

TEMPLATE SYNTHESIS OF NEW SCHIFF-BASE COMPLEXES AND DETERMINATION OF THE STRUCTURE OF THESE COMPLEXES

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ABSTRACT

In this study, two new Zn(II) and Cd(II) acyclic Schiff-base complexes, [Zn(L)](ClO₄)₂ and [Cd(L)](ClO₄)₂, have been prepared via templated [1+2] condensation of 6,6'-bis(2-aminothiophenoxymethyl)-2,2'-bipyridine with 2-furaldehyde. The structure of these complexes was elucidated by using spectroscopic methods.

Keywords: Schiff-base, template synthesis, Cd(II) and Zn(II) complexes.

INTRODUCTION

Schiff-base complexes recently have taken more attention in bioinorganic and biochemistry in medicine because of the fact that it has antimicrobial and chemotherapy features.^[1,2] The potential biological activity of complexes containing sulfur and nitrogen may be reason for this increased interest. In particular complexes with N and/or S donor ligands of copper(II),^[3,4] cobalt(II),^[5] nickel(II),^[3,5] platinum(II)^[1,3,6] and iron(II/III)^[6] are known sometimes to act as antitumor or therapeutic agents. Many efforts have been made to establish further metal-containing cytostatics however, without great success. Only little is known about the antitumor efficacy of some transition metals such as zinc(II),^[7] and cadmium(II). For this reason, we synthesized two new N₄S₂O₂ Schiff base complexes of these transition metals. Recently we also synthesized and characterized some new similar macrocyclic and acyclic Schiff base complexes using these metals.^[8-10]

In this study, in the presence of cadmium(II) and zinc(II) perchlorate salts that control the reaction, by using 6,6'-bis(2-aminothiophenoxymethyl)-2,2'-bipyridine and 2-furaldehyde, open chain N₄S₂O₂ donor complexes were synthesized. The structure of these complexes were elucidated by using spectroscopic methods.

EXPERIMENTAL

Instrumentation

Melting points were determined using an Gallenkamp MPD350.BM2.5 digital melting point apparatus and were uncorrected. The compounds were checked for purity by TLC on silica gel 60 F₂₅₄ (Merck). Elemental analyses were performed on a CHNS-O Carlo Erba EA 1108 elemental analyser; IR spectra were obtained with a Shimadzu 470 IR spectrophotometer using nujol mulls or KBr disc; ¹H NMR spectra were recorded with a Varian (300 MHz) or Bruker spectrometer (250 MHz) in CDCl₃ as solvent. ¹³C NMR spectra were recorded with a Varian (75.5 MHz) in CDCl₃ as solvent; MS-FAB⁺ spectra were obtained with a Finnigan Mat 95 mass spectrometer. ESI MS spectra were recorded on a Finnigan LCQ mass spectrometer.

Materials

THF was distilled from sodium metal in the presence of benzophenone immediately prior to use. 1,4-Dioxane was distilled prior to use. Et₄Ni was dried at 100 °C under reduced pressure. Zinc dust was washed with successive portions of dilute hydrochloric acid, distilled water, ethanol, acetone and diethyl ether immediately prior to use to remove the oxide layer. All other chemicals and solvents were of reagent grade and used as commercially purchased without further purification. Preparation of NiCl₂(PPh₃)₂ was followed to literature method.^[11] 6-Bromo-2-methylpyridine and 6,6'-bis(bromomethyl)-2,2'-bipyridine were prepared according to literature procedures.^[12,13] 6,6'-dimethyl-2,2'-bipyridine was prepared by a slight modification of the method of Iyoda *et. al.*^[14]

Preparation of 6,6'-Bis(2-aminothiophenoxymethyl)-2,2'-bipyridine [10]

Solution of sodium ethoxide (2.30 g sodium, 0.10 mol ; absolute ethanol 150 mL) were added to solution of 2-aminothiophenol (12.5 g, 0.10 mol) in absolute ethanol (150 mL) at room temperature, under argon gas. Then 6,6'-bis(bromomethyl)-2,2'-bipyridine (17.10 g, 0.05 mol) in absolute ethanol (100 mL) was added and the reaction mixture refluxed for 4 h. On cooling, the reaction mixture was poured into water (400 mL). The product (cream colour) was collected by filtration, washed with water and dried (yield 89 %). m.p. 97-99 °C.

