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Catalytic Applications of New Ru (II) Organometallics with Amide Ligands on the Hydrolysis of Etofibrate in Pharmaceuticals

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Abstract: Some new organometallics of ruthenium of the type $[RuCl_2(NO)(PPh_3)(L_2)]$ where L = amide ligands, have been synthesized by using the precursor with the substituted amide ligands in 1:2 molar ratio's and these compounds were characterized by elemental analysis, IR,NMR($^1H^1$,^{13}C and ^{31}P) mass ,and electronic spectral data. On the basis of these studies octahedral geometry for all of these complexes have been proposed. The catalytic activity of all these organometallics were studied and found that they are efficient catalysts for hydrolysis of etofibrate. The hydrolyzed product was separated by column chromatography and the percent yields are found in the range of 98.8% -99.6%. All the ligands and Ru (II) complexes were screened for anti-bacterial activities.
Key words: Synthesis of Ru (II) organometallics, amide ligands, Hydrolysis, Etofibrate, antibacterial activity.

1. Introduction

The Ruthenium (II) amide compounds are effective homogeneous catalysts for hydrolysis[1], hydrogenation and hydroformylation reactions[2-5], in fact most of the Ru (II) complexes are soluble only in organic solvents in order to improve the solubility in polar solvents. We planned to introduce corboxylated groups on tertiary phosphines and synthesized their Ru (II) organometallics[1,5-8]. Hydrolysis of esters, peptides and proteins are important biological processes and very common in chemistry and biochemistry[9,10]. metal catalyzed reactions for the hydrolysis of esters have been extensively investigated[11,12]. However these methods require more time for the complete hydrolysis process, we have already investigated the synthesis, characterization and catalytic hydrolysis of Ru (II) organometallics on rivastigmine tartarate and neostigmine bromide and they are found to be efficient in the hydrolysis[1], as part of our investigation in to designing new organometallics we report here the synthesis, characterization and catalytic applications of Ru(II) organometallics containing 12 amide ligands, these organometallics were synthesized by using the precursor $RuCl_3(NO)(PPh_3)_2$ and their structures were confirmed by elemental analysis, IR,NMR($^1H^1$,^{13}C,^{31}P) mass and electronic spectral data.

2. Experimental

2.1. Materials and Methods

Analar grade reagents and freshly distilled solvents were used throughout the investigations. All the substrates were purified before use. $RuCl_3.3H_2O$ (Johnson Matthey & Co. Ltd.), acetone (Qualigens) and diethyl ether (Qualigens) were used as such, The

precursor $RuCl_3(NO)(PPh_3)_2$ and the 12 amide ligands viz. 2-(anilinocarbonyl) benzoic acid (ACBA), 4-anilino-4-oxo but-2-enoicacid (AOBEA), 4-anilino-4-oxobutanoicacid (AOBA), 2-[(1-naphthyl amino) carbonyl] benzoic acid (NACBA), 4-(1-naphthylamino)4-oxobut- 2-enoicacid (NAOBEA), 4-(1-naphthyl amino)-4-oxobutanoicacid (NAOBA), 2-[(1H-benzimidazol-2-yl amino)carbonyl]benzoic acid (BACBA), 4-(1H-benzimidazol-2-ylamino)-4-oxobut-2-enoic acid(BAOBEA), 4-(1H-benzimidazol-2-ylamino)-4-oxobutanoicacid(BAOBA), 2-[(2-phenylhydrazino) carbonyl] benzoic acid (PHCBA), 4-oxo-4-(2-phenylhydrazino)but-2-enoic acid (OPHBEA), 4-oxo- 4-(2-phenyl hydrazine) butanoicacid (OPHBA), were synthesized as previously reported[1]. Organisms like *Bacillus subtilis* (MTCC-619) and staphylococcus aureus (MTCC-96) Escherichia coli (MTCC-722) and *Klebsiella pneumoniae* (MTCC-109) from IMTECH Chandigarh were used for anti microbial studies.

