



SYNTHESIS, CHARACTERIZATION AND ANTI-MICROBIAL STUDIES OF MIXED D/F TRINUCLEAR COMPLEXES USING N_4O_3 POTENTIALLY HEPTADENTATE SCHIFF-BASE LIGAND

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ABSTRACT

A potentially heptadentate(N_4O_3) tripodal Schiff-base ligand: tris(5-Bromo-2-hydroxybenzylaminoethyl)amine (trenBrSal) have been prepared and characterized by various spectroscopic methods (Conductivity, Solubility, IR, UV-Vis Spectrometry and Mass Spectroscopy). The ligand is derived from the condensation reaction of tris(2-aminoethyl)amine (tren) and 5-bromo-2-hydroxybenzaldehyde in mole ratio 1:3. Two new mixed trimetallic d/f complexes were obtained by one-pot reaction in ethanol using stoichiometric amounts of Tren5BrSal ligand with the metal salts of Mn(II), Fe(II) and Gd(III), the reaction is then basified with triethylamine to give $[GdMn_2(Tren5BrSal)_2]$ and $[GdFe_2(Tren5BrSal)_2]$ complexes respectively. The complexes have been screened for antibacterial (*Escherichia coli* and *Streptococcus Sp.*) and antifungal (*Aspergillus niger* and *Fusarium sp.*) activity. The complexes were found to be active against *Aspergillus niger* and *E. coli*.

Key words: mixed metal, complex, manganese, gadolinium, iron.

INTRODUCTION

Polynuclear transition metal compounds are receiving increasing attention. This is unconnected to the significance of the compounds in topics such as, the nature of orbital interaction, electron transfer in redox reaction processes, and biological electron-transport (Bailey *et al.*, 1995).

The ability of Schiff base ligands to donate lone pairs of electrons into the d or f orbital of transition metal ion makes them important models in designing multinuclear complexes (Mustapha *et al.*, 2008). Among the large number of ligand frameworks studied, Schiff-base derivatives of the TREN moiety $[N(CH_2CH_2NH_2)_3]$ were found to be very effective in the design of multinuclear compounds, most especially those derived from the reaction of salicylaldehyde with TREN (Mustapha *et al.*, 2011; Mustapha *et al.*, 2008; Simon *et al.*, 2003 and Mustapha *et al.*, 2009). This plunged chemists to the search of such compounds and concentrate on studying their chemistry including their coordination mode (Kanesato *et al.*, 2001), we have reported a catalog of such compounds recently (Mustapha *et al.*, 2009 and Mustapha *et al.*, 2011), while in previous study a family of Tren5BrSal ligand have been reported to have an application as chelator of Tc-99 in nuclear medicine (Essig *et al.*, 2001).

This paper reports the synthesis of heptadentate Schiff-base ligand derived from condensation of 5-bromo-2-hydroxybenzaldehyde with tris-(2-aminoethyl)amine and its complexes of Manganese(II), Iron(II) and Gadolinium(III) metal salt, in the ratio of 2:2:1. The complexes were then screened for antimicrobial studies using bacterial and fungal strains.

MATERIALS AND METHODS

All experiments were carried out using standard apparatus, the chemicals were of analytical grade and are used without further purification. UV-Visible Analysis was carried out on JENWAY 6305 Spectrophotometer in the range 280-750nm wavelength. The Elemental analysis was carried out at the regional center for mycology and biotechnology in Al-Azhar University Cairo. Mass spectrometry was carried out on a Thermofinnigan LCQ instrument, samples were introduced via direct injection while the IR spectra were recorded in nujol mulls, potassium chloride discs or liquid films, using a Nicolet Avatar 360 FT - IR spectrometer. The Bacterial isolates are *Escherichia coli* and *Streptococcus Sp.* and that of Fungal are *Aspergillus niger* and *Fusarium sp.* The isolates were obtained and identified at the Micro biology Department, Umaru Musa Yar'adua University.

