

INTERNATIONAL JOURNAL OF CURRENT RESEARCH IN CHEMISTRY AND PHARMACEUTICAL SCIENCES

(p-ISSN: 2348-5213; e-ISSN: 2348-5221)

www.ijcrps.com

DOI: 10.22192/ijcrps

Coden: IJCROO(USA)

Volume 8, Issue 7 - 2021

Research Article



DOI: <http://dx.doi.org/10.22192/ijcrps.2021.08.07.003>

Bis-chelated-arylazoimidazole-bipyridine-Osmium(II) Complexes : Synthesis, UV-Vis-Spectral characterization and electrochemical properties.

Prithwiraj Byabartta*

Inorganic Chemistry Research Laboratory, Department of Chemistry,
Jogesh Chandra Chaudhuri College, 30- Prince, Anwar Shah Road, Kolkata - 700033
E-mail: prbjccc@gmail.com/pribatta@gmail.com

Abstract

Reaction of *ctc*-OsBr₂(RaaiR')₂ [RaaiR' = 1-alkyl-2-(arylazo)imidazole, *p*-R-C₆H₄-N=N-C₃H₂-NN-1-R', where R = H (a), Me (b), Cl (c) and R' = Me (2), Et (3) and CH₂CH₂Ph (4)] with 2,2'-bipyridine (bpy) in presence of AgNO₃ in EtOH followed by the addition of NH₄PF₆ afforded a mixed ligand complex [Os(bpy)(RaaiR')₂](PF₆)₂. The complexes are diamagnetic (low spin d⁶, s = 0) and they show intense MLCT transition in the visible region (480 – 525 nm) in CH₃CN solution. Cyclic voltammetry of the complexes show two metal oxidation, Os (II) / Os (III) at 0.72-0.76 V and Os (III) / Os (IV) at 1.34-1.42 V and three successive ligand reductions in CH₃CN solution.

Keywords: Osmium, 2,2'-bipyridine, arylazoimidazole, electrochemistry, UV-Vis spectra.

1. Introduction

In recent years, ruthenium(II), osmium(II) and Rh(III) complexes of polypyridyl ligands have received much attention because of their rich electrochemical and photophysical properties, and their potential applications in various supramolecular structures as electronic and photomolecular devices [1–7]. Multinuclear systems of this kind can be developed by covalent linking of building blocks with spacers which, therefore, is the key component because the size, shape and electronic nature of the bridge controls

the electronic communication between the chromophores and thereby the molecule as a whole. The ligand 2,4,6-tris(2-pyridyl)-1,3,5-triazine (tptz) is a potential spacer, which functions as a bis-bidentate or simultaneously as a tridentate and a bidentate bridging unit. The ligand tptz is believed to be stable towards nucleophilic attack and has been used as an analytical reagent for various metal ions [8–11]. A few mono and dinuclear complexes of ruthenium(II) of tptz has also been reported [12–14]. However, our studies reveal that under certain experimental conditions tptz undergoes

various metal-assisted reactions [15–19]. Here, we briefly account the reactivities of tptz in presence of rhodium(III), ruthenium(II) and osmium(II), stereochemistry of the products, mechanistic aspects of hydrolysis/hydroxylation and electrochemical properties. The ligands which bind the transition metal ion in a predictable way play important role in modern coordination chemistry since they may determine the reactive sites available at a metal centre and can modulate their reactivity. Fascinating chemistry of transition metal complexes incorporating ligands that are capable of binding the metal centre in facial manner, enhanced the interest on the synthesis of new tridentate ligands that are suitable for obtaining facially coordinated complexes. [1–7] Facially capped piano-stool type of platinum metal complexes have received attention due to their interesting catalytic and biological activity. Conversion of dimethyl oxalate to ethylene glycol and hydrogenation of esters to yield alcohols in homogeneous media using such metal complexes as catalyst are notable examples. [8–21] Although several tridentate facially coordinating ligands, such as 1,4,7 tri aza cyclononane, 1,4,7 trithia cyclononane, tris pyrazolyl borate, a few scorpionate and tripodal ligands, are known to form facially capped *For correspondence platinum metal complexes, [22–34] but only a few of the above mentioned ligands have been utilized for the preparation of Os(II) complexes. [35,36] As a consequence, chemistry of Os(II) complexes with facially coordinating ligands have not been explored considerably. Coordination chemistry of osmium incorporating azo ligands has been studied with a few bidentate (N, N and N, O donors) and tridentate (C, N, O and N, N, N donors) ligands. [37–41] Whereas the coordination chemistry of osmium with tridentate N, N, O donor ligands has not been reported so far. These background information prompted us to study the coordination chemistry of osmium incorporating the N, N, O donor azo-imine ligand system, 1. Complexes with N-heterocycles exhibit rich electrochemistry and interesting optical properties. π -Deficient nitrogen donor ligands are excellent non-innocent molecules and their