2.2. Measurements

The melting points of all the ligands and complexes were determined on a Buchi-510 melting point apparatus. The percentages of carbon, hydrogen and nitrogen were determined using a PerkinElmer CHN analyzer at 240°C the IR spectra were recorded in KBr pellets on PerkinElmer-283 spectrophotometer.The scanning rate was 6 min in the range of 4000–200 cm^{-1}. A Jeol 100 MHz FT-NMR spectrometer was used for ^{1}H-NMR spectra, Brucker WH 270 (67.93 MHz) and Brucker WH 270(109-29 MHz) spectrometers were used for ^{13}C-NMR and ^{31}P-NMR spectra, MICROMASS-7070 spectrometer operating at 70 eV using a direct inlet system was used for mass spectra. UV–visible spectra were recorded with Shimadzu UV-160A, a UV–visible double beam spectrophotometer with matched quartz cells of path length 1 cm, ESR spectra were recorded on JEOL-JES-FE-3X spectrometer. Gouy balance calibrated with Hg [Co (NCS) $_4$] was used for the determination of magnetic susceptibilities of complexes in solid state at room temperature, and the Conductance measurements were done on 10^{-3}M Solution of compounds in dichloromethane at room temperature using Digison Digital conductivity meter model DL-909.

2.3. Synthetic of $Rucl_2$ (NO) (PPh_3) (L_2) from $RuCl_3$ (NO) (PPh_3)$_2$

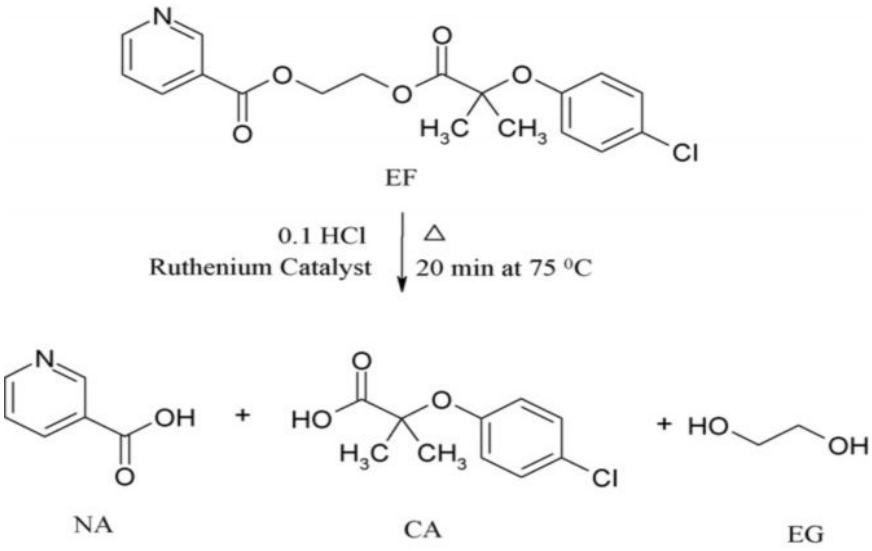
0.304 g $RuCl_3$ (NO) (PPh_3)$_2$ (0.4 m mol) was dissolved in 20 ml acetone. To this solution, 20 ml of ligand solution (0.4 m mol in acetone as above) was added. The reaction mixture was taken in a 100 ml round bottom flask and stirred magnetically for 3 hrs. The resulting solution was concentrated to 5 ml under reduced pressure and a few ml of diethyl ether was added to initiate the crystallization. The resulting precipitate was separated by suction filtration, washed with diethyl ether; vacuum dried to get a crystalline compound and was recrystallised using dichloromethane and diethyl ether solvent mixture.

2.4. Hydrolysis of Etofibrate

100 mg of etofibrate in 10 ml methanol was refluxed with 0.01 m mol of ruthenium (II) catalyst and 100 ml 0.1 M Hydrochloric acid at 60^0 C for 15 to 20 min, it was then evaporated and the residue was dried under vaccum, Two spots were observed on a TLC plate by using ethyl acetate: methanol (70:30, v/v) as mobile phase. The nicotinic acid formed in the process was collected by using a glass column (35 cm x 3 cm) packed with silica gel 60 (0.063 - 0.200 mm particle size) (E.Merch, Darmstadt. Germany) by using ethyl acetate: methanol (80:20, v/v) as mobile phase. The collected nicotinic acid was dissolved in water and a conductometric titration was carried out with 0.1 N sodium hydroxide. The amount of nicotinic acid which directly reflects the hydrolysis of EF was calculated from the graph drawn between the volume of sodium hydroxide and corrected conductance.

