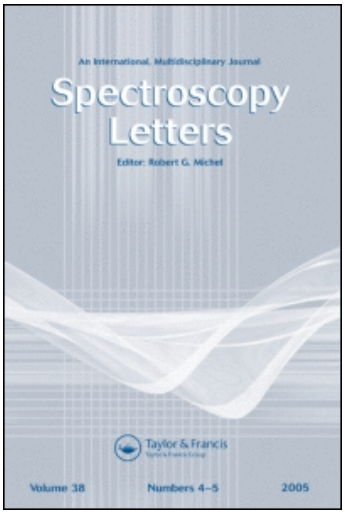

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

A Raman Spectroscopic Investigation of Sulphadiazine and of Its Dirhodium Tetracarboxylate Adducts

R. D. Sinisterra[a]; R. Najjar[a]; L. F. C. de Oliveira[a]
[a] Instituto de Química da Universidade de Sao Paulo, Sao Paulo, Brazil

To cite this Article Sinisterra, R. D. , Najjar, R. and de Oliveira, L. F. C.(1993) 'A Raman Spectroscopic Investigation of Sulphadiazine and of Its Dirhodium Tetracarboxylate Adducts', Spectroscopy Letters, 26: 2, 305 — 318
To link to this Article: DOI: 10.1080/00387019308011533
URL: http://dx.doi.org/10.1080/00387019308011533

SPECTROSCOPY LETTERS, 26(2), 305-318 (1993)

A RAMAN SPECTROSCOPIC INVESTIGATION OF SULPHADIAZINE AND OF ITS DIRHODIUM TETRACARBOXYLATE ADDUCTS

Key words: sulphadiazine; dirhodium tetracarboxylates; rhodium complexes; vibrational spectroscopy.

R.D. Sinisterra, R. Najjar and L.F.C. de Oliveira*

Instituto de Química da Universidade de Sao Paulo
C.P. 20780, CEP 01498, Sao Paulo, Brazil.

ABSTRACT

A tentative assignment of the vibrational modes of sulphadiazine is made, based on the infrared and Raman data. In addition, dirhodium tetracarboxylates and their adducts with sulphadiazine are investigated by Raman spectroscopy, with emphasis in the identify the metal-metal and metal-ligand stretching modes.

INTRODUCTION

Sulphadiazine [4-amino-N-2-pyrimidinyl)benzene-sulphonamide] is a member of the sulpha family, an important class of molecules that have been thoroughly studied in terms of their pharmacological properties [1,2]. However, although this molecule plays an important rule in medical and biological fields, studies involving its vibrational

spectrum are scarse. In fact, in the literature only two papers dealing with the sulphadiazine vibrational spectrum are found, one reporting its Raman [3] and other reporting its infrared spectrum [4]. In the latter there is a more complete tentative vibrational assignment, based on comparision with similar molecules. The paper dealing with the Raman spectrum [4] just lists the bands, without a tentative assignment of the modes. We then considered that it would be of interest to undertake a more involved investigation of the vibrational spectrum of this molecule, and accordingly in this work we present its Raman and infrared spectra with a tentative assignment of the observed modes, based on the previous studies and on the assignment of related molecules.

In addition, sulphadiazine forms stable adducts with dirhodium tetracarboxylates [5]. Since dirhodium tetracarboxylates are known since long to have antitumor activity [6-12], the question arises wheter such activity is preserved or not in their adducts. In this respect a better knowledge regarding the nature of the interaction of sulphadiazine with dirodhium tetracarboxylates would be desirable, and in the present study we also investigate the Raman spectrum of several dirhodium tetracarboxylates and their adducts with sulphadiazine.

EXPERIMENTAL

All the reagents and solvents were analytical grade. The syntheses of the complexes were described in a recent paper [5].

The Raman spectra were recorded in a Jarrel-Ash 25-300 spectrometer equipped with a Czerny-Turner double monochromator, photomultiplier and photon counting detection system, using the rotating disk technique to avoid thermal decomposition. The excitation line used was the 514.5 nm (ca. 200 mW) provided by an Ar^+ ion laser of Spectra Physics model 165. The spectral resolution employed was ca. 7 cm^{-1}.

The ir spectrum of SD was obtained in a Perkin Elmer FTIR model 1750 spectrometer, using the KBr pellet or nujol techniques.