complexes comprise special interest in coordination chemistry. Transition metal complexes of 2,2'-bipyridine (bpy) and related ligands have attracted much attention in this regard [1-5]. This has led to the modification of M-bpy system by choice of substituents and metal. Ligands have been modified by substituting electron withdrawing/donating groups or bulky groups to the aromatic backbone, substituting other heterocycles, appending extra donor centers to aromatic and/or heterocyclic rings etc. [5-17]. Azo conjugated transition metal complexes can provide new opportunity towards redox, magnetic and optical properties originating from the d-orbitals [6-34]. A characteristic feature of these conjugated complexes that the transition metals can interact with each other through the π -conjugated backbone to permit electronic communication. Bis-/tris-hetero chelated complexes may exhibit inter-ligand charge transferances along with some structural distortion and/or backbone deformation [17, 18-27]. Modification has been done substituting six membered pyridine ring by less π -acidic, biologically important five membered imidazole ring e.g., 2-(arylozo)imidazole [12] and by increasing the number of N in pyridine ring viz. 2-(arylozo)pyrimidine [19]. Second modification has been carried out replacing pendent aryl group by sterically more crowded, electronically more susceptible naphthyl group from 2-(arylozo)imidazole to get 2-(naphthylazo)imidazoles [35]. Pseudooctahedral $\text{OsCl}_2(\text{RaaiR}')_2$ may exist, in principle, in five isomeric forms and we have isolated two isomers. One of the isomers has been structurally confirmed by X-ray diffraction measurements [12]. According to the sequence of coordination pairs of Cl, N(imidazole) and N(azo) the isomer is *cis-trans-cis-OsCl}_2(\text{RaaiR}')_2*; the abbreviation is *cis-trans-cis (ctc)*. This molecule carries *cis-OsCl}_2* fragment which can undergo nucleophilic substitution to synthesise mixed ligand complexes. The complexes having *cis-OsBr}_2* bonds are more labile [34-80] than analogous complexes with *cis-OsCl}_2* group and *ctc-OsBr}_2(\text{RaaiR}')_2* (1) has been used in this work.

2. Experimentnal

2.1. Material

1-Alkyl-2-(arylo)imidazole was synthesized by the reported procedure [36]. *ctc*-OsBr₂(RaaR')₂ was prepared by known method [12] using [NH₄]₂[OsBr₆]. Commercially available neutral alumina from SRL was used for chromatographic separations. The purification of solvents for electrochemical and spectral work and [Bu₄N][ClO₄] were prepared as described earlier [36]. All other solvents and chemicals were of reagent grade and were used without further purification.

2.2. Physical measurements

Microanalytical data (C, H, N) were collected using a Perkin Elmer 2400 CHN elemental analyser. Solution electronic spectra were recorded on a JASCO UV-VIS-NIR V-570 spectrophotometer. Infrared (IR) spectra were obtained using a JASCO 420 spectrophotometer (using KBr disks, 4000-200 cm⁻¹). The ¹H NMR spectra in CDCl₃ were obtained on a Bruker 300 MHz FT NMR spectrometer using SiMe₄ as internal reference. Solution electrical conductivities were measured using Systronics 304 conductivity meter with solute concentration ~10⁻³ M in acetonitrile. Electrochemical work was carried out using a EG & G PARC Versastat computer controlled 250 electrochemical system. All experiments were performed under a N₂ atmosphere at 298K using a Pt-disk milli working electrode. All results were referenced to a saturated calomel electrode (SCE). Reported potentials are uncorrected for junction effect.

2.3. Preparation of complexes

2.3.1. [Os(bpy)(MeaaiMe)₂](PF₆)₂.4H₂O (2b)

To an ethanolic suspension of *ctc*-OsBr₂(MeaaiMe)₂ (0.758 g, 1.10 mmol), aqueous AgNO₃ (0.343 g, 2.02 mmol) was added and heated to reflux for 2 h. The red violet solution was filtered with G4 crucible and to the filtrate

2,2'-bipyridine (bpy) (0.195 g, 1.25 mmol) was added and again refluxed for 32 h. After reducing the volume of solution to half of its original, aqueous ammonium hexafluorophosphate was added. A brown red product was obtained which was filtered and washed with cold water followed by cold water-ethanol (1:1 v/v) mixture. The product was dried over CaCl₂ in desiccators. The dry product was dissolved in minimum volume of CH₂Cl₂, and chromatographed over neutral alumina, a red band was eluted with MeCN-C₇H₈ (1:1). On slow evaporation of the eluent, the required complex was obtained in crystalline form; yield 75%. (1.028 g). The other complexes was obtained in the similar procedure, yield 70-75%. The microanalytical data of the complex are given below.

