

# Synthesis, Characterization and Applications of Rh(II) and Ir(II) complexes based on 2, 6-bistetrazolate pyridine oxide ligand

Rayees Ahmad Malik, Amit Chattree, Sarita Khandka, Amita Verma and Manju Gerard

**Abstract:** The two nitrogen and one oxygen bearing tridentate ligand (H<sub>2</sub>pytzo-2, 6-bistetrazolate pyridine oxide) have been prepared by oxidation of 2, 6-bistetrazolate pyridine and then coordinated with transition metals. The complexes of [M(pyto)<sub>2</sub>](NHET<sub>3</sub>)<sub>2</sub>, (M= Rh, Ir) were synthesized in good yields (50% for Rh and 47% for Ir). UV, FT-IR, <sup>1</sup>H NMR, XRD and elemental analysis were used to determine the structure of complexes. The tetrazole groups greatly influence the absorption spectra of complexes towards the visible region (362.2nm for Rh and 357nm for Ir). Further the extended unsaturation, lone pairs and π-excessive nature of ligand promotes the fluorescence spectra upto 560nm for Rh complex and 558nm for Ir complex. The antibacterial activity results showed that *K. pneumoniae* and *S. aureus* showed maximum response followed by *E. coli* and *B. cereus*, respectively. The maximum zone of inhibition of complexes was observed at 6mg/ml concentration viz; *K. pneumoniae*, 13.0±1.73mm for iridium complex and *S. aureus*, 12.3±0.57mm for rhodium complex. Hence 2, 6-bistetrazolate pyridine oxide (H<sub>2</sub>pytzo) ligand triggers the vital applications in the complexes were useful both in biological as well as solid state devices.

**Index Terms:** Coordination Chemistry, Transition metals, tridentate ligand design, Fluorescence, Antibacterial activity.

## 1. INTRODUCTION

Variety of transition metal complexes have been synthesized which show some extent of medicinal, biological and luminescence properties [1]. The organic chromophores provides easy route for energy transfer process from ligands to metal ions. The nitrogen containing compounds tetrazoles are well known examples [2]. Tetzozolates showed excellent coordination ability due to excessive lone pair containing nitrogen atoms. The tetrazoles possess strong affinity to form complexes with

d- and f- metal ions and displayed interesting luminescence and electrochemical properties [3]. In recent times tetrazoles attracted significant attention due to their wide applications in synthetic chemistry and material science [4]. In coordination chemistry tetrazolate derivatives promotes their attention and also lifts luminescence property in metal complexes due to more coordination sites and characteristic π-excessive aromaticity [5]. In UV-visible region the tetrazolate based lanthanide complexes display colored vision which provides an

unbelievable interest in biomedical applications such as in surgical diagnosis [6]. The new terpyridine or bipyridine tetrazolate chromophores suited for development of highly luminescent lanthanide complexes. Also such tetrazolate based chromophores extends absorption window of lanthanide complexes towards the visible region upto 440nm [7]. The visible emission of lanthanides with tridentate bistetrazolate pyridine ligand show high luminescence yields in the solid state[8]. The Eu(III) tetrazole carboxylate complexes enrich the coordination chemistry also displayed characteristic green luminescence [9]. The organic chromophores found characteristic importance to design useful luminescent probes containing lanthanide ions [10]. The combination of pyridine and tetrazole ring enrich the coordination chemistry and provides more coordinating sites for metal ions. A study has reported with these ligands with Cu(II) chloride [11]. The tetrazole containing complexes were used in the medicinal chemistry showed high physiological activity and low toxicity. The tetrazolate complexes were used as substances in the field of biochemical and pharmaceutical destinations viz; complexes of Cu(II), Co(II), Ni(II) and Zn(II) [12].

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The coordination polymers showed potential applications and also with  $d^{10}$  metals, the pyridine oxide tetrazoles displayed as desirable fluorescent materials [13]. The new tridentate pyridine heteroaromatic ligands have been prepared in coordination chemistry and were used widely for several supramolecular designs, optoelectronic and magnetic materials [14]. Two bidentate pyridine tetrazolate ligands (Hpytz, Hpytzo ) have been synthesized and assimilated with  $Fe^{3+}$ ,  $Co^{2+}$ ,  $Ni^{2+}$ ,  $Zn^{2+}$  and  $Ru^{3+}$ . The influence of tetrazolate groups extended the UV-visible as well as fluorescence spectra of complexes. The fluorescence spectra of Hpytz, Hpytzo ligands was amplified upto 522nm to 540nm at 270nm excitation wavelength and for complexes viz;  $Fe^{3+}$ (522.5nm),  $Co^{2+}$ (561, 576nm),  $Ni^{2+}$ (554nm) and  $Zn^{2+}$ (521nm) [15, 16]. The complexes of heavy metals showed great role in antibacterial activity. The Ru(II) complexes with some gram(-) and gram (+) showed mild to moderate antibacterial activity

whereas with methicillin resistant *S. aureus*, *S. aureus*, *K. pneumoniae* and *E. coli* bacterial species showed better activities [17, 18]. The carbene-Rh(I) and Ru(II) complexes were found more active to reduce the growth of *S. aureus*, *E. faecalis*, *S. aureus* at minimum concentration than *Pseudomonas aeruginosa* and *E. coli* [19]. The antibacterial activity of three binuclear Rh(II) complexes found more active against *S. aureus* rather than *E. coli* [20].

## 2. Materials and Methods

### 2.1. Experimental and Characterization

All the materials used for experimental purpose were obtained from Sigma Aldrich- Merk. The chemicals required for the experiment included rhodium trichloride trihydrate, iridium trichloride, 2, 6-Pyridinedicarbonitrile, sodium azide, triethylamine acid, methanol, ethanol, dimethyl sulphoxide, acetic acid, metachloroperbenzoic, nutrient broth (sodium chloride, peptone crystalline, beef extract) and nutrient agar (peptone crystalline, beef extract, Agar agar, sodium chloride).

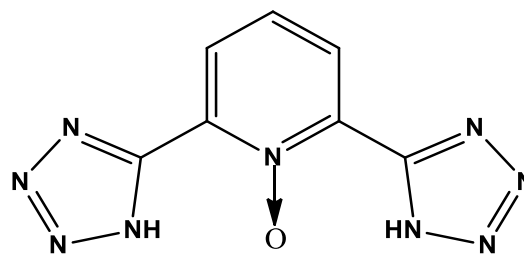
The analytical techniques were used for the characterization of the ligand and their metal complexes. The elemental analysis of samples was performed by using Elemental Analyzer-EUROVECTOR EA 3000. The absorbance maxima ( $\lambda_{\max}$ ) of samples was determined in dimethyl sulphoxide using UV-VIS-NIR spectrometer-SHIMADZU, UV-3600 plus. IR spectra of metal complexes from 4000 to 400 $\text{cm}^{-1}$  was determined using FT-IR-PerkinElmer

spectrum version 10.4.00. The chemical shift of complexes was recorded in  $\delta$  ppm in DMSO- $d_6$  using NMR-JEOLCS-400. X-ray diffraction analysis of complexes was recorded in dried powder form using X-ray Diffractometer-RIGAKU, smartlab3kw. The fluorescence spectra of ligand and their complexes was recorded using PerkinElmer Fluorescence spectrometer-LS 45 in dimethyl sulphoxide and antibacterial activity of complexes was evaluated in Department of Industrial Microbiology (MEC/LF/02) in dimethyl sulphoxide, SHUATS Allahabad.

