Metal complexes of sulfanilamide derivatives. Spectroscopic characterization of the dichloro disulfathiazole methanol copper(II) complex

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(Received March 29, 1993; revised June 4, 1993)

Abstract

The synthesis and spectral characterization of the $[Cu(Hstz)_2(MeOH)Cl_2]$ complex are described. Both polycrystalline powder EPR and single crystal EPR spectra recorded at room temperature show rhombic distortion with values of $g_1=2.25$, $g_2=2.09$ and $g_3=2.03$ in agreement with a copper polyhedron, intermediate between trigonal bipyramid and square pyramidal.

Introduction

The sulfanilamides constitute an important class of antimicrobial agents which exert their antibacterial action by the competitive inhibition of the enzyme dihydropterase synthase towards the substrate *p*-aminobenzoate. Studics on their metal chelates could have much physiological and pharmacological relevance. The metal chelates of sulfadrugs have been found to be more bacteriostatic than the drugs themselves [1, 2]. Sulfathiazole, [4-amino-*N*-2-thiazolylbencenosulfonamide] (Hstz) (Fig. 1) is clinically one of the most used.

Although the synthesis of metal complexes of Hstz has been reported, the structural determination is often incomplete and conflicting [3]. Recently, we have reported the first crystal structure of a Zn–sulfathiazole complex, where the drug acts as a bridging ligand through the N_{amino} and $N_{thiazole}$ atoms [4], and the crystal structure of the title compound [5]. Considering the different ligand behaviour of sulfathiazole, a comparative study of the spectral properties of both complexes must be of interest. In the present paper the spectral characterization of the $[Cu(Hstz)_2(MeOH)Cl_2]$ complex is studied and related to its crystal structure.

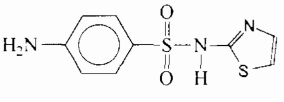

Fig. 1. Sulfathiazole.

Experimental

Synthesis

A methanolic solution of $CuCl_2\cdot 2H_2O$ (2 mmol in 20 ml) was added, with continuous stirring, to 100 ml of hot methanol (60 °C) containing 4 mmol of Hstz. Immediately, the resulting mixture became yellow. Then, the solution was stirred for half an hour, and was left to stand at room temperature. Within one day, prismatic green crystals of $[Cu(Hstz)_2(MeOH)Cl_2]$ were obtained.

Anal. Calc. for $[Cu(Hstz)_2(MeOH)Cl_2]$: C, 33.7; N, 12.4; H, 3.2. Found: C, 33.3; N, 12.2; H, 2.8%.

Techniques

IR spectra was recorded on a Perkin-Elmer 843 instrument. Samples were prepared by using the KBr technique. Vis–UV spectra was recorded with a Perkin-Elmer Lambda 15 spectrophotometer.

Polycrystalline powder and single crystal EPR spectra of the $[Cu(Hstz)_2(MeOH)Cl_2]$ complex were recorded with a Varian E9 spectrometer at X-band frequency at room temperature. EPR suitable single crystals showing well developed faces were oriented with an Enraf Nonius DELFT 586 diffractometer.

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Results and discussion

General considerations

The crystal structure of the title compound (Fig. 2) has been described previously [5]. The unit cell contains two independent molecules. Sulfathiazole, acts as a monodentate ligand through the N atom of the amino group, and the two Cl^- anions and the methanol molecule form a CuN_2Cl_2O chromophore. The Cu(II) ion (Fig. 3) is five-coordinate with a coordination polyhedron intermediate between a square pyramid and a trigonal bipyramid [6]. The geometry of the molecule can be described as a distorted tetragonal pyramid where the basal plane consists of *trans* nitrogen atoms from the sulfathiazole molecules and *trans* chloride ions. The apical site is occupied by the methanolic oxygen atom. The value of T^5 is 0.912 (T = mean in-plane Cu–L bond distance/mean out-of-plane Cu–L bond distance) and $\tau = 0.36$ ($= (\beta - \alpha)/60$), where $\beta = $ N(1)–Cu–N(2) 169.5 and $\alpha = $ Cl–Cu–Cl 147; for perfect tetragonal and trigonal bipyramidal geometries the value of τ is zero and unity, respectively [7]. The value of 0.36 indicates a strong distortion of the square pyramidal geometry.

