (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 quelate rings *per* ligand.

The intermolecular hydrogen bonds are established between the thioamide nitrogen atoms that are bonded to the sulfur atom of a neighbour molecule. These interactions connect the different molecules of ligand along the crystal cell.

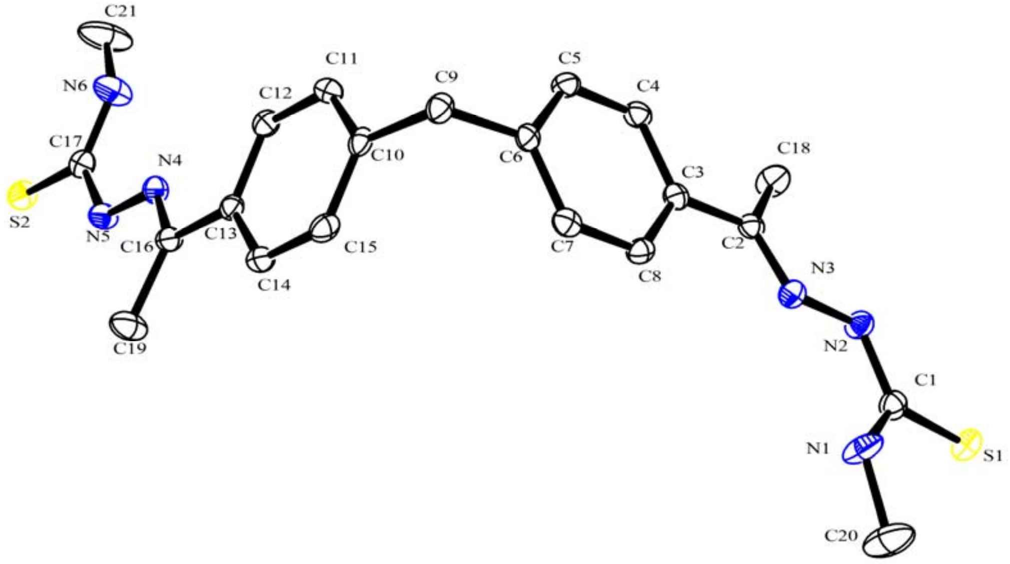


Figure 2

The imine bond distances are 1.287 Å, slightly higher to those expected for conjugated imine bonds (1.279 Å). In the case of the thiourea groups the bond distances C-S are in the expected range [C=S thiourea (1.681 Å)].[8]

Regarding to the **1** 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. Moreover, the introduction of the large and semi-flexible spacer *bis*phenylmethane in the ligand structure guarantees the coordination of each bidentate binding domain [NS] to different metal ions, possibly in a supramolecular helical mode.

Conclusions

The novel thiosemicarbazone ligand **1** 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 neccesary conformational rotation in order to bind a metal center. Thus, considering the presence of a large and semi-flexible spacer and the optimal conformation taken by the free ligand, helical supramolecular metal assemblies are expected.

Acknowledgements

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Table 1

	$1\cdot0.5CH_3CN$
Formula	$C_{22}H_{27.5}N_{6.5}S_2$
Molecular weight	445.14
Crystal system	Monoclinic
Crystal size /mm	0.40 × 0.24 × 0.20
Volume /Å^3	4622.2(3)
Space group	C2/c
Z	4
a/Å	21.1233(7)
b/Å	9.9462(3)
c/Å	22.0101(7)
α/º	90
β/º	91.716(2)
γ/º	90
μ/mm^{-1}	0.25
Measured reflexions	34029
Independent reflexions [R_{int}]	4881 [0.048]
R Final index [I>2σ(I)]	0.0604 [0.1181]
R index [all data]	0.0454 [0.1114]

Table 2

Bond distances (Å)					
C1-S1	1.688(2)	N4-N5	1.377(2)	C1-N2	1.360(3)
C17-S2	1.689(2)	N2-N3	1.376(2)	N5-C17	1.356(3)
N3-C2	1.287(3)	C16-N4	1.287(3)	N1-C20	1.451(3)
Bond angles (º)					
C2-N3-N2	118.27(17)	N1-C1-S1	124.41(17)	N5-C17-S2	119.69(16)
C17-N5-N4	119.62(17)	N2-C1-S1	119.59(16)	C6-C9-C10	109.24(16)

Table 3

D-H···A	**D-H (Å)**	**H···A (Å)**	**D···A (Å)**	**D-H···A (<)**
N(1)-H(1N)···N(3)	0.83(2)	2.19(3)	2.612(3)	112.0(2)
N(1)-H(1)···S(2)^i	0.83(2)	2.84(3)	3.470(2)	135.0(3)
N(6)-H(6N)···N(4)	0.86(3)	2.22(3)	2.612(3)	108.0.(2)

Symmetry operations: i = x, -y, -1/2+z

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