2.5. Catalytic applications

Etofibrate(2-(*p*-chlorophenoxy)-2-methylpropionicacid-2- (nicotinoyl-oxy) ethyl ester, EF), a derivative of nicotinic acid and etofibrate is a lipid regulating drug used in the treatment of hyperlipidaemias[13]. Recently, the hydrolysis of EF by hydrochloric acid leading to the formation of 3-pyridinecarboxylic acid (nicotinic acid, NA), 2-(*p* chlorophenoxy) - 2-methylpropionic acid (clofibric acid, CA) and 1, 2-ethane diol (ethylene glycol, EG) was reported. The formation of NA, CA and EG was also confirmed by IR and PMR analysis. However, it was reported that the hydrolysis process was initiated only after 3 h and completed after 12 h[14]. Since, there is a need for the development of faster hydrolysis method, the newly synthesized ruthenium organometallics were used as catalysts in the present investigations. The hydrolysis time was monitored by determining the produced amount of nicotinic acid (Scheme 1) with conduct metric titration using 0.1N sodium hydroxide. It was observed that the present catalysts are able to successfully hydrolyze EF within 20 min. The percent yields of NA were found to be in the range of 99.2–99.6% **Table 4.**



Scheme 1: Hydrolysis of EF in the presence of ruthenium catalysts

Table-1 .Physical and Analytical data of Ru (II) organometallics

Compound No.	Ru(II)organometallics	Yield (g)	Color	Analyses found calculated (%)			
				C	H	N	Ru
(1)	$RuCl_2(NO)(PPh_3)(ACBA)C_{32}H_{25}Cl_2N_2O_4PRu$	0.21(75%)	Green	54.6(54.5)	3.6(3.5)	4.0(4.0)	14.4(14.3)
(2)	$RuCl_2(NO)(PPh_3)(AOBEA)C_{28}H_{23}Cl_2N_2O_4PRu$	0.19(73%)	Light green	51.4(51.4)	3.5(3.5)	4.3(4.3)	15.4(15.4)
(3)	$RuCl_2(NO)(PPh_3)(AOBA)$ $C_{28}H_{25}Cl_2N_2O_4PRu$	0.20(75%)	Light green	51.3(51.3)	3.8(3.8)	4.3(4.26)	15.3(15.4)
(4)	$RuCl_2(NO)(PPh_3)(NACBA)C_{36}H_{27}Cl_2N_2O_4PRu$	0.30(76%)	Brown	57.32(57.3)	3.5(3.6)	3.3(3.7)	13.4(13.4)
(5)	$RuCl_2(NO)(PPh_3)(NAOBEA)C_{32}H_{25}Cl_2N_2O_4PRu$	0.22(79%)	Light brown	54.6(54.5)	3.5(3.5)	4.0(4.0)	14.4(14.3)
(6)	$RuCl_2(NO)(PPh_3)(NAOBA)C_{32}H_{27}$ $Cl_2N_2O_4PRu$	0.25(73%)	Light brown	54.5(54.4)	3.8(3.8)	4.0(4.0)	14.3(14.3)
(7)	$RuCl_2(NO)(PPh_3)(BACBA)$ $C_{33}H_{25}$ $Cl_2N_2O_4PRu$	0.22(75%)	Grey	53.3(53.2)	3.4(3.4)	7.5(7.5)	13.6(13.6)
(8)	$RuCl_2(NO)(PPh_3)(BAOBEA)$ $C_{29}H_{23}Cl_2N_2O_4PRu$	0.19(72%)	Grey	50.2(50.1)	3.3(3.3)	8.1(8.1)	14.5(14.5)
(9)	$RuCl_2(NO)(PPh_3)(BAOBA)$ $C_{29}H_{25}$ $Cl_2N_2O_4PRu$	0.20(74%)	Grey	49.96(50.0)	3.5(3.6)	8.1(8.0)	14.6(14.5)
(10)	$RuCl_2(NO)(PPh_3)(PHCBA)$ $C_{32}H_{26}$ $Cl_2N_2O_4PRu$	0.20(73%)	Green	53.3(53.4)	3.6(3.6)	5.9(5.8)	14.1(14.0)
(11)	$RuCl_2(NO)(PPh_3)(OPHBEA)$ $C_{28}H_{24}Cl_2N_2O_4PRu$	0.20(74%)	Light green	50.3(50.2)	3.6(3.6)	6.3(6.3)	15.1(15.1)
(12)	$RuCl_2(NO)(PPh_3)(OPHBA)C_{28}H_{26}$ $Cl_2N_2O_4PRu$	0.20(75%)	Light green	50.0(50.1)	3.8(3.8)	6.3(6.2)	15.1(15.0)

3. Result and Discussion

All the complexes are air stable, non hygroscopic. The physical and analytical data is in good agreement with the proposed molecular formulae and the percentages of carbon, hydrogen and nitrogen were determined experimentally using CHN analyzer. The physical and analytical data in Table 1, for the newly synthesized Ru (II) complexes is in good agreement with the proposed molecular formulae *viz* $RuCl_2(NO)(PPh_3)(L_2)$.