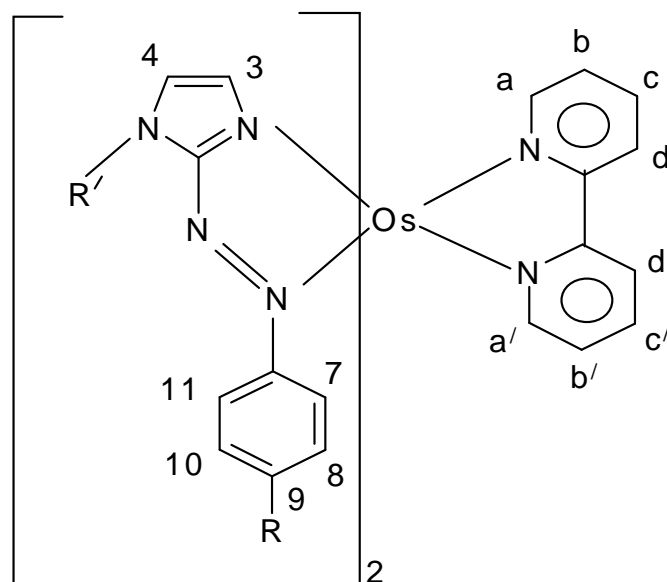
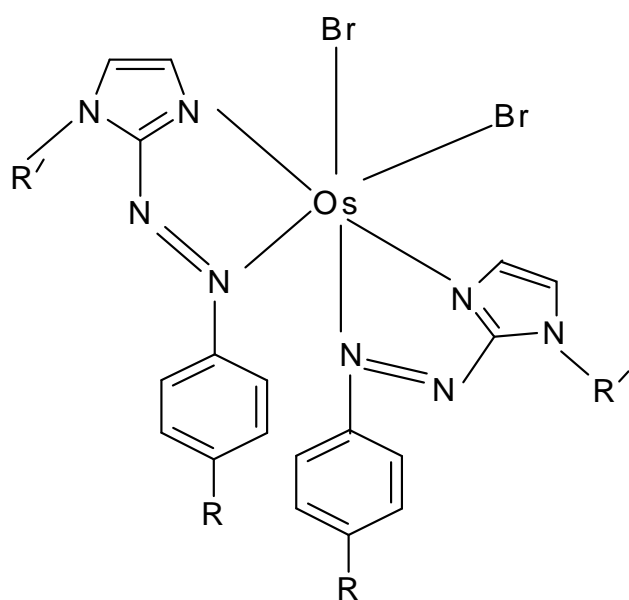
Os(bpy)(HaaiMe)₂(PF₆)₂.4H₂O (**2a**): *Anal.* Found: C, 33.29; H, 3.27; N, 12.88. Calc. for C₃₀H₃₆N₁₀OP₂F₁₂Os: C, 33.36; H, 3.36; N, 12.97. Os(bpy)(MeaaiMe)₂(PF₆)₂.4H₂O (**2b**): *Anal.* Found: C, 34.55; H, 3.57; N, 12.56. Calc. for C₃₂H₄₀N₁₀OP₂F₁₂Os: C, 34.68; H, 3.64; N, 12.64. Os(bpy)(*p*-Cl aaiMe)₂(PF₆)₂.4H₂O (**2c**): *Anal.* Found: C, 31.28; H, 2.89; N, 12.07. Calc. for C₃₀H₃₄N₁₀OP₂F₁₂Os: C, 31.33; H, 2.98; N, 12.18. Os(bpy)(HaaiEt)₂(PF₆)₂.4H₂O (**3a**): *Anal.* Found: C, 34.56; H, 3.57; N, 12.59. Calc. for C₃₂H₄₀N₁₀OP₂F₁₂Os: C, 34.68; H, 3.64; N, 12.64. Os(bpy)(MeaaiEt)₂(PF₆)₂.4H₂O (**3b**): *Anal.* Found: C, 35.84; H, 3.82; N, 12.25. Calc. for C₃₄H₄₄N₁₀OP₂F₁₂Os: C, 35.95; H, 3.90; N, 12.33. Os(bpy)(*p*-Cl aaiEt)₂(PF₆)₂.4H₂O (**3c**): *Anal.* Found: C, 32.51; H, 3.17; N, 11.78. Calc. for C₃₂H₃₈N₈OP₂F₁₂Os: C, 32.62; H, 3.25; N, 11.89. Os(bpy)(HaaiCH₂Ph)₂(PF₆)₂.4H₂O (**4a**): *Anal.* Found: C, 40.77; H, 3.48; N, 11.27. Calc. for C₄₂H₄₄N₁₀OP₂F₁₂Os: C, 40.81; H, 3.59; N, 11.33. Os(bpy)(MeaaiCH₂Ph)₂(PF₆)₂.4H₂O (**4b**): *Anal.* Found: C, 41.76; H, 3.78; N, 11.01. Calc. for C₄₄H₄₈N₁₀OP₂F₁₂Os: C, 41.81; H, 3.83; N, 11.08. Os(bpy)(*p*-Cl₂aaiCH₂Ph)₂(PF₆)₂.4H₂O (**4c**): *Anal.* Found: C, 38.56; H, 3.18; N, 10.65. Calc. for C₄₂H₄₂N₈OCl₂P₂F₁₂Os: C, 38.62; H, 3.24; N, 10.73.

