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Physico-Chemical and Biological Properties of Lanthanide(III) Complexes with Schiff Base of 4-Formyl Antipyrine

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The synthesis of two novel Schiff base ligands *viz.* 4-[*N*-(3-methoxyphenylmethanamine)formyl]-2,3-dimethyl-1-phenyl-3-pyazolin-5-one (3MPMAFA) and 4-[*N*-(4-methoxyphenylmethanamine)formyl]-2,3-dimethyl-1-phenyl-3-pyazolin-5-one (4MPMAFA) was undertaken with the aim of synthesizing a total of 14 novel lanthanide(III) complexes. The synthesized ligands and its lanthanide(III) complexes were characterized by various analytical techniques such as elemental analysis, molecular mass, molar conductance, magnetic moment, FTIR, UV-visible and ^{13}C NMR spectral data. According to the physico-chemical data, both Schiff bases (3MPMAFA and 4MPMAFA) appear as a neutral bidentate ligand coordinated through azomethine nitrogen and carbonyl oxygen atom. With a tentative monocapped octahedral geometry and coordination number seven, all the complexes have the same general formula, $[ML_2(NO_3)_3]$ (where M = La(III), Pr(III), Nd(III), Sm(III), Gd(III), Dy(III), Yb(III) and L = 3MPMAFA/4MPMAFA). The ligands and their Ln(III) complexes were evaluated for their biological activities revealing that all the lanthanide(III) complexes exhibited superior antibacterial capabilities compared to the ligands.

Keywords: Lanthanide(III) complexes, Schiff base, Antipyrine-4-carboxaldehyde, Biological studies.

INTRODUCTION

The chemistry of the lanthanides and its compounds have considerable development due to their larger size and unique properties. Lanthanides have critical role in modern technological applications such as electric car batteries, wind turbines, medical imaging agents, *etc.* [1,2]. Due to the similarities in physical properties lanthanide exhibits multiple challenges in basic science, economics and environmental sustainability [3-7]. The lanthanide ions generally gave higher coordination numbers than transition elements [8-14]. Coordination compounds of lanthanides have an extraordinary flexibility of the coordination sphere [15]. The coordination chemistry lanthanide(III) ions are rapidly expanding due to their application in biology, material science, chemistry and applied research [16,17]. The lanthanides and its Schiff base complexes have wide range applications in medicine and photochemistry [18,19].

In several branches of chemistry, including coordination and analytical chemistry, antipyrine and its derivatives are crucial substances that are constantly being explored for potential applications and usage, irrespective of the pharmaceutical, medical and industrial areas [20]. Antipyrine has been administered as ear drops and is frequently prescribed in diseases affecting the liver's drug-metabolizing enzymes [21-23]. Antipyrine and its derivatives possess numerous fascinating biological characteristics and overall qualities. Many researchers have interest to study about coordination compounds with antipyrine and its derivatives because of the potential oxygen donor bond they can produce stable structural relevant complexes with lanthanides [24,25]. Various compounds formed from antipyrine and derivatives are used for multiple therapeutic purposes because they exhibit fascinating pharmacological properties like antimalarial, anti-inflammatory, antimicrobial, antimalarial, antitumorous activities, *etc.* [26-29].

In view of this, 14 complexes of lanthanide(III) with two novel Schiff bases ligands *viz.* 4-[*N*-(3-methoxyphenylmethanamine)formyl]-2,3-dimethyl-1-phenyl-3-pyazolin-5-one (3MPMAFA) and 4-[*N*-(4-methoxyphenyl-methanamine)formyl]-

2,3-dimethyl-1-phenyl-3-pyazolin-5-one (4MPMAFA) were synthesized and characterized. In present work, the complexes of lanthanide(III) salts with the Schiff bases derived from the condensation of 3-methoxybenzylamine/4-methoxybenzylamine with antipyrine-4-carboxaldehyde were synthesized and characterized by elemental analysis, molar conductance, infrared, UV-visible and ^{13}C NMR analysis. These lanthanide(III) compounds possibly represent a new class of potential antimicrobial agent.