RESULTS AND DISCUSSION

Vibrational Spectrum of Sulphadiazine

The Raman spectrum of sulphadiazine (SD) can be observed in Figure 1, and the Raman shift values, together with the infrared frequency values, are displayed in Table 1. This molecule is a derivative of sulphamic acid, containing a benzenic and a pyrimidinic rings, resulting in a very low symmetry, as can be inferred from its crystal and molecular structure [13]. The stereochemistry around the sulfur atom is a slightly distorted tetrahedron, the pyrimidine ring being distorted from the planar configuration.

The tentative assignment of the vibrational spectrum of sulphadiazine was made by comparison with the assignments of similar molecules, such as pyrimidine [14,15], aniline [16] and the infrared tentative assigment of Krishna Murty and co-workers for sulfadiazine [4] (in the 600-4000 cm^{-1} region). The Raman spectrum of SD described in the literature [3] presents only the tentative assignment of the S-O stretching mode. It is worth mentioning that in SD the individual rings retain their characteristic vibrations almost completely, with minor deviations around their normal values [4].

In the N-H stretching region, in both Raman and ir spectra several bands are observed that can be assigned as the N-H stretching of sulphamide or of aniline . The bands observed in the 3330-3420 cm^{-1} region can be assigned to the NH stretching modes in the $-NH_2$ moiety, according to the observations of Evans [16], for aniline and those observed in the 3140-3255 cm^{-1} region can be assigned to the NH stretching of the sulpha species, according to Blaschette and Burger [17]. The four types of NH_2 bending vibrations at

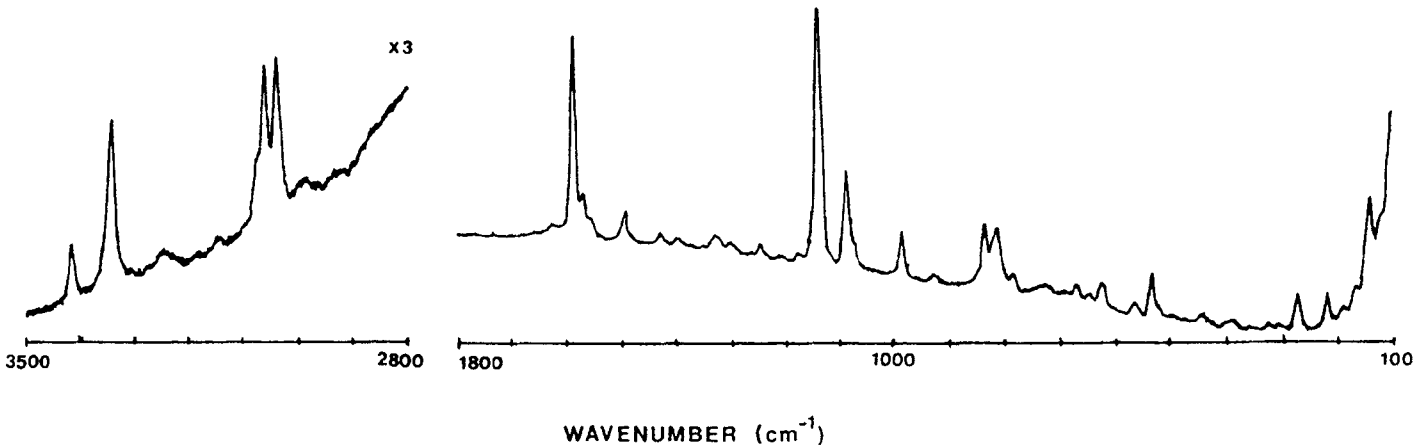

Figure 1 - Raman spectrum of solid sulphadiazine, excited at 514.5 nm laser line. Spectral resolution of 7 cm^{-1}.

222, 674, 1074 and 1619 cm^{-1}, were also observed in the Raman spectrum of SD, and were tentatively assigned to twisting, wagging, rocking and scissoring modes, respectively. This attribution is in accordance with the one of Evans [16] in the aniline molecule, where the author assigns such deformation modes to frequencies at 1618, 1050, 670 and 220 cm^{-1}, respectively.

