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Antibacterial and antifungal activities of Ni (II)-potassium propan-1,3-Diol Di Xanthate

Vivek Kumar and Raj Kumar

Abstract
The complexes of Ni (II) with ligand Potassium Propan-1,3-Diol Di Xanthate (PPDDX) were investigated to determine its antifungal and antibacterial activities using the disc diffusion approach. At higher concentrations, this complex hinders the radial growth of *Kb. pneumoniae*, *E. coli*, *P.aeruginosa* and *S. aureus*. The complex is proven to be extremely toxic to three fungi i.e. *A. flavus*, *C. albicans*, and *A. niger* at different concentration. The disc diffusion approach is applied in this study to analyse the complex behaviour.

Keywords: Antibacterial activity, ligand, fungi, complexes

Introduction
Complexes make up a large number of physiologically active compounds [1] and even the most basic types of complexes have been employed as model molecules in biochemical processes in living systems. Hemoglobin, an iron complex, transfers oxygen to animal cells. Myoglobin, chlorophyll and cytochromes are other important coordination compounds in living systems. Metallic ions and complexes are important cofactors in a variety of enzymes and proteins. The elegance and variety of coordination compounds, as well as a fascinating array of concepts are required to investigate their behaviour, synthesis and attempts to understand their chemical reactions. The occurrence of coordination compounds [2] in living systems is primarily the focus of the rapidly growing subject of inorganic chemistry. In medical field [3] the multidisciplinary subject of bioinorganic chemistry is becoming increasingly important. Antifungal and antibacterial agents are essential for the treatment of a variety of infections. However, the development of drug resistance is a major challenge in the field of antimicrobial therapy. The interest in the in recent years has been increased because of the development of new antimicrobial agents from natural sources. In domain of medical inorganic chemistry, research and development of anticancer cisplatin compounds had a huge impact. The genesis of novel metal chelates for the diagnosis or treatment of disease like cancer, diabetes, and parkinson has received considerable interest since cisplatin success. But the cisplatin treatment is still constrained by its adverse consequences.

The primary building blocks for a healthy existence for humans, plants, and animals are transition metal (II) ions, which have applications in the environmental, bioscience, therapeutic, agricultural, industrial, and pharmaceutical fields [4]. Zinc, iron and copper are the three transition metals that are extensively used in our biological systems.

The impact of lead ion on the adsorption of Sulphide ions on the surface modification of azurite has been analysed by Zhang *et al.* (2023) [5]. According to Cordova *et al.* (2021) [6] there is a lot of potential in employing xanthate-modified alginate to remove Ni(II) ions so that metal-containing derivatives can be used as flame retardant additives. Removing potassium butyl xanthate from wastewater used in mineral processing wastewater using a TiO_2/g-C_3N_4 photocatalyst is done by Zhang [7]. Zhu *et al.* (2021) [8] studied modified xanthate silica as a new multi-functional addition for improving natural rubber characteristics. For tumor hypoxia imaging and assessment of chelates of 4-nitroimidazole xanthate derivative have been investigated by Ruan *et al.* (2020) [9]. Alvarez *et al.* (2021) [10] examined chemical inertness of dithiophosphinates, xanthates and hydroxamic acids, as well as their environmental consequences. The preparation and analysis of aroylethyl-(ethyl)-xanthates as polymeric material stabilisers have been studied [11]. Nanostructured [12] silver antimony sulphide powders made directly from metal xanthate precursors. Qadir [13] investigated the antimicrobial activity of Ni (II) xanthate complexes. In order to image tumor hypoxia, Zhenxiang *et al.* (2016) [14]

explored production and biological assessment of a novel oxo complexes comprising xanthate of metronidazole. The synthesis and analysis of xanthate derivatives and their Fe(II) complexes were done by Torshizi *et al.* (2017) [15]. The metabolism of xanthate and its antimycobacterial effect was explored by Yanev *et al.* (2018) [16]. Several xanthates could become carbonic anhydrase inhibitors and have antiglaucoma [17] effects. The usage of numerous other metal-containing compounds in medicine has increased recently. One such substance is the anticancer drug Cisplatin. Complexes were anticipated to have a strong inhibitory action against a variety of bacterial inoculums. These complexes are efficient antibacterial agents [18] as shown by the Schiff base's ability to chelate Co(II) and Ni(II) ions.