EXPERIMENTAL

Using conventional methods, the nitrates of seven lanthanides [La(III), Pr(III), Nd(III), Sm(III), Gd(III), Dy(III), Yb(III)] were synthesized [30]. Using 50% (v/v) hot nitric acid, Ln_2O_3 were dissolved and residue if any, were then filtered out. The filtrate had been evaporated using a steam bath and then the nitrates of rare earths obtained were crystallized out by cooling the concentrated solutions. All of the lanthanide nitrates were stored in a vacuum desiccator equipped with phosphorus(V) oxide due to their strong hygroscopic nature. Pure antipyrine-4-carboxaldehyde ($\leq$ 99.8%), 3-methoxybenzylamine ($\leq$ 99.8%) and 4-methoxybenzylamine ($\leq$ 99.8%) were procured from Lancaster, Alfa-Aeser and Sigma-Aldrich Chemie in Germany.

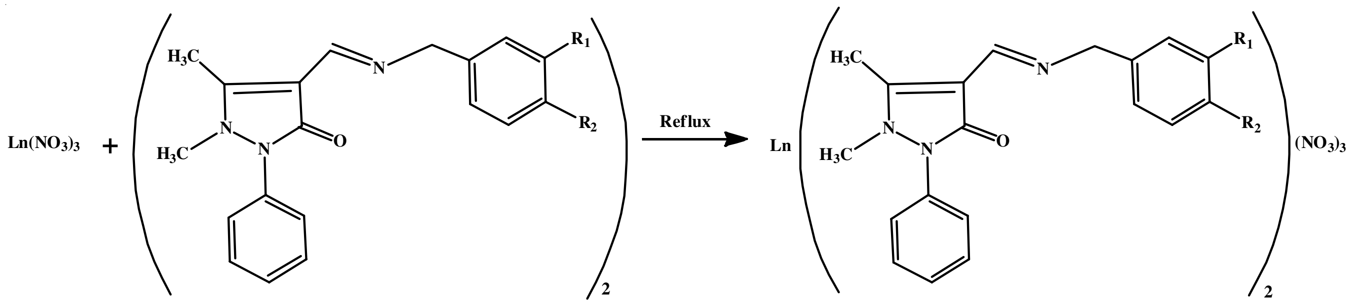
Synthesis of Schiff base ligands: Two Schiff bases of antipyrine-4-carboxaldehyde were synthesized by dissolving 1.372 g of 3-methoxybenzylamine/4-methoxybenzylamine in ethyl alcohol and added to a hot ethanolic solution containing 2.16 g of antipyrine-4-carboxaldehyde. After being refluxed for 5 to 6 h on a steam bath, the solution mixture was cooled. Little amounts of cold ethanol (5 mL) was used to filter and washed the orange-coloured precipitate. The synthesized ligands, 4-[*N*-(3-methoxyphenylmethanamine)formyl]-2,3-dimethyl-1-phenyl-3-pyazolin-5-one (3MPMAFA) and 4-[*N*-(4-methoxyphenylmethanamine)formyl]-2,3-dimethyl-1-phenyl-3-pyazolin- 5-one (4MPMAFA) have 82% yield.

Synthesis of lanthanide(III) nitrato complexes: A common procedure was used for synthesizing fourteen Ln(III) nitrato complexes of two novel Schiff bases, 3MPMAFA and 4MPMAFA. Each of the Schiff bases and methanolic solutions of lanthanide(III) nitrate were blended in a 1:2 mol ratio and refluxed for approximately 7 to 8 h on a steam bath. By evaporating the solvent, the reaction mixture was concentrated to half the volume and then cooled. In order to remove the unreacted ligand, the solid complex was washed thoroughly with benzene. The rare earth metal(III) complex was then dried in a vacuum on P_2O_5 after being recrystallized from ethanol (**Scheme-I**).