3.1. Infrared Spectral

The binding mode of amide ligand to ruthenium in new complexes was studied by comparing the infrared spectra of free ligands and precursor with the spectra of new ruthenium complexes. The stretching frequencies of amide nitrogen are observed in the range of 3367–3252 cm^{-1} in free ligands. In the complexes spectra, appreciable shifts are not observed in this region confirming the non involvement of amide nitrogen in coordination. However, in the IR spectra of complexes having ligands derived from benzimidazoles viz. BACBA,

BAOBEA and BOABA, υ_{N-H} (benz- imidazole) modes are observed at 3266, 3257 and 3266 cm^{-1}, respectively. Similarly, in the IR spectra of complexes having ligands derived from phenylhydrazine viz. PHCBA, OPHBEA and OPHBA, υ_{N-H} (phenylhydrazine) modes are observed at 3266,3288 and 3285 cm^{-1}, respectively. The stretching frequencies of amide oxygen are observed at ca. 1670 cm^{-1} in free amide ligands. In all the complexes spectra, a negative shift by 30–40 cm^{-1} is observed in the 1659–1641 cm^{-1} range indicating the coordination of amide oxygen to ruthenium[15]. In the ligand spectra, strong absorption bands are observed in free ligands around 1710 and 1340 cm^{-1} due to $\upsilon_{C=O}$ stretching and υ_{N-H} deformations of carboxylic acid, respectively. The disappearance of these bands and appearance of new bands in the 1555–1531 and 1388–1373 cm^{-1} range in complex spectra corresponding to υ_{COO^-} (asymmetric) and υ_{COO^-} (symmetric) vibrations indicates the participation of oxygen atom of carboxylic group in chelation[16]. In the precursor spectrum, a strong absorption band is found at 1880 cm^{-1} due to the presence of a nitrosyl group[17]. The same bands are also observed in complexes spectra in the range of 1895–1872 cm^{-1} indicating the presence of nitrosyl ligands in them. Strong absorption band is present in precursor spectrum at 530 cm^{-1}. In complex spectra, these bands are found in the 541–516 cm^{-1} range confirming the presence of Ru-P bond[18]. The coordination of oxygen atom of ligand with ruthenium is also indicated by the presence of a band in the range of 460–400 cm^{-1}. Two bands appear in the ranges of 329–320 and 327–301 cm^{-1} in complexes spectra indicating the presence of two chloride ligands in the cis position around the ruthenium centre.

All other characteristic bands of PPh_3 are observed in the expected regions in precursor spectrum and complexes spectra[19] in **Table 2.**

Table 2: Infrared spectral data of Ru (II) complexes with amide ligands

Compound No.	Complex/Formula	Selected IR bands(cm^{-1})						
		υ_{N-H} (Amide)	$\upsilon_{N=O}$ (Nitrosyl)	$\upsilon_{C=O}$ (Amide)	υ_{COO^-} (asy)	υ_{COO^-} (sy)	υ_{Ru-P}	υ_{Ru-Cl}
(1)	$RuCl_2(NO)(PPh_3)$(ACBA)	3375	1881	1641	1546	1376	517	320,302
(2)	$RuCl_2(NO)(PPh_3)$(AOBEA)	3376	1883	1652	1551	1383	541	324,305
(3)	$RuCl_2(NO)(PPh_3)$(AOBA)	3374	1875	1651	1556	1382	522	322,307
(4)	$RuCl_2(NO)(PPh_3)$(NACBA)	3374	1876	1660	1543	1383	523	326,312
(5)	$RuCl_2(NO)(PPh_3)$(NAOBEA)	3363	1885	1658	1541	1382	528	329,308
(6)	$RuCl_2(NO)(PPh_3)$(NAOBA)	3366	1885	1654	1542	1374	528	329,308
(7)	$RuCl_2(NO)(PPh_3)$(BACBA)	3361	1884	1655	1544	1386	526	321,304
(8)	$RuCl_2(NO)(PPh_3)$(BAOBEA)	3367	1871	1645	1543	1377	529	329,302
(9)	$RuCl_2(NO)(PPh_3)$(BAOBA)	3365	1891	1653	1541	1383	521	309,328
(10)	$RuCl_2(NO)(PPh_3)$(PHCBA)	3367	1895	1654	1532	1375	522	320,312
(11)	$RuCl_2(NO)(PPh_3)$(OPHBEA)	3373	1885	1653	1536	1387	523	322,307
(12)	$RuCl_2(NO)(PPh_3)$(OPHBA)	3371	1886	1652	1538	1378	520	323,305