$\gamma_{\max/\text{cm}^{-1}}$ (KBr disc): 3440-3328 (N-H); 1603, 1561 (aromatic ring).

δ_{H} (300 MHz; CDCl₃): 4.14 (4H, s, CH₂), 4.38 (4H, s, NH₂), 6.61 (2H, t, *J* 7.5 Hz), 6.70 (2H, d, *J* 8.2 Hz), 7.03 (2H, d, *J* 7.6 Hz), 7.09 (2H, t, *J* 7.5 Hz), 7.26 (2H, d, *J* 5.3 Hz), 7.66 (2H, t, *J* 7.8 Hz), 8.18 (2H, d, *J* 7.9 Hz).

δ_{C} (75.5 MHz; CDCl₃): 41.22 (CH₂), 115.28, 117.33 (C), 118.76, 120.23, 123.54, 130.42, 136.85, 137.79, 148.72(C), 155.31 (C), 157.55 (C).

m/z 431 [(M+H)⁺, 100 %]; C₂₄H₂₂N₄S₂ calculated : C 66.9 %, H 5.2 %, N 13.0 %, S 14.9 % found : C 66.7 %, H 5.2 %, N 13.0 %, S 15.3 %.

Metal-ion Controlled Synthesis of L Complexes in the Presence of Zn(II) and Cd(II) perchlorate salts.

The complexes of **L** were obtained from [1+2] Schiff-base condensations of 6,6'-bis(2-aminothiophenoxymethyl)-2,2'-bipyridine and 2-furaldehyde in methanol in the presence of Zn(II) and Cd(II) perchlorate salt (Scheme 1). The yields, colours and API-ES mass (m/z) spectral data and IR data of the complexes are given respectively in Table 1 and Table 2.

Table 1. Colours, yields and the API-ES mass spectrum for the complexes

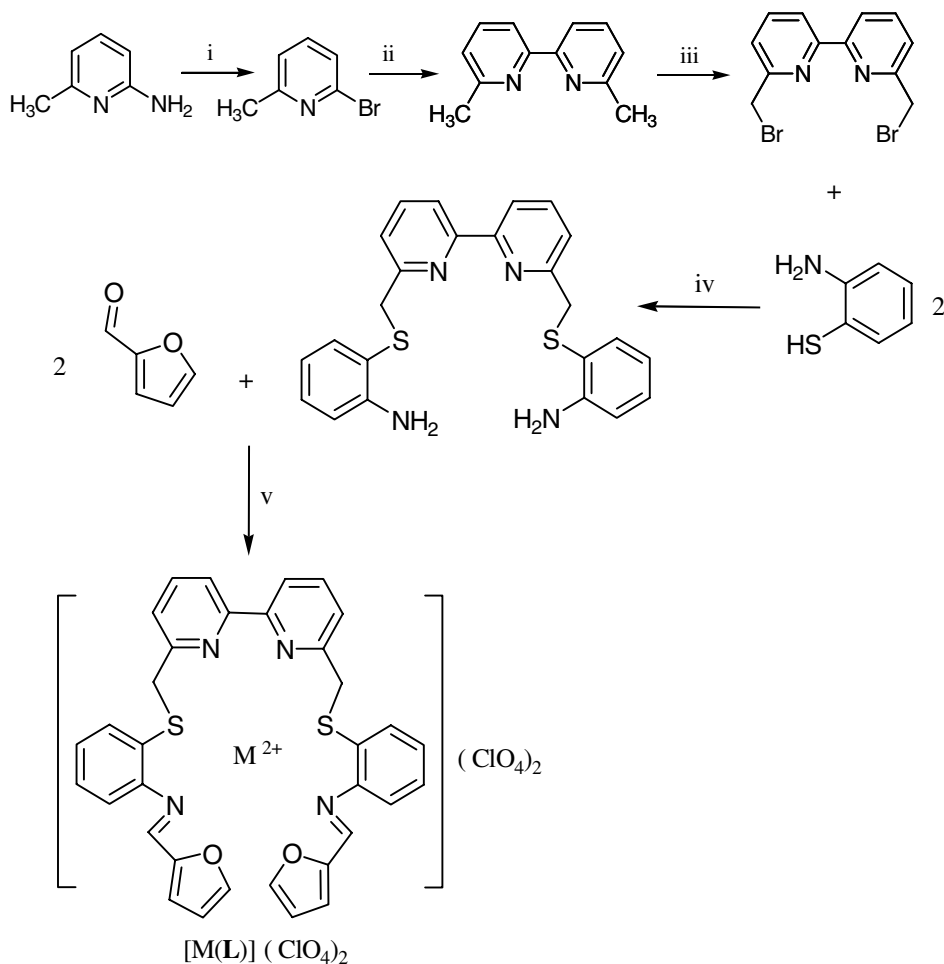
Complex	Colour of complex	% yield	Peak (m/z)	Assignment
[Zn(L)](ClO ₄) ₂	light brown	80	749.0 650.95 587.10 325	[Zn(L)(ClO ₄) ₂] ⁺ [ZnL] ²⁺ [L+H] ⁺ ½[ZnL] ²⁺
[Cd(L)](ClO ₄) ₂	light brown	40	796.90 697.95 587.10 349.9	[Cd(L)(ClO ₄) ₂] ⁺ [CdL] ²⁺ [L+H] ⁺ ½ [CdL] ²⁺