RESULTS AND DISCUSSION

The reported approach [31,32] was used to determine the elemental lanthanide, carbon, hydrogen and nitrogen contents of the complexes and the measured values concur with the theoretical values as shown in Table-1. Compared to the results found for the 1:1 electrolyte in methanol, nitrobenzene and dimethylformamide, the molar conductance measurements of the lanthanide(III) nitrato complexes are significantly lower. Since the rare metal(III) complexes seemed to be non-electrolytes based on the molar conductance values, the nitrate ions are coordinated to the lanthanide ions. At ambient temperature, the complexes of lanthanide(III) and yttrium(III) are diamagnetic, while the remaining complexes are paramagnetic, according to the magnetic moments value of these complexes. The magnetic moment value findings also revealed the non-involvement of 4*f* orbitals in the bonding of complexes since the ligand fields generated by the Schiff base ligands do not disrupt the 4*f* electrons. It is therefore proposed that bonding in the current complexes occurs *via* higher vacant orbitals, such as those in 5*d*, 6*s* and 6*p*. According to the data above, the complexes can be expressed as $[Ln(MPMAFA)_2(NO_3)_3]$ since the metal to ligand ratio appears to be 1:2.

FTIR spectral studies: Table-2 lists the key FTIR spectra assignments of the lanthanide(III) complexes and free ligands. A prominent band at 1663-1662 cm^{-1} is seen in the infrared spectrum of ligands and attributed to the stretching vibration of ν(C=O). Nevertheless, this band is moved to a lower location in the complexes, where it appears at 1633-1632 cm^{-1}. This significant reduction in shift (~30 cm^{-1}) suggests that in all the complexes, the carbonyl group is coordinated to the Ln(III) ions. The stretching mode of C=N of the azomethine group is represented by the strong band seen in the ligands at 1591 cm^{-1}. The coordination compounds have a comparable band in their infrared spectra at 1569-1568 cm^{-1}, suggesting that the azomethine group plays a role in coordination as well. In addition, the bands at 1454 and 1329 cm^{-1} (ν_5 and ν_1 vibrations) with



Schiff base ligand 3MPMAFA = R_1 = OCH_3; R_2 = H
Schiff base ligand 4MPMAFA = R_1 = H; R_2 = OCH_3
Ln = La(III), Pr(III), Nd(III), Sm(III), Gd(III), Dy(III) and Y(III)

Scheme-I: Synthesis of lanthanide(III) nitrato complexes

TABLE-1
ANALYTICAL, MOLAR CONDUCTANCE AND MAGNETIC MOMENT DATA OF SCHIFF BASE LIGANDS AND LANTHANIDE(III) NITRATO COMPLEXES