The spectra of complexes were plotted using Origin Lab OriginPro 9.0 Software. The molecular structure analysis of complexes was performed by using ChemDraw Ultra 12.0 version software.

### 2.2. Synthesis of ligand

The tridentate two nitrogen and one oxygen donor ligand- 2, 6-bistetrazolate pyridine oxide ( $\text{H}_2\text{pytzo}$ ) were prepared according to literature procedure as shown in Fig.1 [16].



**Fig. 1.** 2, 6-bistetrazolate pyridine oxide ( $\text{H}_2\text{pytzo}$ )

### 2. 2.1. Synthesis of 2, 6- bistetrazolate pyridine oxide ( $\text{H}_2\text{pytzo}$ ): 2, 6-bistetrazolate

pyridine oxide was prepared from 2, 6-bistetrazolate pyridine (1g) by oxidation using (2.15g) metachloroperbenzoic acid (mcpba) in methanol in 250ml round bottom flask. A pure white powder of H<sub>2</sub>pytzo precipitate was obtained. Yield: 90%, m. p.: 300°C. Elemental analysis cal. (%) of C<sub>7</sub>H<sub>5</sub>N<sub>9</sub>O<sub>2</sub>: C 37.74, H 2.05, N 55.37; found: C 37.25, H 2.15, N 55.05. UV-visible: λ<sub>max</sub> -342,370nm, abs. 1.971, 2.081, Molar absorption coefficient, ε = 394.2, 416.2, M<sup>-1</sup> cm<sup>-1</sup>. FT-IR (KBr, cm<sup>-1</sup>): 3555.23 (N-H str), 2894.44 (C-H str), 1698.49 (C=C str), 1253.69 (N-O str). <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>, δ, ppm): δ 8.47-8.45 (s, 2H, Ar, J= 8.0 Hz), δ 8.27-8.25 (s, 1H, Ar, J= 7.2 Hz), δ 6.65-6.53 (s, 1H, NH, (J= 7.2 Hz)). Fluorescence: λ<sub>emission</sub> -571nm at excitation wavelength 320nm.

### 2.3. Synthesis of complexes

The complexes were synthesized from 2, 6-bistetrazolate pyridine oxide (H<sub>2</sub>pytzo) ligand in methanol as shown in scheme-I

#### 2.3.1. Synthesis of [Rh(pytzo)<sub>2</sub>](NH<sub>4</sub>)<sub>2</sub>(1):

0.462g of 2, 6-bistetrazolate pyridine oxide, 0.55ml of triethylamine (TEA) were dissolved in 20ml methanol in 250ml round bottom flask, then 0.264g RhCl<sub>3</sub>.3H<sub>2</sub>O dissolved in 2ml methanol was added. The reaction mixture was refluxed 12-16h, Black brown colored precipitate of metal complex (1) appeared. The reaction mixture was cooled, filtered, washed with chilled water and then ethanol to remove salts. Yield: 51%, m. p.: >320°C. Elemental analysis cal. (%) of C<sub>26</sub> H<sub>38</sub> N<sub>20</sub>O<sub>2</sub> Rh.H<sub>2</sub>O: C

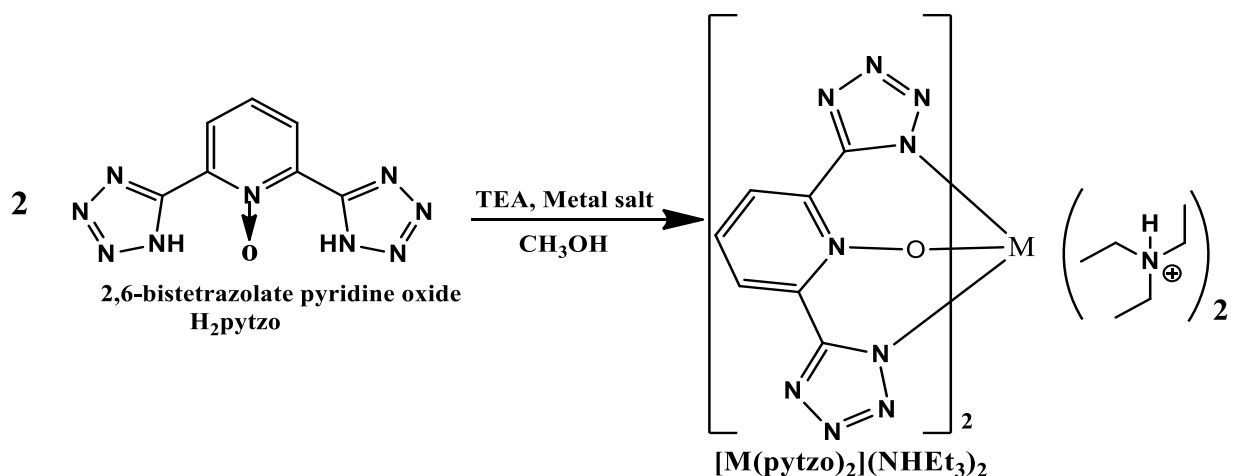
40.79, H 5.00, N 36.59; found: C 40.25, H 4.87, N 37.15. FT-IR (KBr, cm<sup>-1</sup>): 3440.52 (O-H str), 3080.86 (C-H str), 1892.43 (C=C str), 1645.88 (N=N str), 1433.47 (C=N str), 1333.47 (N-O str), 1167.36 (N-H b), 1090.08 (C-H b), 836.74 (C-C str) triethylamine, 490.08 (Rh-N str), 433.47 (Rh-O str). <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>, δ, ppm): δ 8.03- 8.01 (s, 3H, Ar, J= 7.2 Hz), δ 3.53 peak of H<sub>2</sub>O, δ 2.98-2.92 (J= 7.2 Hz) peak of CH<sub>2</sub> group of NH<sub>4</sub><sup>+</sup>, δ 2.45 (DMSO-d<sub>6</sub>) and δ 1.05- 1.01 (J= 7.2 Hz) peak of CH<sub>3</sub> group of NH<sub>4</sub><sup>+</sup> counter ion.

#### 2.3.2. Synthesis of [Ir(pytzo)<sub>2</sub>](NH<sub>4</sub>)<sub>2</sub>(2):

The complex (2) was synthesized in similar way as 1, 0.462g of 2, 6-bistetrazolate pyridine oxide (H<sub>2</sub>pytzo), 0.55ml of triethylamine (TEA) were dissolved in 20ml methanol, then 0.299g IrCl<sub>3</sub> dissolved in 2ml methanol was added. Black colored precipitate of metal complex (2) appeared. Yield: 47%, m. p.: >320°C. Elemental analysis cal. (%) of C<sub>26</sub> H<sub>38</sub> N<sub>20</sub> O<sub>2</sub>Ir.H<sub>2</sub>O: C 36.53, H 4.48, N 32.77; found: C 39.15, H 4.97, N 32.37. FT-IR (KBr, cm<sup>-1</sup>): 3325.33 (O-H str), 2945.37 (C-H str), 1649.29 (C=C str), 1558.78 (N=N str), 1450.08 (C=N str), 1405.50 (N-O str), 1113.70 (N-H b), 1019.91 (C-H b), 450.51 (Ir-N str), 405.50 (Ir-O str). <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>, δ, ppm): δ 8.03-7.98 (s, 3H, Ar, J= 6 Hz), δ 3.38 peak of H<sub>2</sub>O, δ 3.06-3.01 (J= 7.2 Hz) peak of CH<sub>2</sub> group of NH<sub>4</sub><sup>+</sup>, δ 2.45 (DMSO-d<sub>6</sub>) and δ 1.12-1.08 (J= 7.2 Hz) peak of CH<sub>3</sub> group of NH<sub>4</sub><sup>+</sup> counter ion. **2.4. Antibacterial activity**