IR and electronic spectra

The IR spectrum of the complex shows the characteristic bands of the Hstz ligand. The bands at 3180 and 3100 cm^{-1}, assigned to ν_{as} and ν_s (N–H) vibrations of the NH_2 group are significantly shifted with respect to those of the ligand (3320 and 3280 cm^{-1}). Bult and Klasen [8] have considered the value of $\nu^*_{Hstz} - \nu^*_{M\text{-}Hstz}$ ($\nu^* = \nu_{as} + \nu_s/2$) as indicative of the coordination of the NH_2 group to the metal ion. According to this author a value of 160 cm^{-1} in the complex suggests the interaction of the NH_2 moiety, which is also in agreement with the crystal structure. However, this parameter as a measure of the coordination of the amino group must be taken into account carefully. As we have indicated $\nu^*_{Hstz} - \nu^*_{M\text{-}stz}$ for the Zn–stz complex points out the lack of interaction of the NH_2 moiety in spite of NH_2 coordination.

As expected the characteristic vibrations of the SO_2 group at 1320, 1140, 570 and 550 cm^{-1} remain unchanged with respect to those of the ligand. There is no change of the bands at 1540, 920 and 680–640 cm^{-1} assigned to the thiazole ring, S–N and C–S vibrations, respectively. This fact is in agreement with the modifications observed for the same bands for the Zn–stz complex which have been attributed to the deprotonation and coordination of stz$^-$ through the $N_{thiazole}$ ring.

A strong band at 3400 cm^{-1} in the IR spectrum of the complex is consistent with the presence of coordinated methanol [9]. The new band at 1060 cm^{-1} is attributed to bending MOH vibrations [10].

The d–d electronic spectrum of the complex consists of an asymmetric broad band with a maximum at approximately 13 990 cm^{-1}. In order to reveal the correlation of the d orbitals, the solid state visible spectrum was deconvoluted into Gaussian component bands by curve-fitting iteration processes. Three Gaussian component bands (16 020, 14 660 and 12 350 cm^{-1}) with that of the highest frequency having the greatest intensity were resolved ($R = 0.17\%$). On the basis of the d orbital splitting associated with the systematic change from trigonal bipyramidal to square pyramidal symmetry [11, 12], the complex must present its orbitals in an intermediate site as in the following scheme

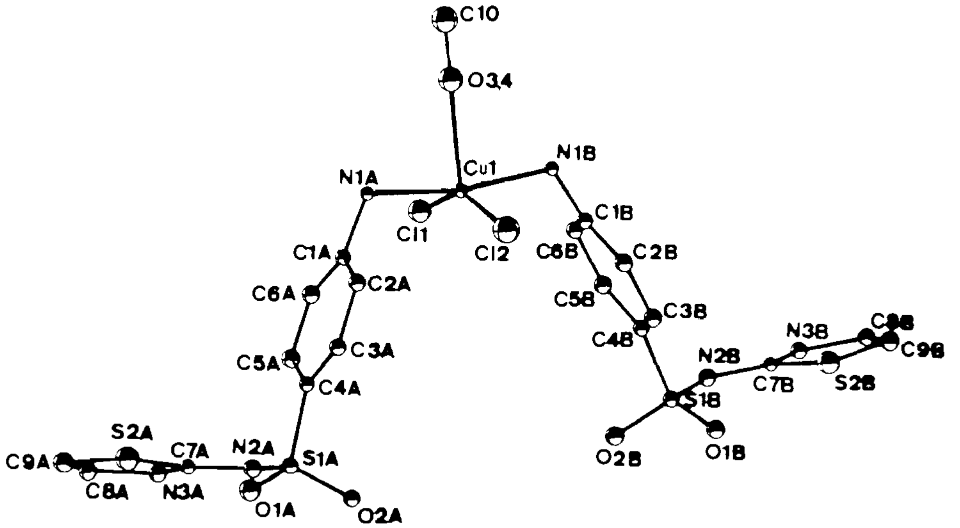


Fig. 2. ORTEP drawing of the $[Cu(Hstz)_2(MeOH)Cl_2]$ complex [5].

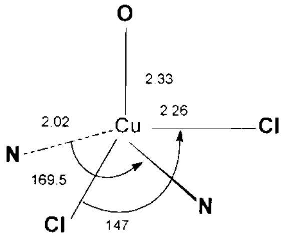


Fig. 3. Coordination polyhedron of Cu(II) in the [Cu(Hstz)$_2$(MeOH)Cl$_2$] complex.