Chelates of hydrazone (HL) and Ni(II) were discovered to be efficient antimicrobial [19] agents due to their DNA binding and biological activity. Saiyed *et al.* (2023) [20] synthesized, characterize and biologically evaluate some metal chelates of Ni(II) containing S and N donor atoms. Maurya *et al.* (2023) [21] synthesized Ni(II) dithiocarbamate complexes and these complexes were evaluated against five human bacterial pathogens (*Staphylococcus aureus*, *Escherichia coli*, *Shigella boydii*, *Aeromonas hydrophila* and *Salmonella typhi*) by disc diffusion method. The Antifungal analyses of Ni(II) and Co(II) Schiff Base Complexes obtained from Benzaldehyde and 2,4-Dinitrophenylhydrazine were analysed by Hussaini *et al.* (2023) [22]. During investigation of the ligand and metal complexes for their antibacterial activity, it was discovered that the metal complexes were active while the ligand was inactive.

Materials and Methods

Culture Media

This study used the following media: Sabouraud Dextrose Broth (Media M034), Nutrient Agar (Media, M010), Yeast malt Broth (Media M428), Soyabean Chloramphenicol Agar (Media M1068). The composition of media is shown below.

Sabouraud Dextrose Broth (Media M034)

Special peptone	15 gram
Dextrose	25gram
D/w	1 litre
Final pH (25°C)	5.7 ± 0.2

The medium (M034) was kept at 15 lbs of pressure (121 °C) using a total weight of 40.0 grams suspended in 1000 ml of distilled water.

Nutrient Agar (Media, M010)

Peptic digest of animal tissues	10 gram
Extract of Beef	2.5 gram
Extract of Yeast	2.5 gram
Agar	20 gram
NaCl	10 gram
D/w	1 litre
Final pH (25˚C)	7.5 ± 0.2

40 grams of nutrient agar (M010) were suspended with 1000 ml of distilled water and autoclaved at 15 lbs of pressure (121 °C) for 15 minutes.

Yeast malt Broth (Media M428)

Peptic digest of animal tissue	10 gram
Extract of Yeast	5 gram
Extract of Malt	5 gram
Dextrose	20 gram
D/w	1 ltr.

The medium (M428) was kept at 15 lbs of pressure (121 °C) using a total weight of 40.0 grams suspended in 1000 ml of distilled water.

Soyabean Chloramphenicol Agar (Media M1068)

Casein enzymatic hydrolysate	10 gram
Peptic digest of animal tissues	10 gram
Chloramphenicol	0.20 gram
Dextrose	40 gram
Agar	20 gram
D/w	1 litre
Final pH (25˚C)	5.7± 0.2

The medium (M1068) was kept at 15 lbs of pressure (121°C) using a total weight of 80.20 grams suspended in 1000 ml of distilled water.

Microorganism

According to IMTech Chandigarh's instructions, it was obtained from them and stored for a long period.

Klebsiella pneumoniae	(MTC No. 108)
Aspergillus niger	(MTC No. 1342)
Pseudomonas aeruginosa	(MTC No. 1685)
Aspergillus flavus	(MTC No. 875)
Escherichia coli	(MTC No. 1689)
Staphylococcus aureus	(MTC No. 734)
Candida albicans	(MTC No. 224)

Ni(II) complex of Potassium Propan-1,3-Diol Di Xanthate (PPDDX)

Disc-diffusion method

After being cultured, the inoculum was created by transferring a loop of the pertinent organism from the stock culture into the sterile broth (at the same temperature and incubation period). A loop of sterile broth measuring 5 ml was used to transfer the microbes. According to the instructions listed below, the microbial cultures were incubated.