The "amide II" band has a high percentage of NH bending character [18,19] and Hadzi [20], examining the spectra of N-substituted sulphonamides, found this vibration at 1410 cm^{-1} in the spectrum of methyl-p-toluenesulphonamide. In SD, this kind of vibration was assigned to the very weak band at 1428 cm^{-1} in the Raman spectrum. The "amide III" band that has contributions from the N-H bending and C-N stretching modes [18,19] was assigned to a very weak band at 1303 cm^{-1} in the Raman spectrum.

In the ring stretching region we found some bands that are very difficult to assign due to the strong coupling of the CN and CC stretching and NH bending modes, as can be seen in the assignment of parent molecules as aniline [16] and pyrimidine [14,15]. In this sense we followed the assignments of these authors, that assigned these bands as correlated to the "ring stretching" in the diazine and in aniline, without further specification of the kind of vibration. However, the band at 1588 cm^{-1} in the Raman spectrum of SD (1590 cm^{-1} in the infrared spectrum) was assigned to a ring stretching mode of pyrimidine ring, since this is a characteristic mode of pyrimidine 2-substituted molecules [18].

The CH stretching modes were assigned to the Raman and infrared bands observed in the 3000-3100 cm^{-1} region, and again it was not possible to assign with certainty the CH stretching bands to the individual rings. The in-plane and out-of-plane CH deformation modes were also previously assigned, and here some of these modes were assigned specifically to the individual rings, as can be seen in Table 1.

Table 1

Raman and infrared frequency values (in cm^{-1}) of sulphadiazine.

Raman	Infrared	Tentative Assignment
222 w		NH_2 twisting
288 w		CH o.p. bend
311 vw		CH o.p. bend
330 vw		CH bend in pyrimidine
391 vw		CH bend in pyrimidine
445 vw		ring bend in aniline
537 w	545 s	SO_2 deformation
568 vw	570 s	assym. ring stretch in pyrimidine
627 vw	635 m	ring i.p. bend in pyrimidine
651 vw	664 m	ring i.p. bend in aniline
674 vw	679 ms	NH_2 wagging
693 vw		
730 vw	715 m	CH o.p. bend
789 vw	792 ms	CH bend in aniline
817 wm	820 m	CH o.p. bend in pyrimidine
840 wm	839 ms	CH o.p. bend in pyrimidine
929 vw	940 ms	SN stretch
985 wm	992 w	ring breath in pyrimidine
998 sh		ring breath in aniline
1074 sh		NH_2 rocking
1088 m	1089 wm	CH i.p. bend
1140 vs	1152 vs	SO_2 symmetric stretch
1179 vw	1182 m	CH i.p. bend
1250 vw	1258 m	CH i.p. bend in pyrimidine
1303 vw		amide III in aniline
1330 vw	1322 vs	SO_2 asymmetric stretch

Table 1 - continued

1399 vw	1404 ms	amide II in aniline
1428 vw	1438 s	ring stretch
1495 w	1489 s	ring stretch
1560 sh		ring stretch
1571 sh	1576 vs	ring stretch
1588 s	1590 vs	ring stretch in pyrimidine
1619 vw		NH_2 scissoring
	1647 m	
	2734 m	1322 + 1404
	2806 m	2 x 1438
	2868 m	2 x 1438
2930 vw	2934 m	1590 + 1258
3040 w	3035 m	CH stretch
3059 w		CH stretch
3071 sh	3071 m	CH stretch
	3098 m	CH stretch
3142 vw		NH stretch in NH
3247 vw	3255 m	NH stretch in NH
3338 w	3351 s	NH stretch in NH_2
3415 vw	3420 ms	NH stretch in NH_2

Abbreviations: w - weak; m - medium; s - strong; wm - weak to medium; ms - medium to strong; vw - very weak; vs - very strong.

The ring breathing vibration of the pyrimidine molecule in the liquid state was assigned to a mode observed at 991 cm^{-1} [14,15], and this vibration in aniline was assigned to a band at 998 cm^{-1} as the most intense in the Raman spectrum [16]. In mono-substituted pyrimidines this mode shifts to lower frequency regions [18]. In the Raman spectrum of SD two bands in this region can be observed, one of medium intensity at 985 cm^{-1} and the other as a shoulder at 998 cm^{-1}. The assignment of these two modes is difficult

to make due to the proximity of the modes; however we may assign the 985 cm^{-1} to the ring stretching mode of the pyrimidine molecule in the sense of the observed frequency shift of this mode in the Raman spectrum, whereas the other band can be tentatively assigned to the ring breath mode of aniline moiety.