Four pathogenic bacterial species were used to evaluate the antibacterial activity of complexes in dimethyl sulphoxide using agar well diffusion method. The bacterial species used gram(-) bacteria- *Escherichia coli*, *Klebsiella pneumoniae* and gram(+) bacteria- *Bacillus*

*cereus*, *Staphylococcus aureus* were obtained from Department of Industrial Microbiology and maintained in nutrient slant at 4°C for future studies. The four bacterial species were poured into four 250ml conical flask containing 150ml of



Scheme-I: Synthesis of  $[M(pytzo)_2](NHEt_3)_2$  complexes (M = Rh, Ir).

of broth media and marked accordingly. The bacterial cultures were incubated at 37 °C and grown upto mid log growth phase. All the bacterial cultures were maintained appropriately for further use.

The antibacterial activity of complexes was tested by using agar well diffusion method against gram (-) and gram (+) bacterial species. The prepared nutrient agar media was autoclaved along with petriplates at 121°C and 15psi. Once pouring the petriplates were allowed to solidify for half an hour and sterilized. The petriplates were poured 100µl bacterial species and then spread uniformly. The wells were prepared using tips, 10µl of required sample concentrations (2, 4, 6mg/ml) were poured into

the wells (size, 6mm) by using micropipette and marked accordingly. To observe the bacterial growth and zone of inhibition the petriplates were incubated for 24h. Subsequently the overnight incubation at 37°C different levels of ZOI were measured. The zone of inhibition of samples were compared with the standard antibiotic-amoxycillin at 6mg/ml concentration. To determine the mean of inhibition zone the measurements were performed in triplicates [21, 22].

### 3. RESULTS AND DISCUSSION

#### 3.1. Physical Properties

The ligand ( $H_2pytzo$ ) and their complexes was found more soluble in polar solvents (methanol, ethanol, dimethyl sulphoxide) but fairly soluble

in chlorinated solvents. The complexes were thermally stable possessing to low reactivity, unaffected to pH changes and possess high melting point.

### 3.2. UV-visible analysis

The absorption spectra of ligand (**H<sub>2</sub>pytzo**) and their complexes was recorded in dimethyl sulphoxide solutions as shown in fig. 2. The absorption spectra of complexes was greatly enhanced by tetrazole groups towards the longer wavelength in the visible region. The sharp

spectra was displayed by rhodium complex  $[\text{Rh}(\text{pytzo})_2](\text{NH}_4\text{Et}_3)_2$  with  $\lambda_{\text{max}}$  at 362.2nm (abs. 2.38,  $\epsilon = 476, \text{M}^{-1} \text{cm}^{-1}$ ). Similar the absorption spectra of iridium complex  $[\text{Ir}(\text{pytzo})_2](\text{NH}_4\text{Et}_3)_2$  showed  $\lambda_{\text{max}}$  357nm (abs. 1.908,  $\epsilon = 381.6, \text{M}^{-1} \text{cm}^{-1}$ ). The complexes of 2,6-bistetrazolate pyridine oxide ligand (**H<sub>2</sub>pytzo**) showed that the absorbance spectra was shifted towards the visible region. Therefore the influence of tetrazole substituents broadens the absorption window which can be very useful tool in numerous photo physical applications