Bacteria	38 °C for 72 hours
Fungus	27 °C for 72 hours
Yeast	27° C for 72 hours

Sterilized base agar in a volume of 20 ml was put in Petri dishes, then permitted to equally set. 0.2 millilitres of old broth were then added to each petri dish. The different quantities of chemical samples were moistened completely on a sterile filter paper discs and then they were kept on seeded agar plates.

The compound's inhibitory action against the tested organisms was discovered after each microorganism had a suitable amount of time to incubate. The disorder made it possible to estimate the the size of the inhibition zone (mm) precisely, close to the nearest millimetre.

***In vitro* antibacterial testing**

Nutrient broths were used to test compounds for antibacterial activities after being inoculated with a loop full of culture from the slants. The broth were cultured at 36 °C for 24 hours. In a fresh 20 ml of media, 0.50 ml of a 24-hour broth cultures were seeded. The compounds were first dissolved to create a 200 mg/ml stock solution, and then first dilution was created by mixing 0.2 ml of the tested material solutions with 1.8 ml of seeded broths.

Table 1: Effect of Ni(II)-PPDDX complexes on radial growth of different bacteria.

Ni(II)-PPDDX complex	Zone of inhibition (mm)			
Concentration (ppm)	*P.aeruginosa*	*E.coli*	*Kb. pneumoniae*	*S.aureus*
500	0.0	0.0	0.0	0.0
800	10.0	11.0	10.5	9.0
1000	10.5	12.0	12.0	11.0

Table 2: Effect of Ni(II)-PPDDX complexes on radial growth of different fungi.

Ni(II)-PPDDX complex	Zone of inhibition (mm)		
Concentration (ppm)	*Aspergillus niger*	*Candida albicans*	*Aspergillus flavus*
500	13	18	16
800	17	20	20
1000	21	24	23