Preparation of Tren5BrSal (C₂₇H₂₇O₃N₄Br₃)

The compound was prepared as reported by Kanesato *et al.*, (2000) with some little modification. Tris(2-aminoethyl)amine (1.46g, 10mmol) was added to a solution of 5-bromosalicylaldehyde (6.03g, 30mmol) in 100ml ethanol. The resulting solution was refluxed for 40mins. A yellow powdered solid was precipitated upon cooling for 24h. The product was filtered off, washed with ethanol and air dried. The yellow powdered solid was recrystallized by dissolving in ethanol/chloroform in the ratio 7:3 and dried on water bath. Yield 77.7% (Mustapha *et al.*, 2008; Kanesato *et al.*, 2000; Kanesato *et al.*, 2001 and Richarson *et al.*, 1968), m/z; 691 Elemental analysis for [C₂₇H₂₇O₃N₄Br₃] : % Calculated C: 46.65; H: 3.91; N: 8.09, found C: 46.84; H: 3.97; N: 6.98

Synthesis of {[Fe(Tren5BrSal)]₂Gd}

Tren5BrSal (1.0g, 1.4mmol) was dissolved in ethanol (50ml) followed by addition of FeCl₃.6H₂O (0.389g, 1.4mmol) in ethanol (10ml). The mixture was stirred after which few drops of triethylamine was added. Gd(NO₃)₃.6H₂O (0.323g, 0.7mmol) in ethanol (10ml) was also added. The solution was stirred at 40°C for 1hour. The resulting solution was allowed to cool overnight. A dark brown powder was filtered off, washed with ethanol and allowed to air-dry (Kahn *et al.*, 1999). Yield 62% (Mustapha *et al.*, 2011; Mustapha *et al.*, 2008; Simon *et al.*, 2003; Mustapha *et al.*, 2009 and Kahn *et al.*, 1999), m/z; 1641 Elemental analysis for {[Fe (Tren5BrSal)]₂Gd}: % Calculated C: 39.23; H: 2.93; N: 6.78, found C: 39.30; H: 2.94; N: 6.86

Synthesis of {[Mn(Tren5BrSal)]₂Gd}

Tren5BrSal (1.0g, 1.4mmol) was dissolved in ethanol (50ml) followed by addition of MnCl₂.4H₂O (0.285g, 1.4mmol) in ethanol (10ml). The mixture was stirred after which few drops of triethylamine was added. Gd(NO₃)₃.6H₂O (0.323g, 0.7mmol) in ethanol (10ml) was also added. The solution was refluxed at 40°C for 1hour. The resulting solution was allowed to cool over night. A greenish-yellow powder was filtered off, washed with ethanol and allowed to air-dry. Yield 48.6% (Mustapha *et al.*, 2011; Mustapha *et al.*, 2008; Simon *et al.*, 2003; Mustapha *et al.*, 2009 and Kahn *et al.*, 1999), m/z; 1651 Elemental analysis for [Mn₂(Tren5BrSal)₂Gd]: % Calculated C: 39.27; H: 2.93; N: 6.79, found C: 39.53; H: 2.91; N: 6.88

RESULTS AND DISCUSSION

The {[Fe(Tren5BrSal)]₂Gd} was obtained as dark brown solid while {[Mn(Tren5BrSal)]₂Gd} was found to be of greenish-yellow color. The complexes showed certain level of stability with respect to heat as their decomposition temperatures are above 200°C. The low values of molar conductivity indicated the absence of electrolytes in the complexes as contained in the literature (Cezar and Angela, 2000). In addition, the compounds' solubility in various organic solvents indicated that the compounds are insoluble in distilled water and soluble in most organic solvents which indicates the covalent nature of the compounds as represented in table 1.

Table 1: Physico-chemical Properties of the compounds

PROPERTY	(C ₂₇ H ₂₇ O ₃ N ₄ Br ₃){[Fe(Tren5BrSal)] ₂ Gd}	{[Mn(Tren5BrSal)] ₂ Gd}	
Colour	Yellow	Dark brown	Greenish-yellow
M.P/Dec. Temp. (°C)	144.3	243.6	238.3
Conductance (S/cm)		0.223	0.095
m/z Expected	695	1715	1714
(Found)	(691)	(1641)	(1651)
ν(O-H) (cm ⁻¹)	340	---	---
ν(C=N) (cm ⁻¹)	1632	1592	1591
Ether	Insoluble	Insoluble	Insoluble
Nitrobenzene	Soluble	Soluble	Soluble
Chloroform	Soluble	Soluble	Soluble
n-hexane	Soluble	Soluble	Soluble
CCl ₄	Soluble	Soluble	Soluble
DMSO	Soluble	Soluble	Soluble
Acetone	Soluble	Soluble	Soluble
Dist. Water	Insoluble	Insoluble	Insoluble