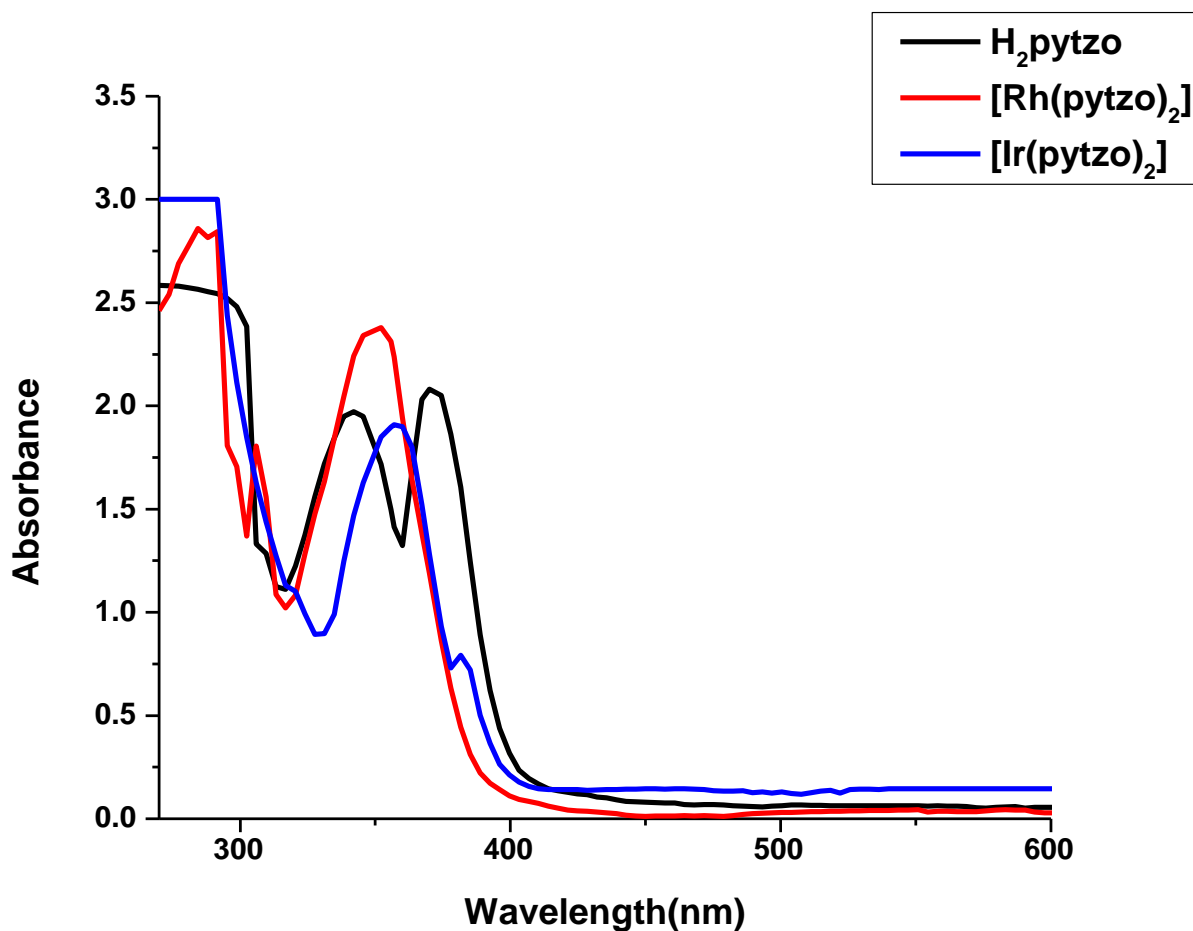


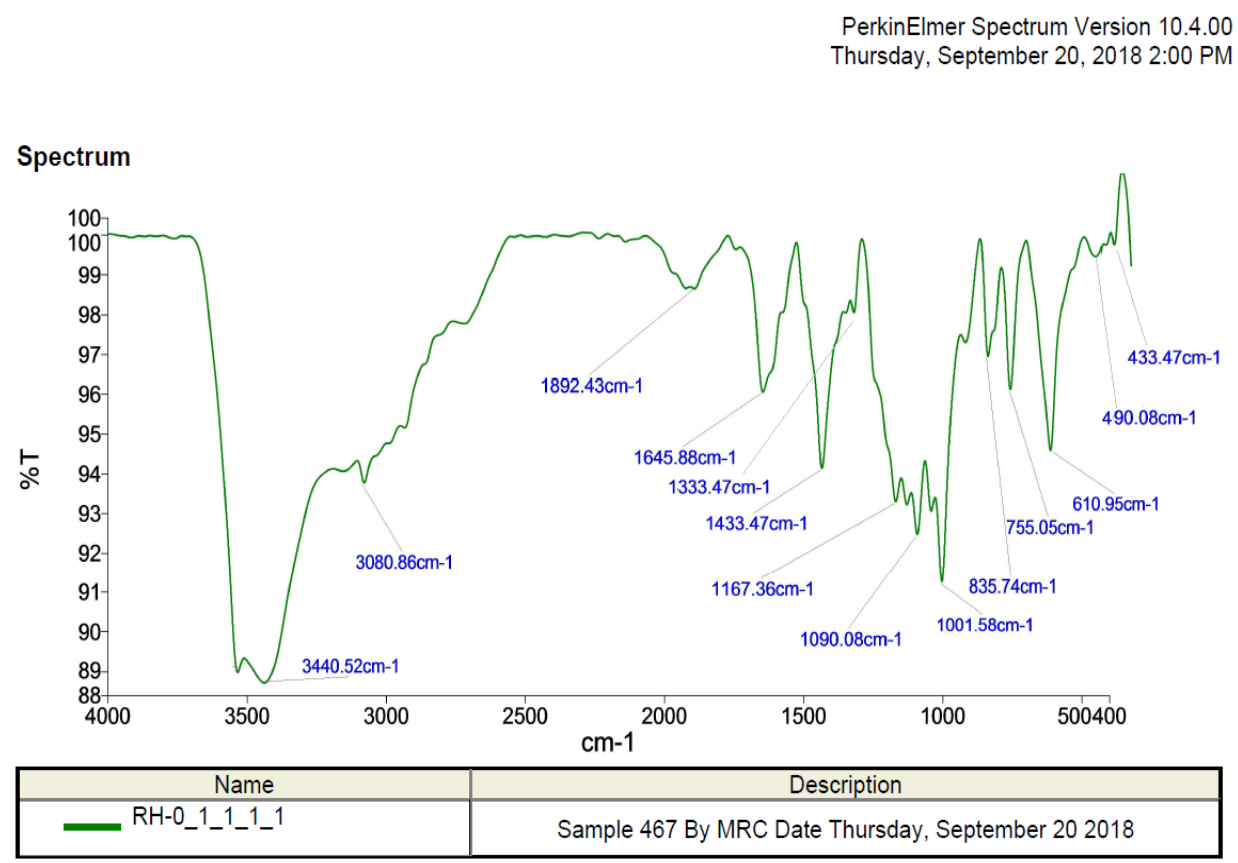
Fig. 2. UV-visible spectra of ligand (**H<sub>2</sub>pytzo**) and their complexes of Rh and Ir

### 3.3. FT-IR analysis

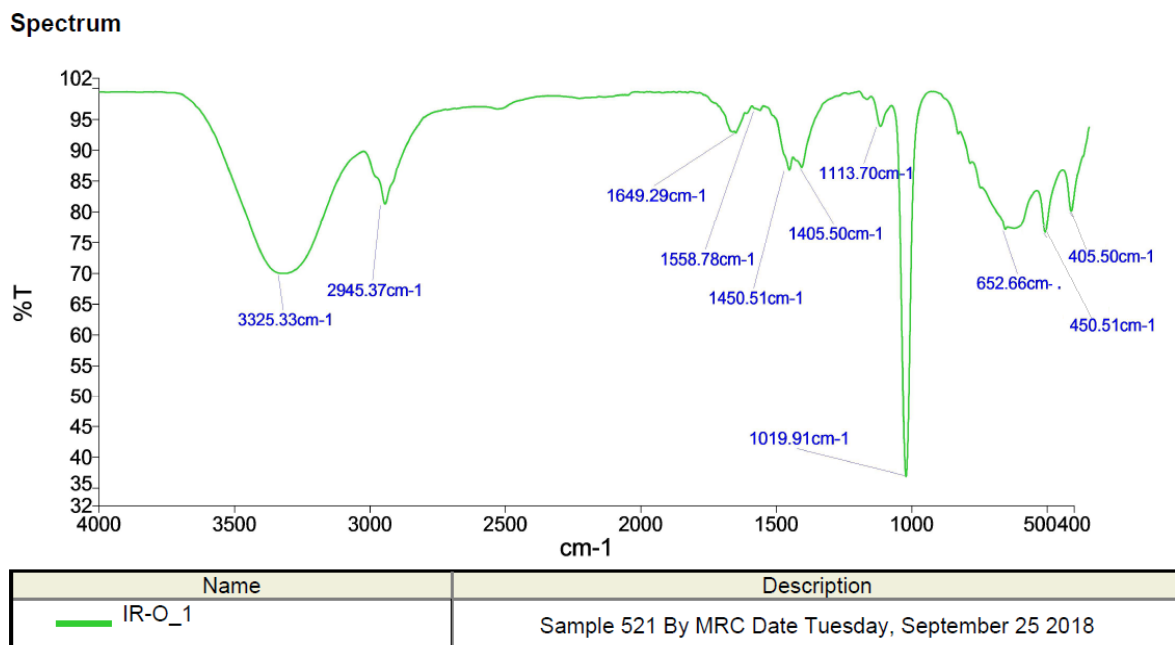
The FT-IR spectra of metal complexes of  $[M(\text{pytzo})_2](\text{NHEt}_3)_2$  ( $M = \text{Rh}, \text{Ir}$ ) as shown in fig.3(a-b). In the spectra of complexes the absence of characteristic N-H stretching frequency (as shown in free ligand) determines the coordination with the metal centre. While the presence of M-N, M-O stretching frequencies in the spectra of complexes confirms the successful formation of complexes [15].

### 3.4. $^1\text{H}$ NMR analysis

The  $^1\text{H}$  NMR spectra of complexes of  $[M(\text{pytzo})_2](\text{NHEt}_3)_2$  ( $M = \text{Rh}, \text{Ir}$ ) confirms the presence of characteristic aromatic C-H peaks of pyridine protons, however the absence of characteristic N-H peak of tetrazole groups (as seen in free ligand) reveals the coordination with metal ion and hence successful formation of complexes. The paramagnetic aromatic ring currents and the magnetic momentum produced by the metal centre predominates, thus hinders the individual splitting of the protons in the complexes as shown in fig. 4(a-b).