The SO_2 stretching modes were assigned according to Krishna Murthy and coworkers [4], that assigned the symmetric SO_2 stretching mode to a band at 1150 cm^{-1} and the assymetric stretching mode to the 1320 cm^{-1} band. Our Raman spectrum of SD shows these bands at 1140 cm^{-1}, with very high intensity, and 1330 cm^{-1}, as a very weak band respectively. In the work of Maschka and Aust [3], where these authors investigated the Raman spectra of some derivatives of sulphamic acid, the symmetric SO_2 stretching mode was assigned to a band in the 1060-1100 cm^{-1} region, whereas the assymetric stretching mode was assigned to a band in the 1130-1180 cm^{-1} region. However, in a more recent work [17] the SO_2 asymmetric stretching mode was assigned to a band at ca. 1320 cm^{-1}, what is in agreement with our tentative assignment. The SO_2 deformation mode was assigned to a band at 537 cm^{-1} in the Raman spectrum (545 cm^{-1} in the infrared spectrum), of weak intensity, according to the assignment of Blaschette and Burger [17].

Other vibrational mode that may be assigned is the SN stretching, based on the tentative assignment of Maschka and Aust [3] in the Raman spectra of sulphamic acid derivatives, in the 900-950 cm^{-1} region. In the Raman spectrum of SD a very weak band at 929 cm^{-1} (940 cm^{-1} in the infrared spectrum) was assigned to the SN stretching mode. In the study of Krishna Murthy and coworkers [4], this mode coupled to the C-N stretching mode was assigned to a band at 840 cm^{-1}. However, in this region we can observe some Raman and infrared bands that are typical of the CH deformation modes of pyrimidine ring, as can be seen in the assignment of Lord et al. [14] and Sbrana et al. [15].

Table 2

Some selected Raman bands for the complexes dirhodium tetracarboxylates (cinnamate, Cim; hydrocinnamate, Hcm and trifluoroacetate, TFA) and their respective adducts with sulphadiazine. Laser excitation at 514.5 nm, spectral resolution of 7 cm^{-1}.

$Rh_2(Cim)_4$	$Rh_2(Cim)_4SD_2$	$Rh_2(Hcm)_4$	$Rh(Hcm)_4SD_2$	$Rh_2(TFA)_4$	Assignment
302 w	285 w	300 vw	283 w	260 w	ν(Rh-Rh)
345 wm	335 w	335 s	325 s	345 w	ν(Rh-O)
402 w	400 vw			385 w	ν(Rh-O)
	1151 vw		1150 w		ν_s(S=O)
	1330 vw		1330 w		ν_{as}(S=O)
1389 w	1395 w	1410 vw	1410 vw	1465 w	ν(COO^-)
1590 w	1590 m		1590 s		ν ring SD

Abbreviations used are the same of Table 1.

Table 3

Some selected Raman bands (in cm^{-1}) for the complexes Rh_2(carboxylate)$_4SD_2$, where carboxylate = acetate (Ac), butirate (But) and propionate (Prop). Laser excitation at 514.5 nm, resolution of 7 cm^{-1}.

$Rh_2(Ac)_4SD_2$	$Rh_2(Prop)_4SD_2$	$Rh_2(But)_4SD_2$	Assignment
285 w	281 w	280 w	ν(Rh-Rh)
318 s	332 s	320 s	ν(Rh-O)
340 m			ν(Rh-O)
1152 m	1150 wm	1142 w	ν_s(S=O)
	1330 w	1320 vw	ν_{as}(S=O)
1572 w			ν ring SD
1587 m	1580 w	1582 s	ν ring SD

Abbreviations used are the same of Table 1.