3. Results and Discussion

3.1. Synthesis and formulation

1-Alkyl-2-(arylazo)imidazole (RaaiR') have been reacted with $[\text{NH}_4]_2[\text{OsBr}_6]$ in 2-methoxyethanol under reflux for 8h. Two isomers, blue-violet ($\geq 45\%$) and red-violet ($< 10\%$), are separated by chromatography. The blue-violet compound belongs to *cis-trans-cis* and red-violet compound is *cis-cis-cis* (*ccc*)- $\text{OsBr}_2(\text{RaaiR}')_2$. The structure of blue-violet complex in case of $\text{OsCl}_2(\text{MeaiMe})_2$ has been established as *cis-trans-cis* by X-ray diffraction study [12]. The abbreviation *cis-trans-cis* (*ctc*) stands for the sequence of coordination of X (X = Cl or Br),

N(imidazole) and N(azo) in the complex. The Ag^+ -assisted Br-substitution from *ctc*- $\text{OsBr}_2(\text{RaaiR}')_2$ in ethanol followed by filtration in sintered crucible (G4) has synthesized $[\text{Os}(\text{EtOH})_2(\text{RaaiR}')_2]^{2+}$. Upon treatment of solvated species with 2,2'-bipyridine (bpy) under refluxing condition and addition of $[\text{NH}_4][\text{PF}_6]$ has isolated $[\text{Os}(\text{bpy})(\text{RaaiR}')_2](\text{PF}_6)_2$. (2-4). The composition of the compounds was formulated by elemental analyses. The diamagnetic (t_{2g}^6) complexes are 1:2 electrolyte in MeCN ($230\text{-}280 \Omega^{-1}\text{cm}^{-1}\text{mol}^{-1}$) and show characteristic absorptions of coordinated RaaiR' and bpy in their spectroscopic data.



ctc- $\text{OsBr}_2(\text{RaaiR}')_2$ (**1**) R= H (**a**), ^{12}OMe (**b**), NO_2 (**c**)
 $\text{R}' = ^{12}\text{Me}$ (**2**), $^{12}\text{CH}_2$ $^{13}\text{CH}_3$ (**3**), $^{12}\text{CH}_2$ ($^{14-18}$) Ph (**4**)

Scheme-1

Spectra and bonding mode

I.R. and U.V. - visible spectra

The infrared spectra of the complexes have been compared with the spectra of $\text{OsCl}_2(\text{RaaiR}')_2$ [12] and $[\text{Ru}(\text{bpy})(\text{RaaiR}')_2](\text{ClO}_4)_2 \cdot \text{H}_2\text{O}$ [37] and the

following conclusions have been drawn. The $\nu(\text{N}=\text{N})$, $\nu(\text{C}=\text{N})$, and $\nu(\text{H}_2\text{O})$ appear at $1370\text{-}1390$, $1590\text{-}1610$ and $3420\text{-}3460 \text{ cm}^{-1}$ respectively. The hexafluorophosphate (PF_6) exhibits strong stretching at $840\text{-}850 \text{ cm}^{-1}$.

UV-Vis absorption spectra of the complexes in acetonitrile solution are dominated by high intense spin-allowed ligand-centred (LC) transitions in the UV region (< 400 nm). An

intense band in the visible region (480-525 nm) is assigned to metal-to ligand charge transfer (MLCT) transition (Table 1).

Table-1: Uv-Vis spectra of the complexes, $[\text{Os}(\text{bpy})(\text{RaaiR}')_2](\text{PF}_6)_2$ in MECN