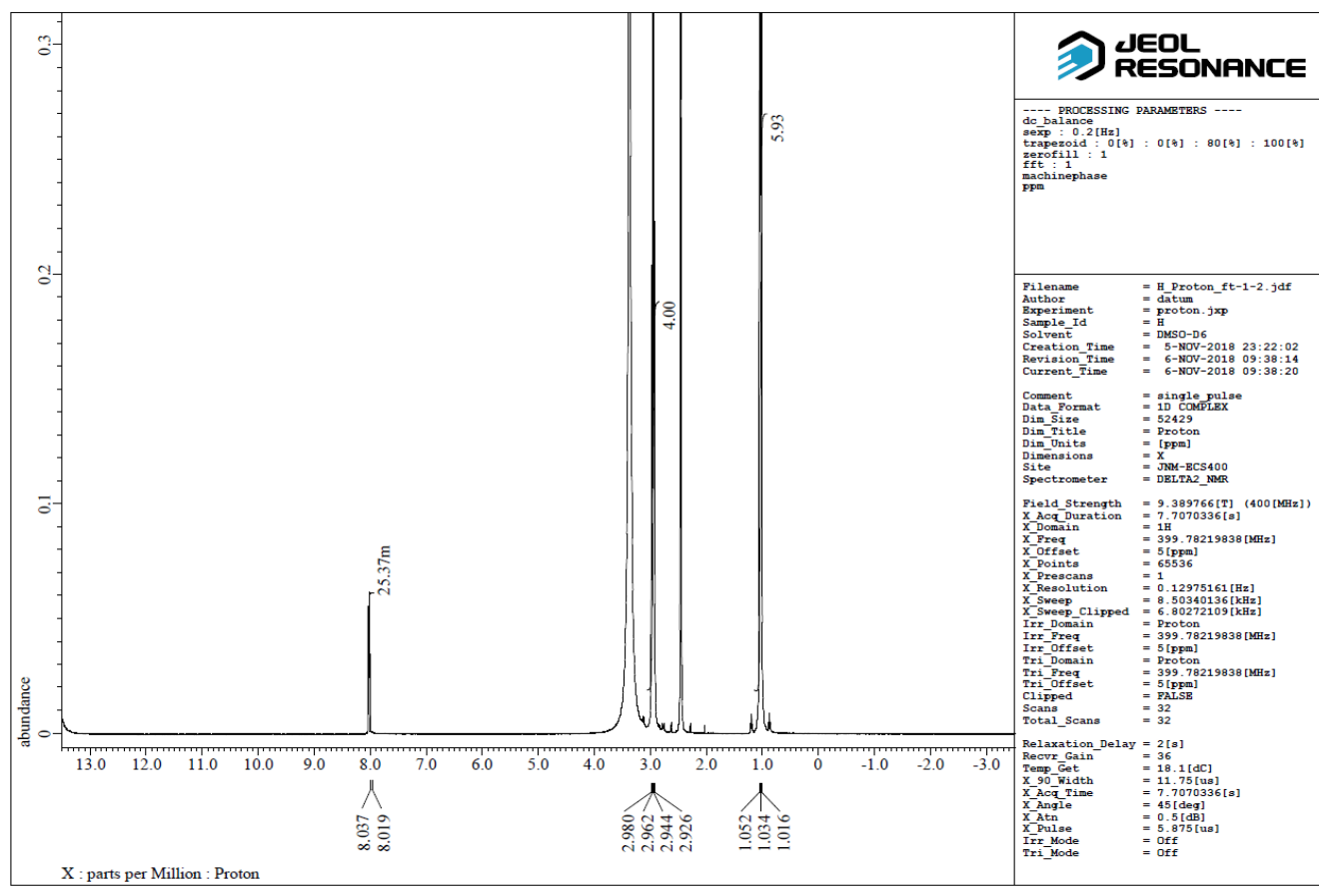
(a)

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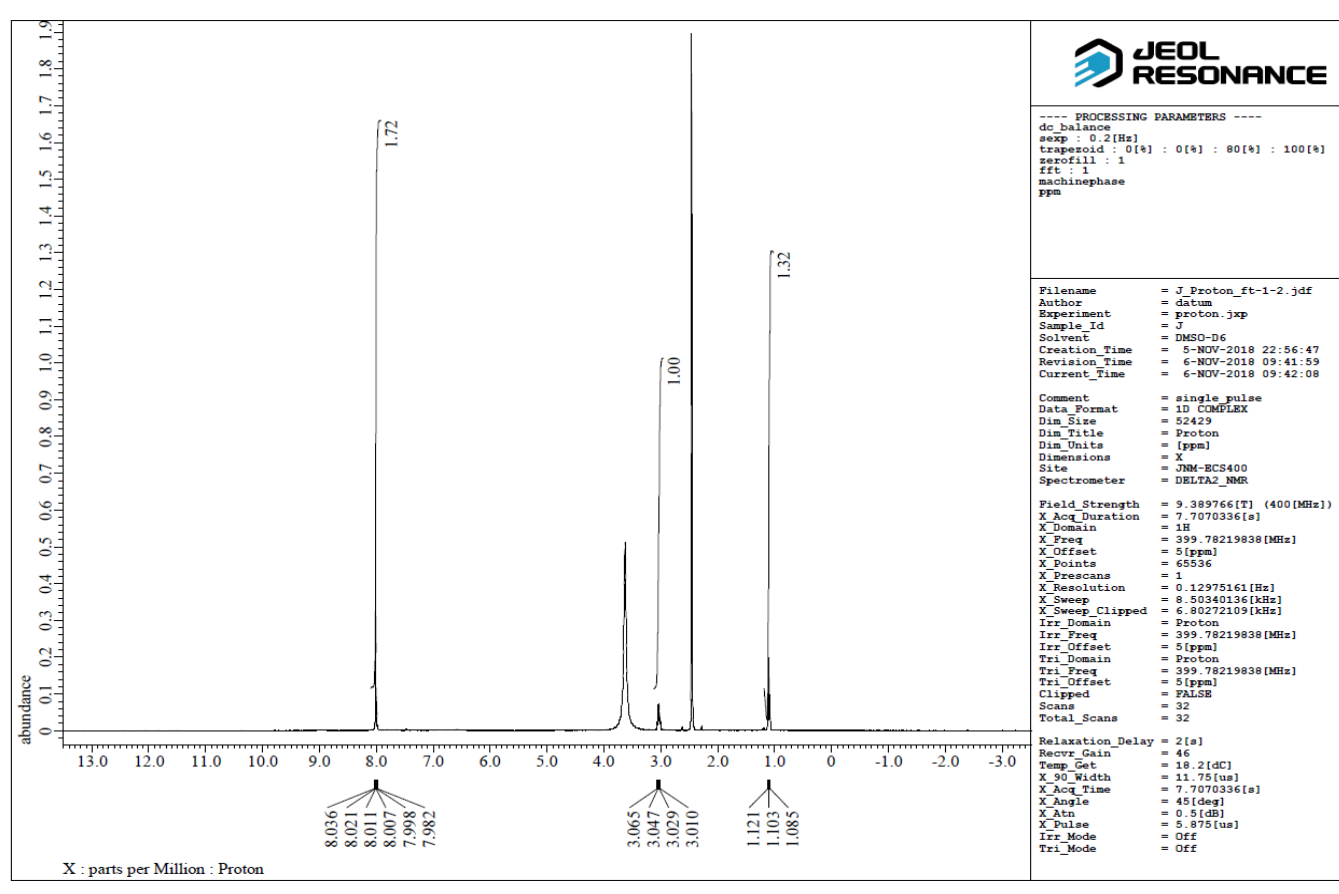
(b)