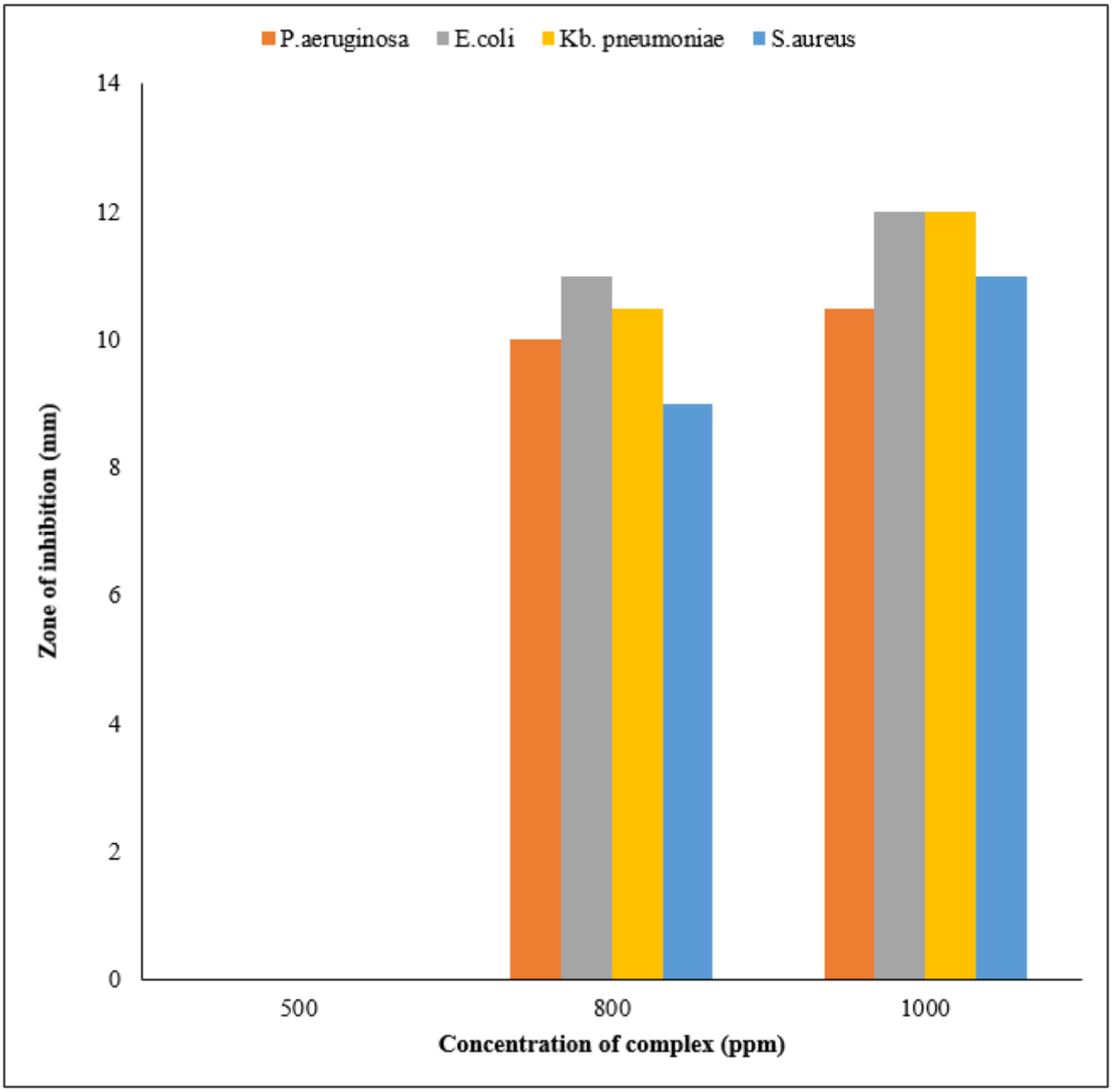

Fig 1: Effect of Ni(II)-PPDDX complexes on radial growth of different bacteria

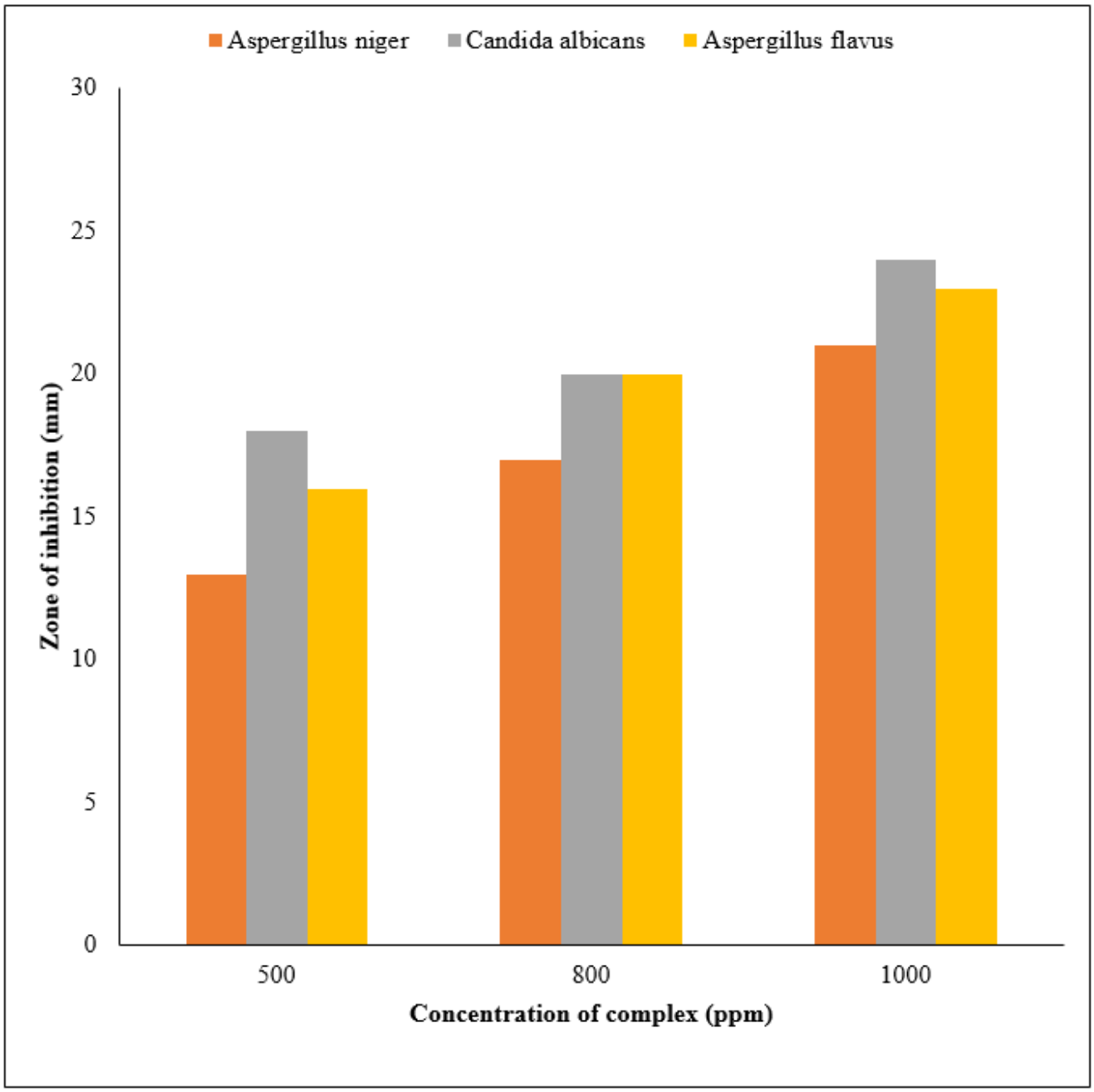

Fig 2: Effect of Ni(II)-PPDDX complexes on radial growth of different fungi

Results and Discussion

Ni(II)-PPDDX complex antibacterial activity

At varied concentrations, the Ni(II)-PPDDX complexes shows less effect on the radial growth *of Klebsiella pneumoniae, Escherichia coli, Staphylococcus aureus* and *Pseudomonas aeruginosa*. At 500 ppm, Ni(II)-PPDDX complex were ineffective against *P. aeruginosa, Kb. Pneumoniae, E. coli* and *S. aureus*. While at higher concentrations (1000 ppm), Ni(II)-PPDDX complex shows a zone of inhibition against, *P. aeruginosa* (10.5), *E. coli* (12.0), *S. aureus* (11.0) and *Kb. Pneumoniae* (12.0).

Ni(II)-PPDDX complex antifungal activity

Various harmful fungus i.e. *Candida albicans, Aspergillus niger* and *Aspergillus flavus* were found to be susceptible to the Ni(II)-PPDDX complex molecule. At 500 ppm, Ni(II)-PPDDX complex had an effect on fungus such *Aspergillus flavus* (16.0 mm), *Aspergillus niger* (13.0 mm) and *Candida albicans* (18.0 mm). All fungi were more inhibited at high concentrations (800 ppm). All test fungi's growth was suppressed by more than a 20.0 mm zone of inhibition at the highest concentration (1000 ppm). The antifungal activity of the Ni(II)-PPDDX complex was significant.

Conclusion

This study investigates the antifungal and antibacterial properties of the complexes of Ni(II)-Potassium Propan-1,3-Diol Di Xanthate (PPDDX). The antimicrobial activity of Ni(II)-PPDDX is thought to be due to its ability to interact with the cell membranes of bacteria and fungi. Ni(II)-PPDDX can disrupt the cell membrane by intercalating into the lipid bilayer. This can lead to leakage of cellular contents and cell death. This complex can also interact with proteins in the cell membrane, which can further disrupt cell function and lead to cell death.

Further, in comparison to their antibacterial properties, Ni(II)-

PPDDX complex is found to be more effective against fungi. Overall, the findings of this study suggested that the Ni(II)-PPDDX complex has promising antibacterial and antifungal activities.

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