Complexes $[\text{Os}(\text{bpy})(\text{RaaiR}')_2](\text{PF}_6)_2$	UV-Vis spectra $\lambda_{\text{max}}(\text{nm})(10^{-3}\epsilon/\text{dm}^3\text{mol}^{-1}\text{cm}^{-1})$
$[\text{Os}(\text{bpy})(\text{HaaiMe})_2](\text{PF}_6)_2$	480 (3.35), 376 (6.84), 314 (8.65), 284 (8.76)
$[\text{Os}(\text{bpy})(\text{MeaaiEt})_2](\text{PF}_6)_2$	506 (7.70), 388 (16.21), 280 (16.80), 242 (16.88)
$[\text{Os}(\text{bpy})(\text{ClaaiBz})_2](\text{PF}_6)_2$	496 (9.20), 378 (17.84), 278 (15.98), 244 (19.71)
$[\text{Os}(\text{bpy})(\text{HaaiMe})_2](\text{PF}_6)_2$	498 (8.64), 374 (19.68), 282 (14.69), 238 (15.79)
$[\text{Os}(\text{bpy})(\text{MeaaiEt})_2](\text{PF}_6)_2$	500 (7.58), 369 (14.17), 284 (21.22),
$[\text{Os}(\text{bpy})(\text{CLaaiBz})_2](\text{PF}_6)_2$	504 (9.77), 380 (20.76), 278 (14.97), 250 (16.07)
$[\text{Os}(\text{bpy})(\text{HaaiMe})_2](\text{PF}_6)_2$	510 (7.49), 368 (13.54), 284 (22.96), 234 (23.49)
$[\text{Os}(\text{bpy})(\text{MeaaiEt})_2](\text{PF}_6)_2$	512 (12.06), 392 (25.56), 278 (21.55), 242 (19.28)
$[\text{Os}(\text{bpy})(\text{ClaaiBz})_2](\text{PF}_6)_2$	522 (10.48), 400 (18.94), 280 (25.86), 240 (14.36)

Redox behavior

The results obtained from electrochemical experiments are collected in Table 2. Cyclic voltammograms positive to SCE as reference are assigned to metal centered oxidations, Os (III) / Os (II) and Os(IV)/Os(III). The redox data of precursor complex $ctc\text{-OsBr}_2(\text{RaaiR}')_2$ and $[\text{Ru}(\text{bpy})(\text{RaaiR}')_2]^{2+}$ are very useful for the assignment of redox data. It is inferred that osmium (II) is oxidized at potentials considerably less positive than Ru (II). Both Os (IV) / Os (III) and Os (III) / Os (II) redox couples are quasireversible in nature as it is evident from $\Delta E_p \geq 70$ mV. The redox responses at negative to SCE are ligand centred reductions. The current height measurements by DPV experiment and on comparing with couple of $\text{Fe}(\text{CN})_6^{4-} / \text{Fe}(\text{CN})_6^{3-}$ exhibit one electron oxidation of each couple. Upon coordination of ligand to Os (II) the reduction potentials are shifted to less negative

values than that of free ligand positions. There are three quasireversible reduction couples ($\Delta E_p \geq 100$ mV) in the potential range 0.0 to -1.6 V. They are due to gradual addition of electron into two azoimine chelates from RaaiR' and one diimine chelate ring in the complex. The bpy is reduced at lowest redox potential which is in support with lower π -acidity of bpy than azoimidazoles [2-8, 30, 34, 36, 37].

Conclusion

A novel series of tris chelated osmium complexes were synthesised from its dichloro precursor. This follows a heteroleptic tris-chelated complex formation pathway. The complexes show intense MLCT transition in the visible region (480 – 525 nm). Cyclic voltammetry of the complexes show two metal oxidation and three successive ligand reductions.

Table-2: Cyclic voltammetric data of the complexes, [Os(bpy)(RaaiR')₂](PF₆)₂ in MECN

Complexes [Os(bpy)(RaaiR') ₂](PF ₆) ₂	E ^{M1} (ΔE _p)	E ^{M2} mV)	-E ^{L1}	-E ^{L2}	-E ^{L3}
[Os(bpy)(HaaiMe) ₂](PF ₆) ₂	0.73(100)	1.38(140)	0.64(120)	1.24(100)	1.62(170)
[Os(bpy)(MeaaiEt) ₂](PF ₆) ₂	0.73(120)	1.37(160)	0.71(140)	1.26(130)	1.65(160)
[Os(bpy)(ClaaiBz) ₂](PF ₆) ₂	0.74(75)	1.41(190)	0.5(130)	1.22(70)	1.60(160)
[Os(bpy)(HaaiMe) ₂](PF ₆) ₂	0.72(90)	1.37(150)	0.69(110)	1.25(120)	1.63(170)
[Os(bpy)(MeaaiEt) ₂](PF ₆) ₂	0.71(75)	1.34(150)	0.76(140)	1.30(140)	1.67(170)
[Os(bpy)(ClaaiBz) ₂](PF ₆) ₂	0.74(107)	1.38(140)	0.60(130)	1.23(160)	1.61(150)
[Os(bpy)(HaaiMe) ₂](PF ₆) ₂	0.74(90)	1.39(120)	0.55(120)	1.20(140)	1.56(140)
[Os(bpy)(MeaaiEt) ₂](PF ₆) ₂	0.72(90)	1.38(160)	0.67(140)	1.22(150)	1.58(160)
[Os(bpy)(aaiBz) ₂](PF ₆) ₂	0.73(90)	1.38(170)	0.64(130)	1.22(160)	1.64(170)

(Platinum disk milli electrode, SCE reference, [Bu₄N][ClO₄])

Supporting electrolyte, scan rate 50mV s⁻¹, E^{M1}=E_{1/2}(Os^{III/II}), E^{M2}=E_{1/2}(Os^{IV/III}), E^{L1}=E_{1/2}(azo/azo⁻), E^{L2}=E_{1/2}(azo⁻/azo²⁻), E^{L3}=E_{1/2}(bpy/bpy⁻) ΔE_p = (E_{pc} - E_{pa})/2, E_{pc} and E_{pa} are cathodic and anodic pick potentials)

Acknowledgment

Department of Science and Technology (DST) is thanked for financial support. (FAST TRACK Grand No. SERB/F/4888/2012-13 Dated 30.11.2012).