**Fig. 3.** FT-IR spectra of complexes (a)  $[\text{Rh}(\text{pytzo})_2](\text{NH}_4\text{Et}_3)_2$  (b)  $[\text{Ir}(\text{pytzo})_2](\text{NH}_4\text{Et}_3)_2$





(a)



(b)

**Fig. 4.**  $^1\text{H}$  NMR spectra of complexes of (a)  $[\text{Rh}(\text{pytzo})_2](\text{NHEt}_3)_2$  (b)  $[\text{Ir}(\text{pytzo})_2](\text{NHEt}_3)_2$

### 3.5. XRD analysis

The X-ray diffraction spectra of complexes of  $[\text{M}(\text{pytzo})_2](\text{NHEt}_3)_2$  ( $\text{M} = \text{Rh}, \text{Ir}$ ) as shown in fig.5(a-b). The diffraction studies was observed from angle ( $\theta$ ) between (5-60), wavelength ( $\lambda = 0.154\text{nm}$ ), radius ( $\text{Rh}, 0.134\text{nm}$ ,  $\text{Ir}, 0.136\text{nm}$ ) by using  $\text{Cu}\alpha$ -radiations. The Xrd spectra reveals the presence of either one 2-fold or one 4-fold symmetry axis showing following types of bravais lattices (primitive, body or end centered) - (100) (110) (111) (200) (201). The X-ray diffraction spectra of complexes confirms the presence of monoclinic space group with four nitrogen and two oxygen coordinating atoms

wraps the metal ion by two deprotonated ligands [7]. The coordinated polyhedron is described as trigonal cap like structure. On the basis of respective bond lengths and bond angles between the metal ion and coordinated ligands, the planarity of the complexes can be explained [23-25].

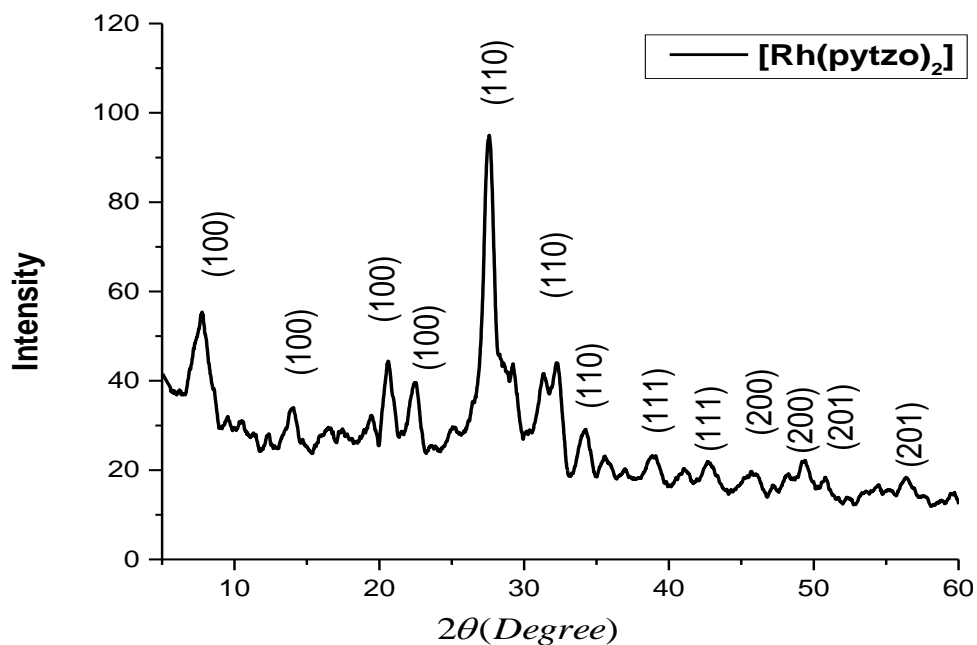
### 3.6. Molecular structure analysis

In the structure of complexes of  $[\text{M}(\text{pytzo})_2](\text{NHEt}_3)_2$ , ( $\text{M} = \text{Rh}, \text{Ir}$ ) where four anionic nitrogen atoms of tetrazole units and two oxygen atoms of pyridine rings of two deprotonated ligands coordinate with the metal

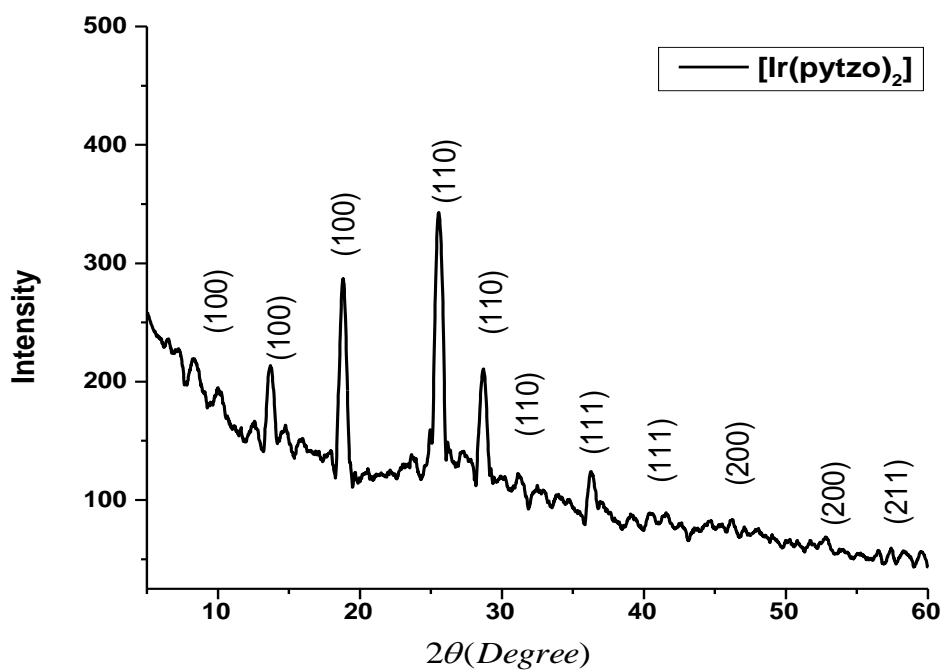
ion. The average bond distance involved by anionic tetrazole nitrogen atoms is 1.9513Å for (Rh-N), 1.9589Å for (Ir-N) and the average bond distance involved by neutral oxygen atoms is 1.9021 Å for (Rh-O), 1.9184 Å for (Ir-O). The bond angle between the metal ion and anionic tetrazolate nitrogen atoms is 115.0386° for N(13)-Rh-N(12), 120.4215° for N(13)-Ir-N(12). The angle between neutral oxygen atom, metal ion and tetrazolate nitrogen atom is 77.4332° for O(34)-Rh-N(13), 72.1903° for O(34)-Ir-N(13) whereas the angle between two neutral oxygen atoms and metal ion is 141.5369° for O(35)-Rh-O(34)), 148.8191° for O(35)-Ir-O(34). The selected bond distances and angles of metal complexes are given in the table 1 [25]. The metal ion is situated on a two-fold symmetry axis in an equatorial plane and defined by coordinating N and O atoms of ligand units. Also the ligands units centrally wrap the metal ion to provide a protective environment from surrounding interactions as shown in fig.6 (a-b) [26, 24].