Compound	m.f. (m.w.)	Elemental analysis (%):				Molar conductance*			μ_{eff} (B.M)
		C	H	N	M	CH_3OH	DMF	$C_6H_5NO_2$	
3MPMAFA	$C_{20}H_{21}N_3O_2$ (335.4)	71.1 (71.7)	6.5 (6.3)	12.7 (12.5)	–	–	–	–	–
$[La(3MPMAFA)_2(NO_3)_3]$	$LaC_{40}H_{42}N_9O_{13}$ (995.7)	48.9 (48.2)	4.6 (4.3)	12.9 (12.7)	13.6 (13.9)	28.18	17.20	7.31	–
$[Pr(3MPMAFA)_2(NO_3)_3]$	$PrC_{40}H_{42}N_9O_{13}$ (997.7)	48.6 (48.1)	4.2 (4.3)	12.8 (12.6)	13.8 (14.1)	28.65	18.36	6.80	3.57 (3.58)
$[Nd(3MPMAFA)_2(NO_3)_3]$	$NdC_{40}H_{42}N_9O_{13}$ (1001.0)	48.4 (48.0)	4.5 (4.2)	12.7 (12.6)	14.1 (14.4)	27.47	18.23	4.25	3.60 (3.62)
$[Sm(3MPMAFA)_2(NO_3)_3]$	$SmC_{40}H_{42}N_9O_{13}$ (1007.2)	47.1 (47.7)	4.3 (4.2)	12.8 (12.5)	14.6 (14.9)	29.32	16.80	3.78	1.59 (1.62)
$[Gd(3MPMAFA)_2(NO_3)_3]$	$GdC_{40}H_{42}N_9O_{13}$ (1014.1)	47.8 (47.4)	4.1 (4.2)	12.6 (12.4)	15.3 (15.5)	20.05	17.91	4.81	7.91 (7.94)
$[Dy(3MPMAFA)_2(NO_3)_3]$	$DyC_{40}H_{42}N_9O_{13}$ (1019.3)	47.2 (47.1)	4.4 (4.2)	12.3 (12.4)	15.1 (15.9)	20.61	15.47	5.17	10.86 (10.61)
$[Y(3MPMAFA)_2(NO_3)_3]$	$YC_{40}H_{42}N_9O_{13}$ (945.7)	49.3 (50.8)	4.6 (4.5)	12.9 (13.3)	9.9 (9.4)	27.54	16.13	6.63	–
4MPMAFA	$C_{20}H_{21}N_3O_2$ (335.4)	71.3 (71.7)	6.3 (6.3)	12.6 (12.5)	–	–	–	–	–
$[La(4MPMAFA)_2(NO_3)_3]$	$LaC_{40}H_{42}N_9O_{13}$ (995.7)	48.1 (48.2)	4.2 (4.3)	12.8 (12.7)	14.1 (13.9)	28.18	17.20	7.21	–
$[Pr(4MPMAFA)_2(NO_3)_3]$	$PrC_{40}H_{42}N_9O_{13}$ (997.7)	47.9 (48.1)	4.1 (4.3)	12.5 (12.6)	14.3 (14.1)	28.56	18.36	6.80	3.57 (3.58)
$[Nd(4MPMAFA)_2(NO_3)_3]$	$NdC_{40}H_{42}N_9O_{13}$ (1001.0)	47.6 (48.0)	3.9 (4.2)	12.8 (12.6)	14.9 (14.4)	27.48	18.23	4.24	3.60 (3.62)
$[Sm(4MPMAFA)_2(NO_3)_3]$	$SmC_{40}H_{42}N_9O_{13}$ (1007.2)	47.3 (47.7)	4.4 (4.2)	12.6 (12.5)	15.2 (14.9)	29.32	16.83	3.78	1.59 (1.62)
$[Gd(4MPMAFA)_2(NO_3)_3]$	$GdC_{40}H_{42}N_9O_{13}$ (1014.1)	47.1 (47.4)	4.5 (4.2)	12.5 (12.4)	15.7 (15.5)	30.15	17.90	4.81	7.91 (7.94)
$[Dy(4MPMAFA)_2(NO_3)_3]$	$DyC_{40}H_{42}N_9O_{13}$ (1019.3)	47.7 (47.1)	4.3 (4.2)	12.1 (12.4)	15.3 (15.9)	30.39	15.47	5.17	10.86 (10.61)
$[Y(4MPMAFA)_2(NO_3)_3]$	$YC_{40}H_{42}N_9O_{13}$ (945.7)	49.6 (50.8)	4.6 (4.5)	12.8 (13.3)	9.1 (9.4)	27.54	16.13	6.63	–

Calculated values are in parentheses, *ohm^{-1} cm^2 mol^{-1}, #10^{-3} M solution.

