Arabian Journal of Chemistry (2016) 9, S668–S677

King Saud University

Arabian Journal of Chemistry

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Synthesis, characterization, anti-microbial, DNA binding and cleavage studies of Schiff base metal complexes

Poomalai Jayaseelan, Selladurai Prasad, Subramanian Vedanayaki, Rangappan Rajavel *

Department of Chemistry, Periyar University, Salem 636011, Tamilnadu, India

Received 19 May 2011; accepted 22 July 2011
Available online 30 July 2011

KEYWORDS

Schiff base;
Binuclear;
Butanedione monoxime;
DNA studies;
Anti-microbial

Abstract A novel Schiff base ligand has been prepared by the condensation between butanedione monoxime with 3,3′-diaminobenzidine. The ligand and metal complexes have been characterized by elemental analysis, UV, IR, ^{1}H NMR, conductivity measurements, EPR and magnetic studies. The molar conductance studies of Cu(II), Ni(II), Co(II) and Mn(II) complexes showed non-electrolyte in nature. The ligand acts as dibasic with two N_4-tetradentate sites and can coordinate with two metal ions to form binuclear complexes. The spectroscopic data of metal complexes indicated that the metal ions are complexed with azomethine nitrogen and oxyimino nitrogen atoms. The binuclear metal complexes exhibit octahedral arrangements. DNA binding properties of copper(II) metal complex have been investigated by electronic absorption spectroscopy. Results suggest that the copper(II) complex bind to DNA via an intercalation binding mode. The nucleolytic cleavage activities of the ligand and their complexes were assayed on CT-DNA using gel electrophoresis in the presence and absence of H_2O_2. The ligand showed increased nuclease activity when administered as copper complex and copper(II) complex behave as efficient chemical nucleases with hydrogen peroxide activation. The anti-microbial activities and thermal studies have also been studied. In anti-microbial activity all complexes showed good anti-microbial activity higher than ligand against gram positive, gram negative bacteria and fungi.

---

* Corresponding author. Mobile: +91 9865094324; fax: +91 04272345124.
E-mail address: drrajavel@rediffmail.com (R. Rajavel).

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.arabjc.2011.07.029
1878-5352

1. Introduction

In the recent and past years a large number of binuclear Schiff base metal complexes have been synthesized and characterized (Atakol et al., 2003). Schiff base ligand played central role in transition metal coordination chemistry (Shebl, 2008; Hobady and Smith, 1972). The tetra dentate Schiff base metal complexes used as metal enzymes (Cerchiaro and Ferreira, 2006), catalyst (Cozzi, 2004; Denmark et al., 2005), material chemistry (Huang et al., 2001), and biomimetic chemistry (Molenveld et al., 2000). The binuclear complexes have greater cleaving efficiency than mononuclear complexes (Oliveira et al., 2005). The Schiff bases are able to inhibit the growth of several animal tumors, and some metals have shown good antitumor activity against animal tumors (Eudnett and Mooney, 1970; Eudnett and Dunn, 1972). The interest in preparation of new metal complexes gained the tendency of studying on the interaction of metal complexes with DNA for their applications in biotechnology and medicine. Although cisplatin and carboplatin are in use, there are several side effects of these chemotherapeutic drugs. Therefore, our main aim is to prepare the chemotherapeutic drugs without side effects or fewer side effects. Many transition metal complexes are known to bind to DNA via both covalent and non-covalent interactions. In covalent binding the labile ligand of the complexes is replaced by a nitrogen base of DNA. On the other hand, the non-covalent DNA interactions include intercalative, electrostatic and groove (surface) binding of cationic metal complexes outside of the DNA helix, major or minor groove. DNA molecules are prone to be damaged under various conditions like interactions with some molecules. This damage may cause various pathological changes in living organisms, which is due to their possible application as new therapeutic agents and their photochemical properties which make them potential probes of DNA structure and conformation (Arturo et al., 2004; Maribel, 2003; Metcalfe and Thomas, 2003).