### 3.7. Fluorescence analysis

The fluorescence spectra of ligand (H<sub>2</sub>pytzo-intense, 571nm, Abs, 744.8) and their complexes was recorded in dimethyl sulphoxide solution at 298k. The emission spectra of complexes of [M(pytzo)<sub>2</sub>](NHEt<sub>3</sub>)<sub>2</sub>, (M = Rh, Ir) was dominated by highly energetic ligand (H<sub>2</sub>pytzo) through ligand to metal energy transfer process (L→MCT). The fluorescent spectra of complexes displayed weak as well as intense peaks of various intensities. At 330nm excitation wavelength, the rhodium complex [Rh(pytzo)<sub>2</sub>](NHEt<sub>3</sub>)<sub>2</sub> showed characteristic transition of 560nm, Abs, 927.4. Similarly, at 335nm excitation wavelength, the iridium complex [Ir(pytzo)<sub>2</sub>](NHEt<sub>3</sub>)<sub>2</sub> displayed following transition of 558nm, Abs, 820.9 [16]. The π-electron releasing effect of 2,6-bistetrazolate pyridine oxide ligand boosts the energy transition through energy transfer process (L→MCT) in complexes which tunes sharp emission spectra in the visible region as shown in fig.7 [27].

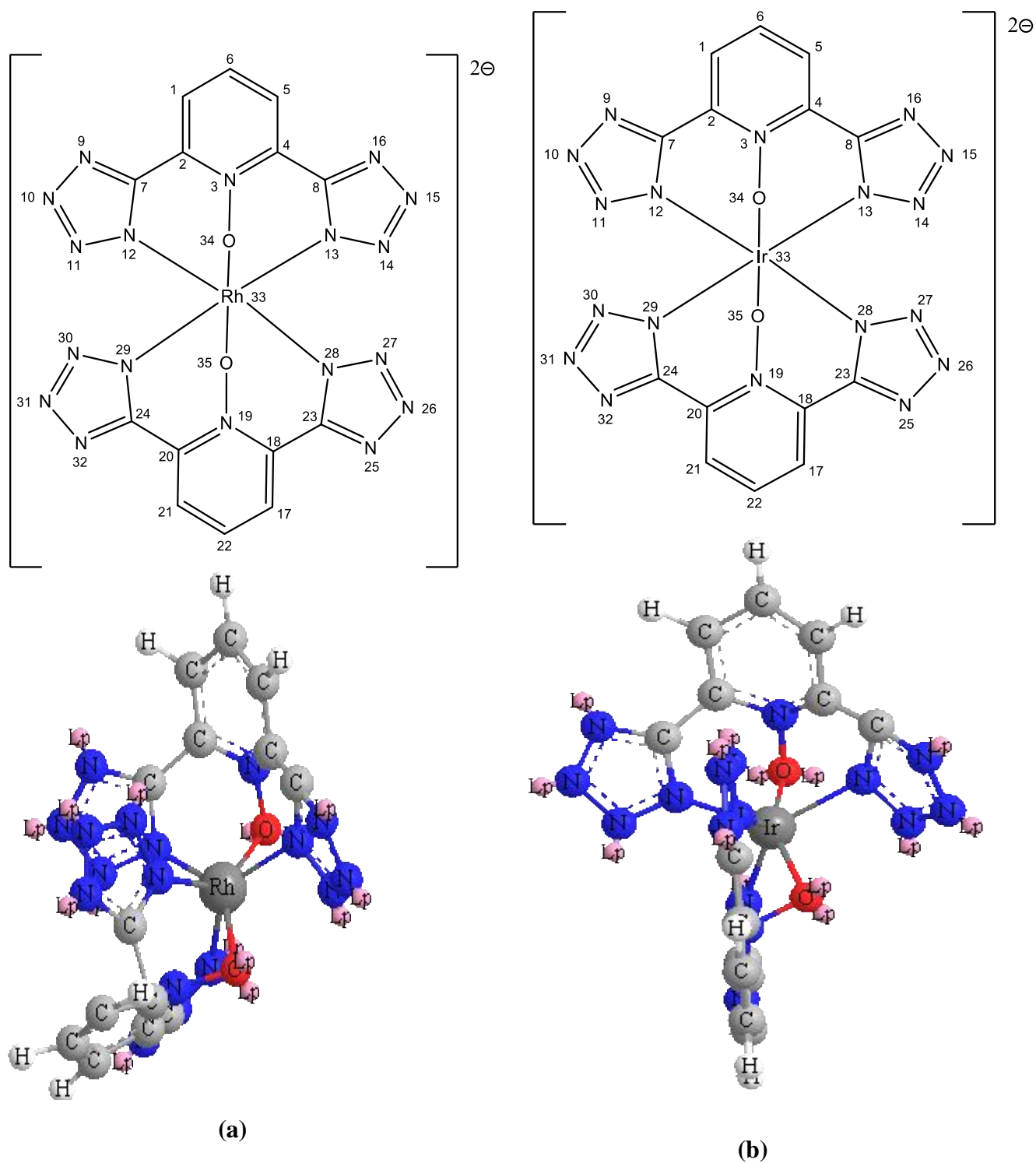


(a)



(b)

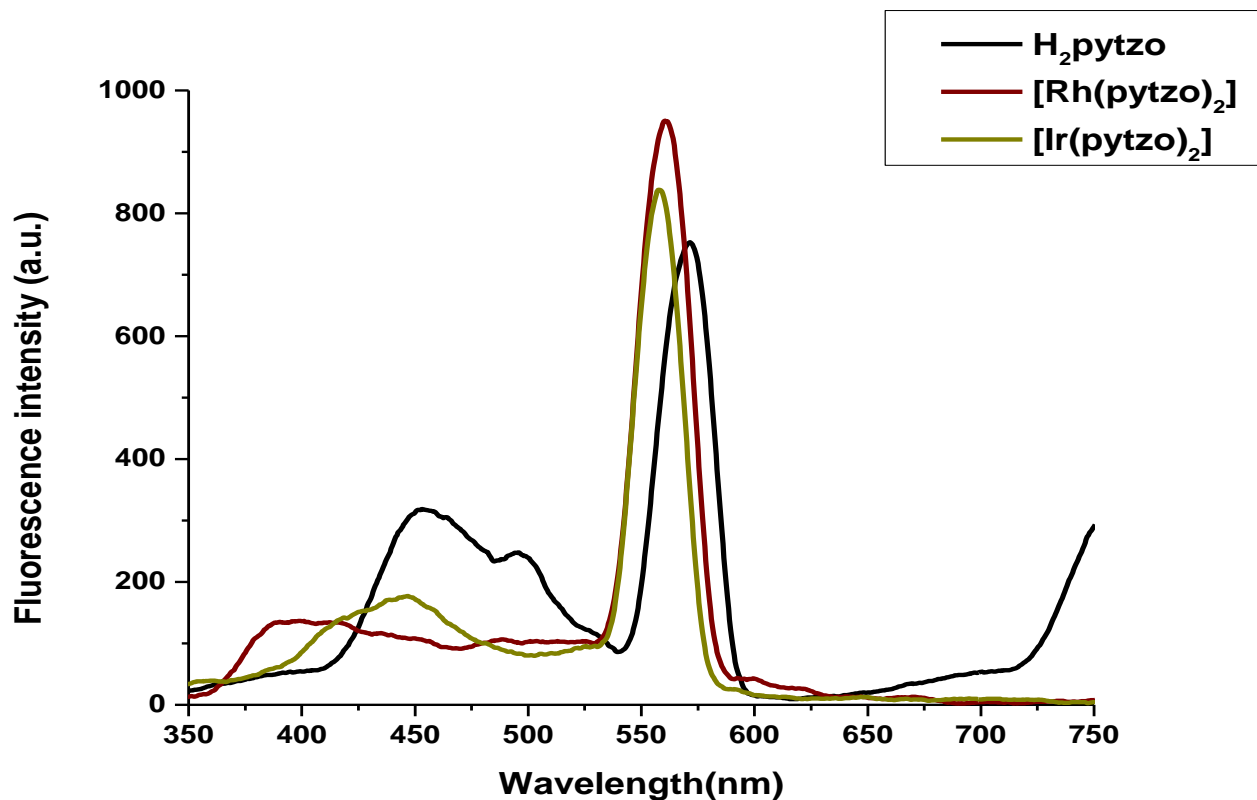
**Fig. 5.** XRD spectra of complexes of (a) [Rh(pytzo)<sub>2</sub>](NH<sub>4</sub>)<sub>2</sub> (b) [Ir(pytzo)<sub>2</sub>](NH<sub>4</sub>)<sub>2</sub>



