Turkish Journal of Biology

Volume 30 | Number 1 Article 1

1-1-2006

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Turk J Biol
30 (2006) 1-4

Biological Properties of Chloro-salicylidene Aniline and Its Complexes with Co(II) and Cu(II)

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Received: 12.10.2005

Abstract: New complexes of chloro-salicylidene aniline with Co(II) and Cu(II) were synthesised and screened for antibacterial activity against several bacterial strains, namely Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa. The metal complexes showed enhanced antibacterial activity compared to uncomplexed ligands.

Key Words: Antibacterial activity, chloro-salicylidene, metal ions

Introduction

Various studies (1-5) have shown a relationship between the metal ions and their metal complexes as antitumour (6-8) and antibacterial agents, which is a subject of great interest. The inorganic pharmacology started to be an important field with more than 25 inorganic compounds being used in therapy as antibacterial, antiviral and anticancer drugs (8-11).

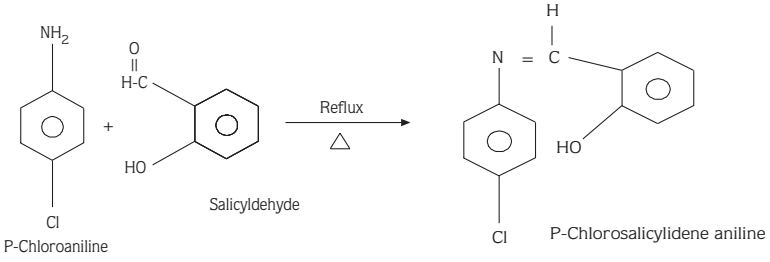
It was seen that the biological active compounds become more bacteriostatic and carcinostatic upon chelation with metal ions. Schiff bases have also attracted considerable attention in terms with their chelating abilities and analytical applications (12-14). The chloro-salicylidene aniline Schiff base is also of the same type. The aim of the present work was to support and evaluate the chelation behaviour of such a class of new ligand having (C = N) and (OH) groups, which shows its probable colour, reaction and stabilities towards Cu^{2+} and Co^{2+} metal ions.

Materials and Methods

All the chemicals and solvent were of analytical reagent grade. The metal(II) salts were used as their chlorides. I.R. spectra were recorded on a Philips Analytical – PU 9800 FTIR. UV-visible spectra were obtained in methanol by Specord – 200 spectrophotometer and Acuta 710 software. Melting points were determined by digital GallenKamp apparatus.

Synthesis of Schiff Base

1.1 g of salicyldehyde (1 M) was mixed with 10 ml of ethanol and then added to this ethanolic solution of 1.28 g P-chloro aniline (1 M), magnetically stirred with the addition of 2 to 3 drops of concentrated H_2SO_4, refluxed for 2 h and left overnight at room temperature. The solid coloured product formed was filtered, washed with ethanol and ether consecutively. It was dried at room temperature and recrystallised with hot ethanol to give the required Schiff base.



Synthesis of metal complexes

4.62 g (0.02 mol) of Schiff base was dissolved in 25 ml of ethanol. To this solution was added 0.01 mol of Cu and Co salts dissolved in 20 ml of ethanol. This mixture (1:2 metal-ligand) was magnetically stirred while being refluxed for 2 h. This product was cooled to room temperature. Upon cooling, coloured precipitates were formed, which were filtered and washed with dry ethanol and vacuum dried.

Antibacterial Studies

Preparation of discs

The ligand complex, 30 µg ∅ in DMF (0.01 ml) was applied to a paper disc with the help of micropipette. The discs were left in an incubator for 48 h at 37 °C and then applied to the bacteria grown on agar plates (15).

Preparation of agar plates

Minimal agar was used for the growth of specific bacterial species. For the preparation of agar plates for E. coli, MacConkey agar (40 g) obtained from Merck was suspended in 1 l of freshly distilled water. It was allowed to soak for 15 min and then boiled on a water bath until the agar was completely dissolved. The mixture was autoclaved for 15 min at 120 °C and then poured into previously washed and sterilised petri dishes and stored at 40 °C for incubation.

Procedure for inoculation

Inoculation was performed with the help of a platinum wire loop, which was made red hot in a flame, cooled and then used for the application of bacterial strains.

Application of discs

Sterilised forceps were used for the application of the paper disc on the earlier inoculated agar plates. When the discs were applied, they were incubated at 37 °C for 24 h. The zone of inhibition (diameter in mm) was then measured around the disc.