TABLE-2
IMPORTANT IR SPECTRAL BANDS (cm^{-1}) OF SCHIFF BASE LIGANDS AND ITS LANTHANIDE(III) NITRATO COMPLEXES

Compound	ν(C=O)	ν(C=N)	$\nu_5(NO_3)$	$\nu_1(NO_3)$	ν(Ln-N)	ν(Ln-O)
3MPMAFA	1663s	1591s	–	–	–	–
$[La(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1452m	1313m	502w	410w
$[Pr(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1452m	1313m	501w	410w
$[Nd(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1452m	1313m	502w	409w
$[Sm(3MPMAFA)_2(NO_3)_3]$	1634s	1569s	1454m	1313m	501w	410w
$[Gd(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1452m	1312m	501w	410w
$Dy(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1454m	1313m	501w	409w
$[Y(3MPMAFA)_2(NO_3)_3]$	1633s	1569s	1452m	1313m	501w	409w
4MPMAFA	1662s	1591s	–	–	–	–
$[La(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$[Pr(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$[Nd(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$[Sm(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$[Gd(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$Dy(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w
$[Y(4MPMAFA)_2(NO_3)_3]$	1632s	1568s	1454m	1329m	503w	408w

s = strong, m = medium, w = weak

magnitude splitting around 140 cm^{-1} and ~125 cm^{-1}, indicating that the nitrate ions are unidentifiably coordinated to the lanthanide ions. In far-infrared spectra of the rare earth metal(III) complexes, the appearance of two additional weak bands, which are caused by the stretching vibrations of the Ln–N and Ln–O modes, respectively. The spectra of the complexes and the ligands share a large number of similar bands. These consist of two bands at 1491 and 1383 cm^{-1} are attributed due to the phenyl and pyrazolone rings' stretching vibrations respectively, as well as a vibration at 1263 cm^{-1} since the OCH_3 vibration seen in the free ligands are still present in the complexes' spectra. These common bands show that the methoxy group, phenyl ring and pyrazolone ring are not engaged in coordination. The spectra of the free ligands and the complexes also show the vibrational bands at 3062, 2944, 974, 698 and 637 cm^{-1}, which are attributed to the C–H aryl, C–H aliphatic, CH_3 rocking, C=O in-plane bending and C=O out-plane bending, respectively. These results demonstrated that the ligands 3MPMAFA and 4MPMAFA behave as neutral bidentate in all the lanthanide(III) nitrato complexes and coordination occurs through azomethine nitrogen and carbonyl oxygen.

UV-visible studies: The electronic spectral bands of the lanthanide(III) nitrato complexes and Schiff base ligands are displayed in Table-3. The absorption peaks in the electronic spectra of free ligands are located at 34680-35010 and 37840-38412 cm^{-1}, respectively and are ascribed to the n-π and n-π* transitions. These two bands are shifted at 28660-30840 cm^{-1} and 34180-35680 cm^{-1} regions, respectively, in the complexes. The lanthanide(III) complexes show a further band around 20645-20820 cm^{-1}, which is caused by transitions in the charge transfer from the ligand to the metal. In the visible region of the lanthanide(III) complexes, no absorption bands resulting from the *f-f* transition are discernible. These findings further suggest that in the ligand field of the complexes the 4*f* orbitals did not significantly participated.

The key characteristics of the ^{13}C NMR spectra of the Schiff base and its yttrium(III) and lanthanum(III) complexes are presented in Table-4. The pyrazolone ring carbonyl and azomethine carbon signals are detected at 166.3-166.7 and 150.1-148.8 cm^{-1}, respectively, in the ligands. The lanthanum(III) and yttrium(III) complex spectra exhibit a slight shift in these signals. These changes imply that the Schiff base role as a neutral bidentate ligands, forming bonds with the azomethine nitrogen and carbonyl oxygen in the complexes. Fig. 1 illustrates the proposed structure of Schiff base lanthanide(III) metal complexes.