References

- [1] P.Tomarik, Z. Ratajewicz, The Chemistry of Heterocyclic Compounds: part 6, Pyridine Metal Complexes, Wiley, New York, vol.14. (1985).
- [2] S. Campagna, S. Serroni, F. Puloriero, C. Di Pietro, in Electron Transfer in Chemistry (Ed.), V. Balzani, VCH-Wiley, Weinheim, vol. 5. (2001).
- [3] K. Kalyansudaram, Photochemistry of Polypyridine and Porphyrine complexes, Academic press, London, (1992).
- [4] C. Kaes, A. Katz, M.W. Hosseini, Chem. Rev. **100** 3553, (2000).
- [5] E.C. Constable, Coord. Chem. Rev. **93** 205 (1989).
- [6] B.K. Ghosh, A. Chakravorty, Coord. Chem. Rev. **95** 239 (1989).
- [7] A.H. Velders, H. Keojiman, A.L. Spek, J.G. Haasnoot, D. de Vos, J. Reedijk, Inorg. Chem. **39** 2966. (2000).
- [8] A. Saha, P. Majumdar, S.-M. Peng, S. Goswami, Eur. J. Inorg. Chem. 2631 (2000) and references therein.
- [9] K. Pramanik, M. Shivakumar, P. Ghosh, A. Chakravorty, Inorg. Chem. **39** 195 (2000).
- [10] J. Fees, H.D. Hausen, W. Kaim, Z. Naturforsch. 50B 15 (1995).
- [11] B.K. Santra, G.K. Lahiri, Proc. Indian Acad. Sci (Chem Sci.). **111** 509 (1999) and references therein.
- [12] P. Byabartta, S. Pal, T.K. Misra, C. Sinha, F.-L. Liao, K. Panneerselvam, T.-H. Lu, J. Coord. Chem. **55** 479 (2002) and reference therein.
- [13] T. Akasaka, J. Otsuki, K. Araki, Chem. Eur. J. **130** (2002).
- [14] F. Wu, C.M. Chamchoumis, R. P. Thummel, Inorg. Chem. **39** 584 (2000).
- [15] M. Menon, A. Pramanik, A. Chakravorty, Inorg. Chem. **34** 3310 (1995).
- [16] J. Otsuki, K. Sato, M. Tsujino, N. Okuda, K. Araki, M. Seno, Chem. Lett. 847 (1996).
- [17] P.K. Santra, P. Byabartta, S. Chattopadhyay, L.R. Falvello, C. Sinha, Eur. J. Inorg. Chem. 1124 (2002)