Results and Discussion

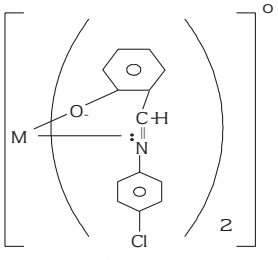
The structure of the ligand was established with the help of I.R. and previous analytical data available in the literature (4,7,8,12,14). Both the metal complexes of this ligand were analysed for elemental analysis. The colour change of the complexes along with decomposition point >152 °C shows characteristic differences between the Schiff base and metal complexes. Upon heating the ligand melts at 123 °C without decomposition, whereas metal complexes of this ligand melt at 152 °C along with decomposition. This shows that thermal energy accumulated in the complex not only changes its physical characteristics, i.e. melting, but also breaks chemical bonds, i.e. decomposition. The same kind of phenomenon is observed in starch and starch-like biopolymers.

I.R. spectra of the ligand (Table 1) showed the absence of bands at ~1735 and 3315 cm^{-1} due to the carbonyl $\upsilon(C = O)$ and $\upsilon(NH_2)$ stretching vibrations and a strong new band appeared at ~1630 cm^{-1} assigned to azomethene $\upsilon(HC=N)$ linkage, showing that amino and aldehyde moieties of the starting material are absent and have been converted into the ligand, i.e. p-chloro salicylidine aniline.

The comparison of I.R. spectra of the ligand and its metal chelates indicated that the ligand is principally coordinated to the metal ion in 2 ways, thus acting as a bidentate ligand. The band appearing at ~1630 cm^{-1} due to azomethene was shifted to a lower frequency by ~1-15 cm^{-1} in both complexes, indicating participation of azomethene nitrogen in the interaction with the metal ion. A broad band appearing at 3415 cm^{-1} assigned to the $\upsilon(OH)$ in the ligand was no longer found in the spectra of the metal complexes but instead a new band appeared at ~1380 cm^{-1}, indicating deprotonation and coordination of hydroxyl oxygen with the metal ion.

Structure of Complex

Further conclusive evidence of the coordination of the ligand with metal ions was shown by the appearance of new weak low frequency bands at 550 to 555 cm^{-1} and 565 to 570 cm^{-1}. These were assigned to $\upsilon(M-O)$ metal oxygen and metal-nitrogen $\upsilon(M-N)$ vibrations, respectively. The new bands were only observable in the spectra of metal complexes and not in the spectra of uncomplexed ligand, thus confirming the participation of groups (O and N) in coordination.



M = Co (II) or Cu (II)

Table 1. Physicoanalytical properties.

S. No.	Colour	Solubility	Melting points	I.R. cm^{-1}	U.V/Vis. nm λmax.	% metal	
						Observed	Calculated
Ligand	Yellow	Ethanol, DMF, Acetone	123 °C	3421 (Ph-OH), 1630 (CH=N), 1310 (S, CH)	252	-	-
CuL_2	Bright Yellow	Ether, *DMF, *DMSO, Methanol	Decomposes > 152 °C	1380 (M-O), 1620 (CH=N) 550 (M-N), 570 (M-O)	311	12.3%	22.02%
CoL_2	Pale Yellow	Ether, *DMF, *DMSO, Methanol	Decomposes > 152 °C	1380 (M-O), 1618 (CH=N) 555 (M-N), 565 (M-O)	316	11.57%	20.75%

*DMF = Dimethyl formamide, *DMSO = Dimethyl sulphoxide

Table 2. Antibacterial activity data.

Schiff base / complex	Microbial species		
	Escherichia coli	Staphylococcus aureus	Pseudomonas aeruginosa
Ligand	+ +	+	+ +
CoL_2	+ + +	+ + +	+ +
CuL_2	+ +	+ +	+ + +

L = p-nitrosalicyledene aniline, Inhibition zone diameter (mm) = +≅ 6 – 10, + + ≅10 – 14, + + + ≅ 14 – 18

The title Schiff base and its metal chelates were evaluated for their antibacterial activity against bacterial species, i.e. Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa. The compounds were tested at a concentration of 30 µg/0.01 ml in DMF solution using paper disc diffusion. The diameters of the susceptibility zones were measured (in mm) and the results are presented in Table 2. It was observed that the metal chelates are more antibacterial than uncomplexed ligands are. On the basis of the above observations, it is concluded that the process of chelation (15) dominantly affects the biological behaviour of the compounds that are potent against some bacterial strains.

Acknowledgement

The authors acknowledge the help of the Department of Microbiology, University of the Punjab, Lahore, in undertaking the antibacterial studies.

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