The Electronic spectra

The spectrum of the free ligand shows a band at λ_{\max} 380nm and 420nm which is attributed to ($\pi \longrightarrow \pi^*$) and ($n \longrightarrow \pi$) transition. The intense dark brown color of $[\text{Fe}_2(\text{Tren5BrSal})_2\text{Gd}]$ complex, showed a broad band at λ_{\max} 530nm and another band with low intensity at λ_{\max} 460nm which are attributed to

charge transfer and electronic transition that took place as a result of complexation respectively. The greenish-yellow $[\text{Mn}_2(\text{Tren5BrSal})_2\text{Gd}]$ complex showed a strong absorption band at 640nm and another band at 390nm which are also attributed to charge transfer and electronic transition respectively.

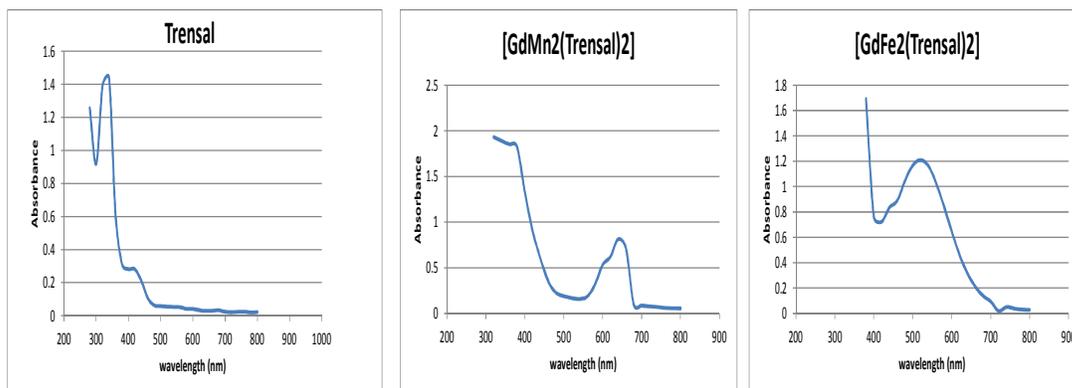
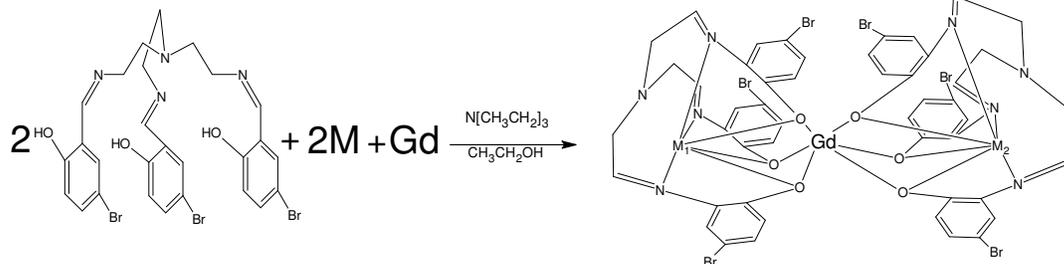


Fig 1: UV-Visible Spectrum for ligand and the mixed trimetallic complexes

Infrared Spectral studies

The spectrum of the ligand exhibits broad band at 3400 cm^{-1} which was assigned to (OH) stretching vibration while the band that appear in the range ($3063\text{-}3034\text{ cm}^{-1}$) in the spectra is attributed to the C-H aromatic stretching vibration [Kanesato *et al.*, 2001]. The vibration bands for C=N stretching appears in the range ($1632\text{-}1591\text{ cm}^{-1}$) and C=C aromatic

was observed at 1464 cm^{-1} and 1463 cm^{-1} . The observed value for (C=N) stretching shifted slightly to lower frequency 1591 , and 1592 cm^{-1} for $[\text{Mn}_2(\text{TrenSal})_2\text{Gd}]$ and $[\text{Fe}_2(\text{TrenSal})_2\text{Gd}]$ complexes respectively, due to coordination with metal. The disappearance of band for (OH) vibration in the spectra of the complexes indicates the coordination of phenolic oxygen with metal ions (Mustapha *et al.*, 2008).