- [18] M.D. Ward, J.A. Mc Cleverty, J. Chem. Soc., Dalton Trans. 275 (2002).
- [19] P.K. Santra, D. Das, T.K. Misra, R. Ray, C. Sinha, S.-M. Peng, Polyhedron **18** 1909 (1999).
- [20] H. Hartmann, T. Scheiring, J. Fiedler, W. Kaim, J. Organomet. Chem. **604** 267 (2000).
- [21] Y.-K. Au, K.-K. Cheung, W.-T. Wong, Inorg. Chim. Acta. **238** 193 (1995).
- [22] H. Bock, R. Dienelt, H. Schodel, T.T.H. Van, Struet. Chem. **9** 279 (1998).
- [23] W. Kaim, S. Kohlmann, J. Jordanov, D. Fenske, Z. Anorg. Alleg. Chem. 598/599 217 (1991).
- [24] W.Y. Wong, S.-H. Cheung, S.-M. Lee, S.Y. Leung, J. Organomet. Chem. **596** 36 (2000).
- [25] K. Pramanik, M. Shivakumar, P. Ghosh, A. Chakravorty, Inorg. Chem. **39** 195 (2000).
- [26] M. Shivakumar, K. Pramanik, I. Bhattacharya, A. Chakravorty, Inorg. Chem. **39** 4332 (2000).
- [27] M. Shivakumar, K. Pramanik, P. Ghosh, A. Chakravorty, Chem. Chommun. 2103 (1998).
- [28] M. Shivakumar, K. Pramanik, P. Ghosh, A. Chakravorty, Inorg. Chem. **37** 5968 (1998).
- [29] B. Mondal, H. Paul, V.G. Puranik, G.K. Lahiri, J. Chem. Soc., Dalton Trans. 481(2001).
- [30] A.K. Deb, S. Goswami, Polyhedron **12** 1419 (1993).
- [31] A.K. Deb, P.C. Paul, S. Goswami, J. Chem. Soc., Dalton Trans. 2051 (1988).
- [32] P. Byabartta, Sk. Jasimuddin, B.K. Ghosh, C. Sinha, A.M.Z. Slawin, J.D. Woollins, New J. Chem. **26** 1415 (2002).
- [33] S. Goswami, A.R. Chakravorty, A. Chakravorty, J. Chem. Soc., Chem. Commun. 1288 (1982).
- [34] P.K. Santra, R. Roy, C. Sinha, Proc. Indian Acad. Sci. (Chem. Sci.). **112** 523 (2000).
- [35] J. Dinda, P.K. Santra, C. Sinha, L. R. Falvello, J. Organomet. Chem. **629**, 28 (2001).
- [36] T.K. Misra, D. Das, C. sinha, P.K. Ghosh, C.K. Pal, Inorg. Chem. **37** 1672 (1998).
- [37] S. Pal, T.K. Misra, C. Sinha, A.M.Z. Slawin, J.D. Woollins, Polyhedron **19** 1925 (2000).
- [38]. Pouchert J (Ed.), *The Aldrich library of NMR spectra*, Vol 2, Aldrich Chem Co Inc, USA 1993;
- [39]. Cotton F A and Wilkinson G, *Advanced Inorganic Chemistry*, 5th Edn, Wiley-Interscience, 1994, p-338;
- [40]. Greenwood N N and Earnshaw A, *Chemistry of the Elements*, Pergamon Press, 1989 Oxford, p-519.
- [4]. Grover N, Gupta N and Thorp H H, 1932 *J. Am. Chem. Soc.*, **114**, 3390 .
- [42]. van Vliet. P M, Haasnoot J G and Reedijk J, 1994, *Inorg. Chem.* **33**, 1934.
- [43]. Misra T K, Das D, Sinha C, Ghosh P K and Pal C K, 1998 *Inorg. Chem.*, **37**, 1672.
- [44]. Misra T K. and Sinha C, 1999 *Indian J. Chem.*, **38A**, 346; 1999. *Transition Met. Chem.*, **24**
- [45] Pal S, Misra T K, Sinha C, Slawin A M Z and Woollins J D, 2000 *Polyhedron*, **19**, 1925.
- [46] Byabartta. P, Dinda J, Santra P K, Sinha C, Panneerselvam K, Liao F -L and Lu T -H, 2001 *J. Chem. Soc., Dalton Trans.*, 2825.
- [47] Byabartta P, Jasimuddin Sk, Ghosh B K, Sinha C, Slawin A M Z and Woollins J D, 2002 *New J. Chem.*, **26**, 1415.
- [48] Byabartta P, Santra P K, Misra T K, Sinha C and Kennard C H L, 2001 *Polyhedron*, **20**, 905. Byabartta P, Pal S, Misra T K, Sinha C, Liao F -L, Panneerselvam K and Lu T -H, 2002 *J. Coord. Chem.*, **55(5)**, 479.
- [49] Byabartta P, Pal S, Ray U and Sinha C, 2001, *Indian J. Chem.*, **40A**, 896.
- [50] Constable E C, 1989 *Coord. Chem. Rev.*, **93**, 205; Bottomley F and Mukaida M, 1982 *J. Chem. Soc., Dalton Trans.*, 1933.