**Fig. 6.** Molecular structure of complexes of (a)  $[\text{Rh}(\text{pytzo})_2]^{2-}$  anion (b)  $[\text{Ir}(\text{pytzo})_2]^{2-}$  anion

**Table 1.** The selected bond distances and angles of  $[\text{Rh}(\text{pytzo})_2](\text{NHEt}_3)_2$ ,  $[\text{Ir}(\text{pytzo})_2](\text{NHEt}_3)_2$  complexes

$[\text{Rh}(\text{pytzo})_2]^{2-}$	Bond Distances ( $\text{\AA}$ )	Bond Angles ( $^\circ$ )	
O(34)-Rh(33)	1.9063	N(28)-Rh-N(13)	83.3476
O(35)-Rh(33)	1.8980	N(28)-Rh-N(12)	82.1711
N(29)-Rh(33)	1.9586	N(13)-Rh-N(12)	115.0386
Rh(33)-N(28)	1.9419	Rh-O(35)-N(19)	101.2990
N(13)-Rh(33)	1.9557	O(34)-Rh-N(13)	77.4332
N(12)-Rh(33)	1.9491	O(35)-Rh-O(34)	141.5369
$[\text{Ir}(\text{pytzo})_2]^{2-}$	Bond Distances ( $\text{\AA}$ )	Bond Angles ( $^\circ$ )	
O(34)-Ir(33)	1.9195	N(28)-Ir-N(13)	83.5981
O(35)-Ir(33)	1.9174	N(28)-Ir-N(12)	83.7937
N(29)-Ir(33)	1.9607	N(13)-Ir-N(12)	120.4215
Ir(33)-N(28)	1.9425	Ir-O(35)-N(19)	100.9694
N(13)-Ir(33)	1.9672	O(34)-Ir-N(13)	72.1903
N(12)-Ir(33)	1.9655	O(35)-Ir-O(34)	148.8191

**Fig. 7.** Fluorescence spectra of ligand ( $\text{H}_2\text{pytzo}$ ) and their complexes of Rh and Ir

### 3.8. Antibacterial analysis

Medicinally important tetrazole mixed drugs have been approved as medicinal compounds. The medicinal activity shown was due to the bioequivalent behaviour of tetrazole moiety with respect to carboxylic group [28]. The tetrazoles and their derivatives exhibit wide applications both in clinical as well as pharmacological properties [29, 30]. Therefore tetrazolate compounds play vital role in the field of medicinal chemistry. Presently a serious challenges arises for medicinal practitioners due to development of antibiotic resistance. Hence to acquire the essential medicinal benefits from them, a proper attention should be given towards

the chemistry of tetrazoles. In the current study the antibacterial activity of 2, 6-bistetrazolate pyridine oxide ( $H_2pytzo$ ) complexes of  $[M(pytzo)_2](NH_4)_2$  ( $M = Rh, Ir$ ) was evaluated against four bacterial species using agar well diffusion method in dimethyl sulphoxide. For negative control, the wells were loaded with dimethyl sulphoxide alone whereas amoxycillin was used as positive control. To determine the mean of inhibition zone the measurements were performed in triplicates (excluded diameter of well, 6mm). The results obtained are given in table 2:

**Table 2.** Antibacterial activity of metal complexes of  $[Rh(pytzo)_2](NH_4)_2$ ,  $[Ir(pytzo)_2](NH_4)_2$  against four bacterial species

Concentration (mg/ml)	Zone of inhibition diameter (mm)			
	<i>Escherichia coli</i>	<i>Klebsiella pneumoniae</i>	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>
<b><math>[Rh(pytzo)_2](NH_4)_2</math></b>				
Negative Control	0	0	0	0
2	4.3±0.57	5.0±1.00	4.0±1.00	5.3±1.15
4	7.0±1.00	8.3±1.15	8.3±0.57	8.6±0.57
6	11.3±0.57	12.0±1.73	10.6±0.57	12.3±0.57
<b><math>[Ir(pytzo)_2](NH_4)_2</math></b>				
2	6.3±0.57	6.0±1.73	4.3±0.57	4.3±0.57
4	8.0±1.73	8.6±0.57	8.3±0.57	8.0±0.57
6	12.6±0.57	13.0±1.73	12.3±0.57	12.0±1.73
Positive Control	27.3±1.52	29.0±1.73	26.6±1.73	28.0±1.52

Mean±S.D, n=3.

From table 2, the antibacterial activity showed that  $[Ir(pytzo)_2](NH_4)_2$  complex was found to

be more active (*K. pneumoniae*, 13.0±1.73mm) than  $[Rh(pytzo)_2](NH_4)_2$  complex (*S. aureus*,

12.3±0.57mm). The zone of inhibition of [Ir(pyztzo)<sub>2</sub>](NH<sub>4</sub>Et<sub>3</sub>)<sub>2</sub> complex against all bacterial species viz; *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus cereus* and *Staphylococcus aureus* was 12.6±0.57, 13.0±1.73, 12.3±0.57, 12.0±1.73mm. The zone of inhibition of [Rh(pyztzo)<sub>2</sub>](NH<sub>4</sub>Et<sub>3</sub>)<sub>2</sub> complex against all bacterial species viz; *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus cereus* and *Staphylococcus aureus* was 11.3±0.57, 12.0±1.73, 10.6±0.57, 12.3±0.57mm [20, 19]. Hence, iridium complex was found more active with maximum ZOI at 6mg/ml concentration.

#### 4. CONCLUSION

The dianionic tridentate ligand have been prepared in straightforward manner and then assembled with transition metals (Rh, Ir) for coordination. UV, <sup>1</sup>HNMR in solution as well as in solid state (FT-IR, XRD) and elemental analysis were used to demonstrate the structure of complexes. The absorption window of complexes was shifted towards the visible region up to 362.2nm. The complexes showed sharp fluorescence spectra in the visible region, both were desirable features in photonic applications. The antibacterial activity reveals that iridium complex was found to more active than rhodium complex, respectively. Hence, tetrazolates presents a new coordination design and wide applications in solid state devices.

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