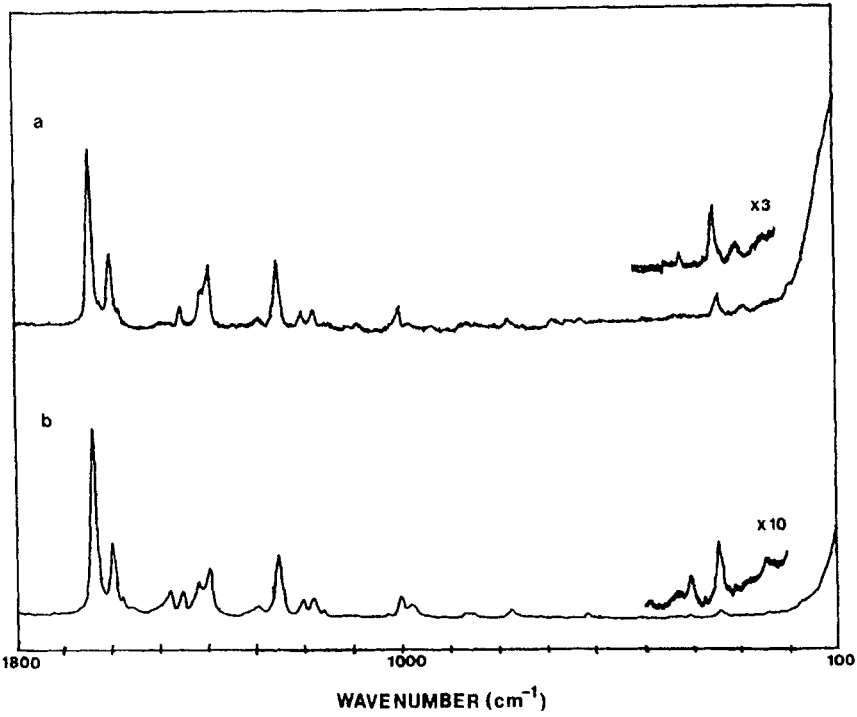

Figure 2 - Raman spectra of (a) dirhodium tetracinnamate and (b) of its sulphadiazine adduct. Laser excitation at 514.5 nm; spectral resolution of 7 cm^{-1}. In detail is shown the metal-metal stretching region with expanded gain.

Raman Spectra of Dirhodium Tetracarboxylates and of their Adducts with Sulphadiazine

In Tables 2 and 3 some selected Raman bands of dirhodium tetracarboxylates and of their adducts with sulphadiazine are displayed with a tentative vibrational assignment, based mainly in comparison with the data reported in the literature for similar complexes. In Figure 2 are displayed the Raman spectra of dirhodium tetracinnamate (a) and of its sulphadiazine adduct (b), both in the solid state, as an example of the investigated series.

As can be seen in Tables 2 and 3, it was possible to identify some important Raman bands of the dirhodium tetracarboxylates and of their respective adducts. The rhodium-rhodium stretching vibration, assigned to a weak band in the range 260-300 cm^{-1} in the complexes, was tentatively assigned based on the studies of Clark and coworkers [21-24], where use was made of the resonance Raman technique to investigate similar compounds. In other investigation Pruchnik et al. [25] carried out a normal coordinate analysis of a series of dirhodium tetracarboxylates, confirming the ideas of Clark and co-workers concerning the assignment of the metal-metal bond. It is worth mentioning that dirhodium tetraacetate adducts with $AsPh_3$ (triphenylarsine) and $SbPh_3$ (triphenylstibine) [23] and with PPh_3 (triphenylphosphine) [22] show this stretching mode at 297, 307 and 289 cm^{-1}, respectively. In the case of the series studied in this work, an important observation is the shift to lower frequency regions of the metal-metal stretching mode of the dirhodium tetracarboxylate under coordination in the axial positions, as we can see in the data of Table 3, so denoting the strengthening of the rhodium-rhodium bond in the adducts, upon the coordination of SD in the axial positions.

Other Raman bands that were possible to assign in the investigated compounds are the rhodium-oxygen stretching in the case of dirhodium tetracarboxylate complexes, appearing in the 315-345 cm^{-1} range. In the case of the adducts with SD we can observe an increase of the relative intensity of these bands in the Raman spectra, interpreted as a coupling of the rhodium-oxygen and rhodium-nitrogen stretching modes, according to the calculations of Pruchnik et al. [25], who studied several compounds of this type.

In the $Rh_2(carboxylate)_4$ complexes the Raman bands at 1390, 1410 and 1465 cm^{-1} were assigned to the symmetric stretching of the carboxylate moiety for cinnamate and hydrocinnamate adducts, whereas to the trifluoroacetate this mode was observed at 1465 cm^{-1}.