- [51] Das D, *Ph. D. Thesis*, 1998, Burdwan University, Burdwan;
- [52] Saha A, Das C, Goswami S and Peng S –M, 2001, *Indian J. Chem*, **40A**, 198;
- [53] Seal A and Ray S, 1984 *Acta Crystallogr., Sect C : Struct. Commun.*, **C40**, 929.
- [54] Mondal B, Paul H, Puranik V G and Lahiri G K, 2001 *J. Chem. Soc., Dalton Trans.*, 481.
- [55] Samanta R, Munsu P, Santra B K and Lahiri G K, 1999 *Polyhedron* **19**, 995;
- [56] Srinivasan B R, Sarkar S, 1990 *Inorg. Chem.*, **29**, 3898.
- [57] Chattopadhyay S, Ghosh K, Pattanayak S and Chakravorty A, 2001 *J. Chem. Soc., Dalton Trans.*, 1259.
- [58] Ghosh P, Pramanik A, Bag N, Lahiri G K and Chakravorty A, 1993 *J. Organomet. Chem.*, **454**, 237.
- [59] Perrin D D and Armarego W L F 1988 Purification of laboratory chemicals, 3rd edn.; New York: Pergamon .
- [60] Parshall G W 1974 *Inorg. Synth.* XV 48 and 50 .
- [61] Trost B M and Verhoeven T R 1982 in: Comprehensive organometallic chemistry, E Abel, F G A Stone, G Wilkinson (Eds.), vol. 8; Oxford: Pergamon Press .
- [62] Pattanayak P, Pratihar J L, Patra D, Burrows A, Mohan M and Chattopadhyay S 2007 *Eur. J. Inorg. Chem.* 4263 .
- [63] Parr R G and Yang W 1989 Density functional theory of atoms and molecules; Oxford: Oxford University Press .
- [64] Frisch M J, Trucks G W, Schlegel H B, Scuseria G E, Robb M A, Cheeseman Jr J R, Montgomery J A, Vreven T, Kudin K N, Burant J C, Millam J M, Iyengar S S, Tomasi J, Barone V, Mennucci B, Cossi M, Scalmani G, Rega N, Petersson G A, Nakatsuji H, Hada M, Ehara M, Toyota K, Fukuda R, Hasegawa J, Ishida M, Nakajima T, Honda Y, Kitao O, Nakai H, Klene M, Li X, Knox J E, Hratchian H P, Cross J B, ammi R, Pomelli C, Ochterski J W, Ayala P Y, Morokuma K, Voth G A, Salvador P, Dannenberg J J, Zakrzewski V G, Dapprich S, Daniels A D, Strain M C, Farkas O, Malick D K, Rabuck A D, Raghavachari K, Foresman J B, Ortiz J V, Cui Q, Baboul A G, Clifford S, Cioslowski J, 62 Poulami Pattanayak et al. Stefanov B B, Liu G, Liashenko A, Piskorz P, Komaromi I, Martin R L, Fox D J, Keith T, Al-Laham A, Peng C Y, Nanayakkara A, Challacombe M, Gill P M W, Johnson B, Chen W, Wong M W, Gonzalez C, Pople J A, Gaussian 03W, revision C.02 Gaussian, Inc., Wallingford, CT, 2004.16 .
- [65] Becke A D 1993 *J. Chem. Phys.* 98 5648 . Lee C, Yang W and Parr R G 1998 *Phys. Rev. B* 37 785.
- [66] Schaefer A, Hube C and Ahlrichs R 1994 *J. Chem. Phys.* 100 5829 . Schaefer A, Horn H and Ahlrichs R 1992 *J. Chem. Phys.* 97 2571 .
- [67] Sheldrick G M 1990 SHELXS-97, Göttingen, Germany: University of Göttingen.
- [68] Sheldrick G M 1997 SHELXL-97, Program for the refinement of crystals structures from diffraction data, Göttingen, Germany: University of Göttingen .
- [69] Patra D, Pattanayak P, Pratihar J L and Chattopadhyay S 2007 *Polyhedron* 26 484 .
- [70] Ray U, Chand B, Mostafa G, Cheng J, Lu T-H and Sinha C 2003 *Polyhedron* 22 2587.
- [71] Pattanayak P, Pratihar J L, Patra D, Puranik V G and Chattopadhyay S 2008 *Polyhedron* 27 2209.
- [72] Saluzzo C and Lemaire M 2002 *Adv. Synt. Catal.* 344 915.
- [73] Harmon R E, Gupta S K and Brown D J 1973 *Chem. Rev.* 73 21 .
- [74] Pintar A and Batista J 1999 *Catal. Today* 53 35 .
- [75] Mallat T, Bodmer M and Baiker A 1997 *Catal. Lett.* 44 95.
- [76] Venkatachalam G and Ramesh R 2005 *Tetr. Lett.* 46 5215.

- [77] Kannan S, Ramesh R and Liu Y 2007 J. Organomet. Chem. 692 3380 .
- [78] Pratihar J L, Bhaduri S, Pattanayak P, Patra D and Chattopadhyay S 2009 J. Organomet Chem. 694 3401.
- [79] Bianchini C, Peruzzini M, Farnetti E, Kagpar J and Graziani M 1995 J. Organomet Chem. 488 91. Clapham S E and Morris R H 2005 Organometallics 24 479 .
- [80] Bianchini C, Farnetti E, Graziani M, Peruzzini M and Polo A 1993 Organometallics 12 3753.

Access this Article in Online	
	Website: www.ijcrops.com
	Subject: Chemistry
Quick Response Code	
DOI: 10.22192/ijcrops.2021.08.07.003	

How to cite this article:

Prithwiraj Byabartta. (2021). Bis-chelated-arylazoimidazole-bipyridine-Osmium(II) Complexes : Synthesis, UV-Vis-Spectral characterization and electrochemical properties. Int. J. Curr. Res. Chem. Pharm. Sci. 8(7): 24-32.

DOI: <http://dx.doi.org/10.22192/ijcrops.2021.08.07.003>