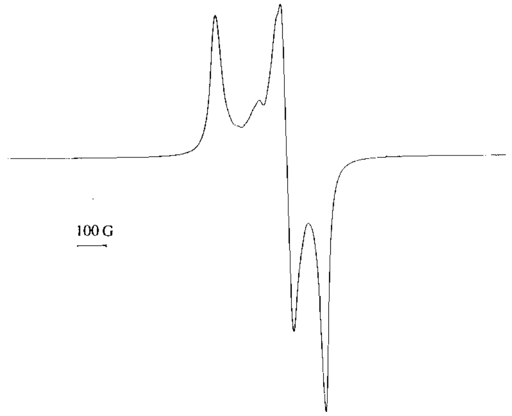
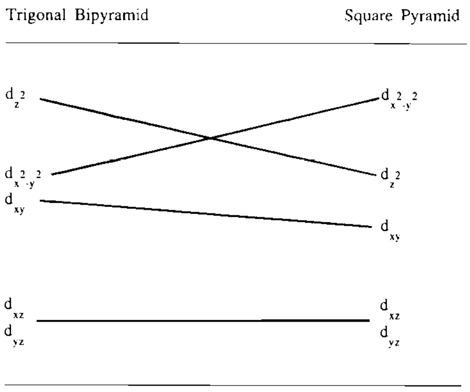


Fig. 4. Polycrystalline EPR spectrum of the [Cu(Hstz)$_2$(MeOH)Cl$_2$] compound.



EPR spectra of the [Cu(Hstz)$_2$(MeOH)Cl$_2$] complex

The polycrystalline EPR spectrum of the compound is rhombic (Fig. 4) with the lowest value of g only slightly above 2.00.

The single crystal EPR spectrum was recorded at room temperature and X-band frequency by rotating around the b, $a' = bxc^*$ and $c^* = axb$ axes. The angular dependence of g and the linewidth is shown in Fig. 5. The usual analysis [13] gave the principal g values: $g_1 = 2.25$, $g_2 = 2.09$ and $g_3 = 2.03$. The corresponding principal directions are shown in Fig. 6. g_1 is roughly parallel to the Cu–O direction, while g_3 is within error parallel to the Cu–N1A and Cu–N1B bond directions.

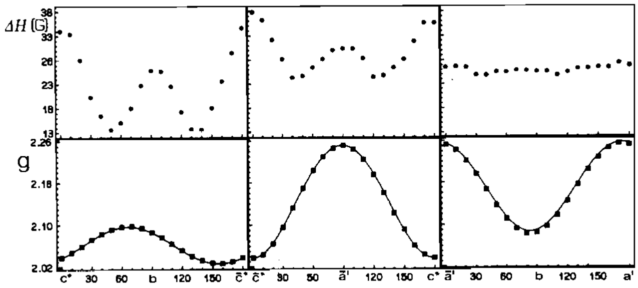


Fig. 5. Angular dependence of the transition fields for [Cu(Hstz)$_2$(MeOH)Cl$_2$] in the three orthogonal b, $a' = bxc^*$ and $c^* = axb$ axes. The added lines represent the calculated values.

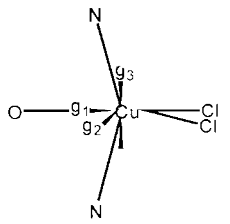


Fig. 6. Principal directions of the g tensor of [Cu(Hstz)$_2$(MeOH)Cl$_2$] complex.

The g values indicate a ground state which is a large admixture of x^2-y^2 and z^2 orbitals and a coordination intermediate between a square pyramid and a trigonal bipyramid. The direction of g_1 corresponds to the z axis of the square pyramid, while g_3 corresponds to the z axis of the trigonal bipyramid. The $R = g_2 - g_1/g_3 - g_2$ value is 0.5 suggesting according to Hathaway and Billing [14], that the distortion from the regular geometries is strong.

The angular dependence of the linewidth in the rotation around a' and b shows maxima and minima in agreement with the magic angle, i.e. $(3\cos^2\theta - 1)^n$, dependence [15]. The maximum linewidth is seen parallel to g_3. This behaviour indicates that the intermolecular exchange interactions are smaller than the Zeeman energy (0.3 cm^{-1}).

Therefore the EPR spectra are in agreement with the crystal structure and the electornic spectrum.

Acknowledgements

J.C., G.A. and J.B. appreciate financial support from FAR91-197(CICYT). J.C. acknowledges the Generalitat Valenciana for a grant.

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