Table 2. Infrared (KBr/disc) spectral data for the complexes

Complex	v[C=N]	pyridine	v(anion)
[Zn(L)](ClO ₄) ₂	1612	1596	1094, 624
[Cd(L)](ClO ₄) ₂	1612	1596	1094, 624

RESULTS AND DISCUSSION

All the complexes were prepared by a template synthesis, in which the Schiff base macrocyclic ligand resulted from the condensation of 6,6'-bis(2-aminothiophenoxymethyl)-2,2'-bipyridine with 2-furaldehyde in methanol in the presence of Zn(II) and Cd(II) perchlorate salt (Scheme 1). For the synthesis of diamine compound, 6,6'-bis(2-aminothiophenoxymethyl)-2,2'-bipyridine, 6-amino-2-methylpyridine was brominated with concentrated aqueous hydrobromic acid and bromine.^[12] Then 6,6'-dimethyl-2,2'-bipyridine was prepared using 6-bromo-2-methylpyridine by a modification of the method described by Iyoda *et. al.*^[14] and it was reacted with 47 % hydrobromic acid.^[13] Then, one equivalent of 6,6'-bis(bromomethyl)-2,2'-bipyridine was reacted with two equivalents of 2-aminothiophenol in ethanol under an inert atmosphere. Physical data for all compounds are given in the Experimental Section.



Scheme 1. Synthetic route to $[ML](ClO_4)_2$.

i: %47 HBr, Br_2 , $NaNO_2$ then NaOH, *ii:* $NiCl_2(PPh_3)_2$, Zn, Et_4NI , THF under argon gas, *iii:* CCl_4 , NBS then benzoyl peroxide, *iv:* Na, EtOH under argon gas, *v:* MeOH, $[M(ClO_4)_2]$ ($M=Zn^{2+}$, Cd^{2+}).

The complexes were obtained with 40-80 % yields. The infrared spectra of these metal complexes in the region $400-4000\text{ cm}^{-1}$ show a strong absorption band at 1612 cm^{-1} , which assigned to the C=N stretching vibration, indicating the formation of the Schiff base products. Furthermore, the absence of C=O and N-H stretching vibrations in the spectra of the complexes, as compared to the aldehyde and diamine, respectively. For the metal complexes absorptions at 1094 and 624 cm^{-1} were assigned to the ν_3 and ν_4 stretching modes of ionic perchlorate.^[15]

The API-ES mass spectrum of the complex, $Zn(L)(ClO_4)_2$ and $Cd(L)(ClO_4)_2$ in positive ion mode is structurally enlightening, since it displays a series of intermediate breakdown species. The loss of an anionic perchlorate ion from the neutral parent molecule generates the cationic $[Zn(L)(ClO_4)]^+$ and $[Cd(L)(ClO_4)]^+$, which is the first peak observed at respectively m/z 749.0 and 796.90 in the mass spectra. The loss of a second perchlorate anion occurs to generate $[ZnL]^{2+}$ at m/z 650.95 and $[CdL]^{2+}$ at m/z 697.95. The loss of counterion for these complexes is also accompanied by the presence of the free ligand at m/z 587.10 for $[L+H]^+$ in the mass spectrum.

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