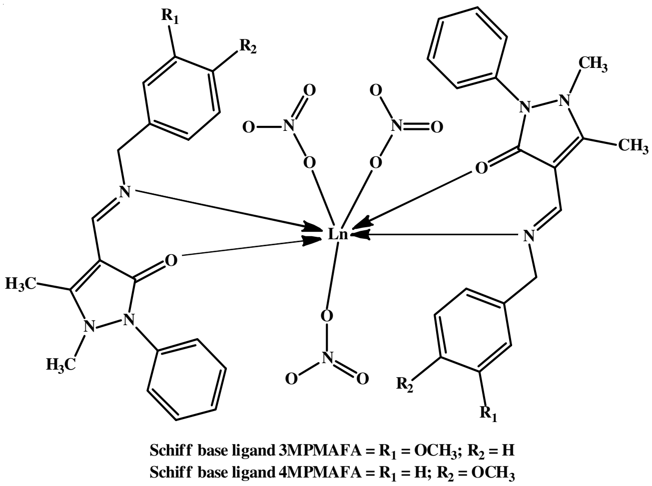


Fig. 1. Tentative structure of Schiff base lanthanide(III) nitrato complexes (Ln = La(III), Pr(III), Nd(III), Sm(III), Gd(III), Dy(III) and Y(III))

Antimicrobial studies: Lanthanide complexes with Schiff base ligands have been thoroughly inquisitive due to the structural peculiarities and diversities broad range of biological applications [33]. The *in vitro* recognition of antibacterial and

TABLE-3
ELECTRONIC SPECTRAL BANDS (cm^{-1}) OF SCHIFF BASE LIGANDS AND ITS LANTHANIDE(III) NITRATO COMPLEXES

Complex	Abs. max.	Complex	Abs. max.	Tentative assignment
3MPMAFA	34680 37840 28660	4MPMAFA	35010 38412 30840	n-π π-π* n-π
[La(3MPMAFA)$_2$(NO$_3$)$_3$]	35680 20180 29430	[La(4MPMAFA)$_2$(NO$_3$)$_3$]	34275 20763 30840	π-π* Charge transfer n-π
[Pr(3MPMAFA)$_2$(NO$_3$)$_3$]	35220 20320 29250	[Pr(4MPMAFA)$_2$(NO$_3$)$_3$]	34275 20763 30840	π-π* Charge transfer n-π
[Nd(3MPMAFA)$_2$(NO$_3$)$_3$]	34760 20670 28690	[Nd(4MPMAFA)$_2$(NO$_3$)$_3$]	34275 20760 30790	π-π* Charge transfer n-π
[Sm(3MPMAFA)$_2$(NO$_3$)$_3$]	34890 20580 28740	[Sm(4MPMAFA)$_2$(NO$_3$)$_3$]	34180 20710 30790	π-π* Charge transfer n-π
[Gd(3MPMAFA)$_2$(NO$_3$)$_3$]	34820 20290 28120	[Gd(4MPMAFA)$_2$(NO$_3$)$_3$]	34180 20649 30695	π-π* Charge transfer n-π
Dy(3MPMAFA)$_2$(NO$_3$)$_3$]	34760 20480 29420	Dy(4MPMAFA)$_2$(NO$_3$)$_3$]	34180 20645 30720	π-π* Charge transfer n-π
[Y(3MPMAFA)$_2$(NO$_3$)$_3$]	34980 19880	[Y(4MPMAFA)$_2$(NO$_3$)$_3$]	34195 20820	π-π* Charge transfer

TABLE-4
^{13}C NMR SPECTRAL DATA (δ, ppm) OF SCHIFF BASE LIGANDS AND ITS LANTHANUM(III) AND YTTRIUM(III) NITRATO COMPLEXES

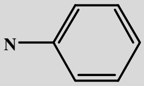
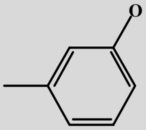
3MPMAFA	[La(3MPMAFA)$_2$(NO$_3$)$_3$]	[Y(3MPMAFA)$_2$(NO$_3$)$_3$]	4MPMAFA	[La(4MPMAFA)$_2$(NO$_3$)$_3$]	[Y(4MPMAFA)$_2$(NO$_3$)$_3$]	Assignment
165.7	168.2	168.2	166.7	169.2	169.2	Pyrazolone carbonyl carbon
148.3	142.4	142.4	148.8	142.4	142.4	Azomethine carbon
53.8	62.8	62.8	53.6	69.6	69.6	$N-CH_3$
127.8 -133.2	128.5-143.6	128.5-143.6	127.1-132.2	127.5-142.2	127.5-142.2	
114.3-159.8	114.3-161.5	114.3-161.5	166.7	114.2-161.2	114.2-161.2	