3.2. ^{1}H NMR spectral

The bonding modes of amide ligands are conformed by comparing the ^{1}H-NMR spectra of the precursor, free ligands with Ru (II) complexes. The integral intensities of each signal in the ^{1}H-NMR spectra of precursor, ligands and complexes are found to agree with the number of different types of protons present. The carboxylic proton signals in the 10.02 - 12.13 δ range which are present in ligand spectra are not observed in complexes spectra indicating the deprotonation of carboxylic acid followed by the chelation through oxygen atom. The broad signal of amide proton is observed in the 5.08- 9.99 δ and 5.10 - 9.91 δ range in ligands spectra and complexes spectra, respectively, confirming the non participation of this group in chelation. However, in the spectra of complexes with ligands derived from benzimidazoles, viz. BACBA, BAOBEA and BOABA, signals of N-H proton in benzimidazolole are also found in the 7.12 - 9.22 δ range. Similarly, in the spectra of complexes with ligands derived from phenylhydrazines viz. PHCBA, OPHBEA and OPHOPHBA, signals of N–H proton in phenylhydrazine are also found in the 7.17–9.58 range. The spectra of ligands viz. AOBEA, NAOBEA, BOABEA, OPHBEA contains doublet of doublet in the range of 6.12 – 6.73 δ indicating the presence of CH = CH unit and the spectra of ligands viz. AOBA, NAOBA, BOABA, OPHBA and their corresponding complexes contains triplet of triplet in the 2.16–2.57 δ range indicating the presence of CH_2-CH_2 unit[20]. These signals almost remain unchanged in the spectra of respective complexes. Multiplets observed in the complexes spectra around 6.27 - 7.88 δ has been assigned to the aromatic protons of ligands and triphenylphosphines [21] .Table 3**.**

3.3. ^{13}C NMR Spectral

^{13}C-NMR spectra of free amide ligands and new Ru (II) complexes, compared signals, are found to have a consistent pattern. In the spectra of complexes, ^{13}C signal are observed in the downfield regions of 182.28-185.26 δ and 178.19–181.52 δ indicating the coordinated carboxylic carbon and carbonyl carbon of amide group respectively. The spectra of complexes with ligands, viz. AOBEA, NAOBEA, BOABEA, OPHBEA, exhibit a signal around 117.21 δ confirming the presence of doubly bonded carbon[22]. Similarly, the spectra of complexes with ligands, viz. AOBA, NAOBA, BOABA, OPHBA, exhibit a signal around 32.43 δ confirming the presence of singly bonded carbon. The aryl carbons are found to resonate in the 117.15–132.92 δ range[23].

Table 3. ^{1} H NMR spectral data of Ru (II) organometallics with amide ligands

Compound No.	Ru(II)organometallics	^{1}H Peak position (ppm)			
		Amide Proton	CH=CH Proton	CH_2-CH_2 Proton	Atomic Proton
(1)	$RuCl_2(NO)(PPh_3)$(ACBA)	8.16	-	-	6.86-7.25
(2)	$RuCl_2(NO)(PPh_3)$(AOBEA)	5.93	6.73	-	6.89-7.88
(3)	$RuCl_2(NO)(PPh_3)$(AOBA)	5.90	-	2.16	6.92-7.12
(4)	$RuCl_2(NO)(PPh_3)$(NACBA)	8.76	-	-	6.31-7.65
(5)	$RuCl_2(NO)(PPh_3)$(NAOBEA)	5.83	6.65	-	6.64-7.65
(6)	$RuCl_2(NO)(PPh_3)$(NAOBA)	5.78	-	2.24	6.76-7.82
(7)	$RuCl_2(NO)(PPh_3)$(BACBA)	9.72	-	-	6.38-7.52
(8)	$RuCl_2(NO)(PPh_3)$(BAOBEA)	7.54	6.53	-	6.64-7.72
(9)	$RuCl_2(NO)(PPh_3)$(BAOBA)	7.34	-	2.36	6.75-7.66
(10)	$RuCl_2(NO)(PPh_3)$(PHCBA)	9.93	-	-	6.27-7.82
(11)	$RuCl_2(NO)(PPh_3)$(OPHBEA)	7.95	6.12	-	6.66-7.79
(12)	$RuCl_2(NO)(PPh_3)$(OPHBA)	7.65	-	2.57	6.78-7.71