In the adducts with SD the most important Raman features were assigned to the bands at 1570-1590 cm^{-1}, due to the ring stretching of the pyrimidine moiety in the SD molecule, and the symmetric and asymmetric stretching modes of SO_2 group, in the ranges 1140-1150 and 1320-1330 cm^{-1}, respectively. In this type of compound, the coordination between SD and rhodium appears to take place through a pyrimidine ring nitrogen, as can be inferred from the change in the 1580-1200 cm^{-1} region of the infrared spectra [12]. In the Raman spectra, although the strongest Raman band in this region is the 1590 cm^{-1} one, assigned to a ring stretching of the pyrimidine moiety, some shifts in the same region reinforces that assumption about the coordination site of the SD molecule. It is important to note that the SO_2 stretching modes do not shift in the adducts when compared with the respective complexes. In another paper investigating the coordination properties of SD with platinum complexes [26] the authors, based on the infrared and proton magnetic resonance data, proposed the coordination of SD to platinum through the same site, i.e., a nitrogen atom of the pyrimidine moiety.

ACKNOWLEDGMENTS

L.F.C.O. acknowledges FAPESP for the grant of a post-doctoral fellowship. This work was supported by grants of FAPESP, CAPES and CNPq. The authors are indebted to Prof. O. Sala for the use of Raman equippment.

REFERENCES

1 - Abel G., Connors T.A., Ross W.C.J., Nam N.-H., Hoellinger H. and Pichat L. Europ. J. Cancer 1973; 9: 49.

2 - Pasini A. and Bersanetti E. Inorg. Chim. Acta 1989; 80: 90.

3 - Maschka A. and Aust H. Mh. Chem. 1954; 85: 891.

4 - Krishna Murthy P., Rangacharyulu M. and Premaswarup D. Indian J. Pure & Appl. Phys. 1982; 20: 844.

5 - Sinisterra R.D., and Najjar R. Spectrosc. Lett., accepted.

6 - Hughes R.G., Bear J.L. and Kimball A.P. Proc. Am. Assoc. Cancer Res. 1962; 13: 120.
7 - Bear J.L., Gray H.B., Rainen L., Chang I.M., Howard R., Serio G. and Kimball A.P. Cancer Chemoth. Rep. 1975; 59: 611.
8 - Howard R.A., Spring T.G., and Bear J.L. Cancer Res. 1976; 36: 4402.
9 - Howard R.A., Sherwood E., Erck A., Kimball A.P. and Bear J.L. J. Med. Chem. 1977; 20: 943.
10 - Najjar R., Netto E.R. and Takano I. Inorg. Chim. Acta 1984; 84: 53.
11- Najjar R., Oliveira W. and Carducci J.B. Polyhedron 1989; 8: 115.
12- Syngier S., Kimura E. and Najjar R. Brazilian J. Med. Biol. Res. 1989; 22: 397.
13- Cook D.S. and Turner M.F.J. Chem. Soc., Perkin II 1975; 1021.
14- Lord R.C., Marston A.L. and Miller F.A. Spectrochim. Acta 1957; 9: 113.
15- Sbrana G., Adembri G. and Califano S. Spectrochim. Acta 1966; 22: 1831.
16- Evans J.C. Spectrochim. Acta 1960; 16: 428.
17- Blaschette A. and Burger H. Z. Anorg. Allg. Chem. 1974; 378: 104.
18- Dolish F.R., Fateley W.G. and Bentley F.F. "Characteristic Raman Frequencies of Organic Compounds", New York: Wiley, 1974.
19- Varsányi G. "Vibrational Spectra of Benzene Derivatives", Budapest: Academic Press: 1969.
20- Hadzi D. J. Chem. Soc. 1957: 847.
21- Clark R.J.H., Hempleman A.J. and Flint C.D. J. Am. Chem. Soc. 1986; 108: 518.
22- Clark R.J.H. and Hempleman A.J. Inorg. Chem. 1989; 28: 746.
23- Clark R.J.H. and Hempleman A.J. Inorg. Chem. 1989; 28: 92.
24- Best S.P., Clark R.J.H. and Nightingale A.J. Inorg. Chem. 1990; 29: 1383.

25- Pruchnik F., Hanuza J., Hermanowicz K., Wajda-Hermanowicz K., Pasternak H. and Zuber M. Spectrochim. Acta 1989; 45A: 835.

26- Pasini A., Bersanetti E., Zunino F. and Savi G. Inorg. Chim. Acta 1983; 80: 99.

Date Received: 08/19/92
Date Accepted: 09/22/92