Scheme 1: Preparation of the mixed metal complexes (M= Fe or Mn)

The mass spectra and elemental analysis recorded for the complexes confirm the formation of the structure depicted above. The two metal ions are sitting in the core center of the ligand which are coordinated *via* three azomethine nitrogen atoms and three phenolic oxygen atoms revealing an octahedral arrangement, while the two monometallic complexes having one residual charge, each complex is coordinated to a third Lanthanum metal through three phenolic oxygen from each monometallic complex, making the coordinating environment octahedral through the six bridging oxygen. With this arrangement,

the complex is neutral as it does not carry any charge. This type of arrangement is previously reported by Simon *et al.*, 2003, where a mixed trimetallic Ni/Ln assume the depicted structure above as it is characterized using x-ray crystallography analysis.

Antimicrobial Studies

Antibacterial activity of the ligands and metal complexes were carried out using the disc diffusion method (Bauer *et al.*, 1966). The trensal ligand and the two complexes were individually tested against two bacterial species, namely *Escherichia coli* and *Streptococcus Sp.* The isolates were obtained

and identified at the Microbiology Department, The Bacteria culture was maintained on Nutrient agar at 37°C. The Nutrient agar was inoculated with a broth culture of the respective bacterial strains and poured over previously washed and sterilized 90 mm Petri dishes. The $[\text{Mn}_2(\text{TrenSal})_2\text{Gd}]$ and $[\text{Fe}_2(\text{TrenSal})_2\text{Gd}]$ complexes, and the Trensal were dissolved in DMSO to a final concentration of 10mg/cm. The concentrations were varied to 10mg/cm using serial dilution method in order

Umaru Musa ‘Yaradua University. to measure the activity in different concentrations. A sterile Whatman filter paper (6 mm) discs were separately impregnated with each sample to be tested at 10^1 , 10^2 and 10^3 mg/cm³ and placed on the inoculated agar. The plates were incubated at 37°C for 24 hrs and the zones of inhibition were measured at the end of the incubation period as shown in Tables 2 and 3.

Table 2: The antibacterial Analysis

Antibacterial (Inhibition zone in mm)	ANALYSIS IN DIFFERENT CONCENTRATIONS		COMPOUNDS		
			(C ₂₇ H ₂₇ O ₃ N ₄ Br ₃)	{[Fe(Tren5BrSal)] ₂ Gd}	{[Mn(Tren5BrSal)] ₂ Gd}
10 ¹	10	<i>E. coli</i>	6	16	12
		<i>Strept. sp.</i>	6	21	6
	10 ¹	<i>E. coli</i>	6	10	6
		<i>Strept. sp.</i>	6	14	6
	10 ²	<i>E. coli</i>	6	6	6
		<i>Strept. sp.</i>	6	10	6

The Antifungal activity of the ligand and metal complexes was also carried out using the pour plate technique. The complexes and the ligand were tested against two fungal species, namely *Aspergillus niger* and *Fusarium sp.* The organisms were obtained at the Microbiology Department, Umaru Musa ‘Yaradua University. A potato dextrose agar was prepared and mixed

thoroughly with various concentrations of the ligand and complexes. The mixture is poured into previously washed and sterilized mini-bottles and allowed to cool at slated position. Each mixture is inoculated with a broth culture of the respective fungal strain and allowed to stand for 2-3 days and the fungal was observed and recorded as shown in Table 3.

Table 3: The antifungal Analysis

Antifungal Analysis					
10 ¹	10	<i>Fusarium sp.</i>	-	-	-
		<i>Aspergillus niger</i>	-	-	-
	10 ¹	<i>Fusarium sp.</i>	-	-	-
		<i>Aspergillus niger</i>	-	-	-
	10 ²	<i>Fusarium sp.</i>	-	-	-
		<i>Aspergillus niger</i>	-	-	-

The antimicrobial study indicates that the $[\text{Mn}_2(\text{Trensal})_2\text{Gd}]$ complex have high antibacterial activities. It was also revealed that all the complexes have no antifungal effect against all the tested.

CONCLUSION

We have successfully synthesized mixed trimetallic complexes using potentially (N₄O₃) heptadentate ligand. However, magnetic measurement was not conducted on the complexes, as such the measurement could unfold the potentiality of these complexes in the area of single molecule magnet (SMM). The $[\text{Mn}_2(\text{Tren5BrSal})_2\text{Gd}]$ complex also show a

significant antibacterial activity with *Escherichia coli* and *Streptococcus Sp.* It is also observed that the synthesized compounds have no antifungal activity against the tested organisms and could be enhanced through either attaching a functional group on the ligand or changing the coordinating site on the ligand, such as employing soft ligand like sulphur.

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