Table 4: Percent yields of NA formed after EF using ruthenium catalysts

Compound No.	Ru(II)organometallics	Yield (%)
(1)	$RuCl_2(NO)(PPh_3)$(ACBA)	99.1
(2)	$RuCl_2(NO)(PPh_3)$(AOBEA)	99.2
(3)	$RuCl_2(NO)(PPh_3)$(AOBA)	99.2
(4)	$RuCl_2(NO)(PPh_3)$(NACBA)	98.7
(5)	$RuCl_2(NO)(PPh_3)$(NAOBEA)	98.9
(6)	$RuCl_2(NO)(PPh_3)$(NAOBA)	99.3
(7)	$RuCl_2(NO)(PPh_3)$(BACBA)	99.6
(8)	$RuCl_2(NO)(PPh_3)$(BAOBEA)	98.8
(9)	$RuCl_2(NO)(PPh_3)$(BAOBA)	99.1
(10)	$RuCl_2(NO)(PPh_3)$(PHCBA)	99.6
(11)	$RuCl_2(NO)(PPh_3)$(OPHBEA)	98.9
(12)	$RuCl_2(NO)(PPh_3)$(OPHBA)	99.1

3.4. ^{31}P NMR Spectral

^{31}P NMR spectra of all the complexes exhibit singlet's around 33.91 δ due to the presence of a single PPh_3 ligand[24].

3.5. Magnetic measurements, Electronic Spectral and Conductance measurements

All these Ru (II) complexes have a diamagnetic nature and hence, ruthenium has +2 oxidation states in the complexes and all the complexes are diamagnetic, showing the +2 oxidation state for ruthenium. The ground state of Ru (II) (t^6_{2g} configuration) is $^1A_{1g}$, the excited states, corresponding to the $t^5_{2g}e_{1g}$ configuration, are $^3T_{1g}$, $^3T_{2g}$, $^1T_{1g}$ and $^1T_{2g}$ in the order of increasing energy. Hence, four bands are possible corresponding to the $^1A_{1g} \rightarrow {}^3T_{1g}$, $^1A_{1g} \rightarrow {}^3T_{2g}$, $^1A_{1g} \rightarrow {}^1T_{1g}$ and $^1A_{1g} \rightarrow {}^1T_{2g}$ transitions. In the electronic spectra of all the complexes, two bands appeared in the regions of 450–470 nm and 270–320 nm regions corresponding to the transitions $^1A_{1g} \rightarrow {}^1T_{1g}$ and $^1A_{1g} \rightarrow {}^1T_{2g}$ respectively. Sometimes the higher energy transition is totally obscured by intense charge transfer bands. Other higher energy bands can be assigned as ligand $\pi \rightarrow \pi^*$ and other ligand to metal charge-transfer transitions. This data suggests octahedral geometry for all the Ru (II) complexes[25]. The low molar conductance values of the present complexes, determined in CH_2Cl_2 indicate the non electrolytic nature of these complexes.

3.6. Antibacterial Activity

The Antimicrobial activities of the ligands and there metal complexes have been screened against four different bacteria by the cup plate method[26]. Preliminary screening for all the compounds was performed at fixed concentrations of 2 mg/ml. Each of the compounds was found to be acting on two types of gram +ve (*Bacillus subtilis* (MTCC-619) and staphylococcus aureus (MTCC-96)) and gram O$^-$ve bacteria (Escherichia coli (MTCC-722) and *Klebsiella pneumoniae* (MTCC-109)). Out of 12 amide ligands, only three namely BACBA, BAOBEA and BAOBA (Table-5), were found to be very effective based on the obtained values of relative zone of inhibition[27]. It has also been observed in the antimicrobial screening studies that the ruthenium complexes showed higher activity than the corresponding free ligands against the same microorganism under identical experimental conditions. It was concluded that the ligands with the N and O donor systems might have inhibited enzyme production. Chelation reduces the polarity of the central ion mainly because of the partial sharing of its positive charge with the donor groups and possible π-electron delocalization within the whole chelate ring; this Chelation increases the liophilic nature of the central atom, which favors its permeation through lipid layers of the cell membrane[28]. From the preliminary screening, Ru (II) compounds were found to be active against four different strains of bacteria and their rank order was as follows:

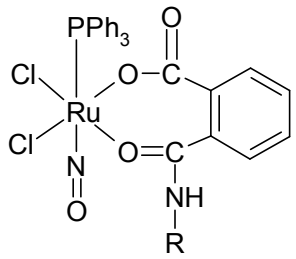
complex **8>7>9>11>10>12>5=4>6>2>1=3**.

Table-5: Zones of Inhibition for Ru (II) Complexes with Coordinated Amide against Four Different Bacteria

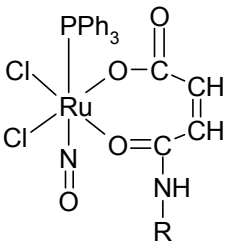
Compound No.	Ru(II)organometallics	Zone of inhibition (mm)			
		MTCC-619	MTCC-96	MTCC-722	MTCC-109
(1)	$RuCl_2$ (NO)(PPh_3)(ACBA)	01	01	02	02
(2)	$RuCl_2$(NO)(PPh_3)(AOBEA)	04	04	07	07
(3)	$RuCl_2$(NO)(PPh_3)(AOBA)	01	02	02	02
(4)	$RuCl_2$(NO)(PPh_3)(NACBA)	07	06	11	13
(5)	$RuCl_2$(NO)(PPh_3)(NAOBEA)	07	06	11	13
(6)	$RuCl_2$(NO)(PPh_3)(NAOBA)	05	05	08	12
(7)	$RuCl_2$(NO)(PPh_3)(BACBA)	11	12	17	17
(8)	$RuCl_2$(NO)(PPh_3)(BAOBEA)	13	13	18	18
(9)	$RuCl_2$(NO)(PPh_3)(BAOBA)	09	12	15	17
(10)	$RuCl_2$(NO)(PPh_3)(PHCBA)	08	09	13	15
(11)	$RuCl_2$(NO)(PPh_3)(OPHBEA)	10	10	14	15
(12)	$RuCl_2$(NO)(PPh_3)(OPHBA)	08	09	13	14

3.7. Structures of the Ru (II) complexes

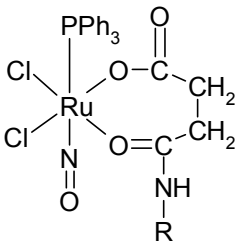
On the basis of analytical and spectral analysis, octahedral structures (Scheme 2) have been tentatively proposed for all of the Ru (II) complexes with amide ligands.



Complexes-(1),(4), (7) & (10)

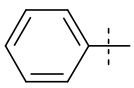


Complexes-(2), (5), (8) & 11

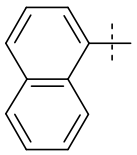


Complexes(3), (6), (9) & (12)

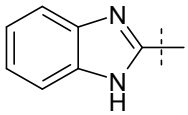
where R =



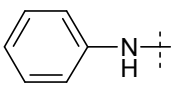
for complexes 3.1, 3.2 & 3.3



for complexes 3.4, 3.5 & 3.6



for complexes 3.7, 3.8 & 3.9



for complexes 3.10, 3.11 & 3.12

Scheme 2: Structures of Ru (II) organometallics derived from $RuHCl(NO)(PPh_3)_3$

4. Conclusions

Twelve Ru (II) complexes with coordinated amide have been synthesized from the precursor $RuCl_3$ (NO) $(PPh_3)_2$, characterized and assigned octahedral geometry. These complexes were used as catalysts in the hydrolysis of ester containing drugs. The catalytic hydrolysis method is simple to setup requires short reaction times, and features high product yields. This method is successfully applied for the oxidation of alcoholic drugs in their pharmaceuticals. All the complexes synthesized have stronger antibacterial activity against gram +ve and gram –ve bacteria than the corresponding ligands.

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