In this paper the novel complexes derived from butanedione monoxime with 3,3′-diaminobenzidine were synthesized and characterized by elemental analysis, molar conductance, UV, IR, NMR, EPR and magnetic studies. Thermal study has also been studied. The Schiff base ligand and its complexes were investigated for their DNA binding, cleavage, anti-bacterial and anti-fungal properties.

2. Experimental

2.1. Materials and reagents

All the chemicals used were of analytical reagent grade and the solvents were dried and distilled before use according to a standard procedure (Vogel, 1989). Butanedione monoxime and 3,3′-diaminobenzidine were purchased from Aldrich and were used as received.

2.2. Physical measurements (apparatus and experimental condition)

C, H and N contents were determined by Perkin Elmer CHN 2400 elemental analyzer, and IR Spectra were recorded in the range 4000 cm^{-1}–100 cm^{-1} with a Bruker IFS66V in KBr and polyethylene medium for all complexes. The molar conductance of the complexes in DMF (10^{-3} M) solution was measured at 27 ± 3 °C with an Elico model conductivity meter. UV–visible spectra were recorded in DMF with Perkin–Elmer Lambda 35 spectrophotometer in the range of 200–800 nm. ^{1}H NMR spectra were recorded on Bruker 300 Hz spectrophotometer using DMSO d_6 as solvent. Chemical shifts are reported in ppm relative to tetramethylsilane, using the solvent signal as internal reference. EPR spectra were recorded at room temperature on JEOL JESTE100 ESR spectrometer. The spectrometer was operated at X-band (8–12 GHz) with microwave power of 1 mW. The room temperature magnetic moments were measured on a PAR vibrating sample magnetometer (Model-155). The TGA and DTA curves of the complexes were recorded on NETZSCH-STA 409PC thermal analyzer in heating rate of 10 K/min with the range of 50 °C to 900 °C

2.3. Anti-microbial activity

The Schiff base ligand and its complexes were investigated for anti-bacterial and anti-fungal against *Staphylococcus aureus* and *Streptococcus pyogenes* as gram positive *bacteria* and *Escherichia coli* and *Klebsiella pneumoniae* as Gram-negative and the *fungi Fusarium oxysporum* and *Aspergillus fumigatus* by using disc-agar diffusion method. All complexes exhibit anti-bacterial and anti-fungal activities against these organisms and are found to be more effective than the free ligand.

The anti-microbial activity was carried out at Progen Lab at Salem, Tamilnadu (India). The standard disc-agar diffusion method (Gross and De vay, 1977) was followed to determine the activity of the synthesized compounds against the sensitive organism *S. aureus* and *S. pyogenes* as gram positive bacteria and *Escherichia coli* and *K. pneumoniae* as Gram-negative and the *fungi F. oxysporum* and *A. fumigatus*. The antibiotic chloramphenicol was used as standard reference in the case of Gram-negative bacteria, tetracycline was used as standard reference in case of Gram-positive bacteria and clotrimazole was used as standard anti-fungal reference. The tested compounds were dissolved in DMF (which have no inhibition activity), to get concentration of 100 μg/mL. The test was performed on medium potato dextrose agar contains infusion of 200 g potatoes, 6 g dextrose and 15 g agar (William and Stephen, 1989). Uniform size filter paper disks (three disks per compound) were impregnated by equal volume from the specific concentration of dissolved tested compounds and carefully placed on incubated agar surface. After incubation for 36 h at 27 °C in the case of bacteria and for 48 h at 24 °C in the case of fungus, inhibition of the organism which evidenced by clear zone surround each disk was measured and used to calculate mean of inhibition zones.

2.4. DNA binding studies

The DNA binding experiments were performed in Tris–HCl/NaCl buffer (50 mM Tris–HCl/1 mM NaCl buffer, pH 7.5) using DMF (dimethylformamide) solution (10%) of the metal complexes. The concentration of calf-thymus (CT) DNA was determined from the absorption intensity at 265 nm with a ε value (Li et al., 2010) of 6600 M^{-1} cm^{-1}. Absorption titration experiments were made using different concentrations of CT-DNA [40, 60, 80 μM], keeping the concentration of the complexes constant, with due correction for the absorbance of