TABLE-5
ANTIBACTERIAL AND ANTIFUNGAL ACTIVITY OF SCHIFF BASE LIGANDS AND ITS Ln(III) NITRATO COMPLEXES

Compound	Bacteria			Fungal	
	Escherichia coli	*Staphylococcus aureus*	*Bacillus subtilis*	*Penicillium notatum*	*Aspergillus niger*
3MPMAFA	Slightly active	Slightly active	Slightly active	Slightly active	Slightly active
[La(3MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Moderately active	Highly active	Moderately active	Moderately active
[Pr(3MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Moderately active	Highly active	Highly active	Highly active
[Nd(3MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Highly active	Moderately active	Highly active	Highly active
[Sm(3MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Highly active	Highly active	Moderately active	Moderately active
[Gd(3MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Moderately active	Moderately active	Moderately active	Moderately active
[Dy(3MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Moderately active	Moderately active	Moderately active	Moderately active
[Y(3MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Highly active	Moderately active	Moderately active	Moderately active
4MPMAFA	Slightly active	Slightly active	Slightly active	Slightly active	Slightly active
[La(4MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Highly active	Moderately active	Moderately active	Highly active
[Pr(4MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Moderately active	Highly active	Moderately active	Moderately active
[Nd(4MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Highly active	Moderately active	Highly active	Moderately active
[Sm(4MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Moderately active	Moderately active	Moderately active	Moderately active
[Gd(4MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Moderately active	Highly active	Moderately active	Moderately active
[Dy(4MPMAFA)$_2$(NO$_3$)$_3$]	Highly active	Moderately active	Highly active	Moderately active	Moderately active
[Y(4MPMAFA)$_2$(NO$_3$)$_3$]	Moderately active	Slightly active	Moderately active	Slightly active	Moderately active

antifungal activity was performed depending on the diffusion technique [34-36]. Three bacterial species *Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis* were employed in the disc diffusion technique to test the antibacterial abilities of Schiff base ligands and their Ln(III) nitrate complexes. The antifungal activity of the ligands and complexes was further evaluated using the pathogenic fungi *Aspergillus niger* and *Penicillium notatum*. According to Table-5, which presents the data from the biological studies, all the synthesized La(III) nitratocomplexes possessed higher antibacterial activity than their respective ligands. The enhanced activity of the complexes could be attributed to the characteristics of metal ions, the metal ion adsorbed on the cell wall of the microorganisms with blocking the protein synthesis that is an important for further growth of the microorganism. In other words, metal ions are necessary for the growth-inhibitory influence.

Conclusion

Fourteen novel biologically relevant lanthanide(III) complexes were synthesized from Schiff base ligands (3MPMAFA) and (4MPMAFA). Elemental analysis, molar conductance, magnetic susceptibility, infrared and electronic spectral investigation have all been used for evaluating the coordination compounds. The complexes appear to be non-electrolytes based on their conductance and molecular mass measurement, which also indicates that all three nitrate groups are present within the coordination sphere. The spectral analyses also illustrated that the carbonyl oxygen and azomethine nitrogen in the Schiff base ligands *viz.* 3MPMAFA and 4MPMAFA, coordinated as neutral bidentate ligands. On the basis of physico-chemical data, all Ln(III) nitrato complexes have the general formula $[LnL_2(NO_3)_3]$. This implies that the compounds have a tentative monocapped octahedral geometry with coordination number seven. The antibacterial and antifungal properties of the Schiff base ligands (3MPMAFA and 4MPMAFA) and their corresponding Ln(III) nitrate complexes were evaluated against bacterial species like *E. coli*, *S. aureus* and *B. subtilis* as well as pathogenic fungi like *A. niger* and *P. notatum*. The results revealed that all the lanthanide(III)nitrato complexes exhibit high antimicrobial activities than their respective Schiff base ligands.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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