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# Iridium–Quinoline Coordination Complex in Catalysis

Dr. H.D. Chaudhari[1], Dr.Haresh R.Patel[2],

[1]Department of Chemistry, Hemchandracharya North Gujarat University, Patan, India

[2]Department of Chemistry, Navjivan School of Science(P.G.), Deesa, India

Email:- [1]haresh09032007@gmail.com , [2]hareshpatel6900@yahoo.com

**Abstract: -**

The combination of certain rare metal ions with the biologically important ligand Quinoline derivative to form coordination compound represents a significant area of current research. In this study, the relatively less explored Quinoline derivative ligand was reacted with solutions of selected rare metal perchlorate to synthesize solid Quinoline derivative complex. These complex was characterized by various analytical techniques, including UV-Visible spectroscopy, IR spectroscopy, mass spectrometry, thermogravimetric analysis (TGA), and elemental analysis. Furthermore, the catalytic activity of these complex was investigated in both homogeneous and heterogeneous phases. The antimicrobial properties of the synthesized complex were also evaluated using standard methods, and efforts were made to correlate their structural features with the observed physicochemical and biological properties.

**Keywords: -**Quinoline derivative, Biologically, Characterization, antimicrobial activity, Iridium complex.

**Catalytic Activity:- Catalytic Study of Three Iodine-Forming Reactions Using Coordination Complexes**

Three well-known redox reactions—(i) $K_2S_2O_8$ + KI, (ii) $KBrO_3$ + KI, and (iii) $H_2O_2$ + KI—were selected for catalytic investigation. These reactions are typically carried out in neutral or acidic media and proceed at moderate rates, with rate constants (K) in the range of $10^{-2}$ to $10^{-5}$ $min^{-1}$. In each case, iodine is formed as the primary product, which is quantitatively titrated using standard aqueous sodium thiosulphate solution in the presence of starch as an indicator.

Due to the ease of monitoring reaction progress via simple kinetic methods, these systems offer an excellent platform for evaluating the catalytic efficacy[1-7] of synthesized coordination compounds.[1-7]

In the present study, kinetic measurements and experimental procedures for all three second-order reactions were conducted according to established protocols. All reactions were performed at ambient temperature. The synthesized complexes were dissolved in methanol, and blank experiments were conducted using the same volume of methanol to ensure identical solvent conditions. Catalytic quantities of each complex were then introduced into the respective reaction mixtures. The results of these kinetic studies are presented below.

**Reactions:-**

**(i) Reaction-1**

$$K_2S_2O_8 + 2KI \longrightarrow 2K_2SO_4 + I_2$$

$$2Na_2S_2O_3 + I_2 \longrightarrow 2NaI + Na_2S_4O_6$$

**(ii) Reaction-2**

$$KBrO_3 + HCl \longrightarrow KCl + HBrO_3$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

**(iii) Reaction-3**

$$H_2O_2 + 2HI \longrightarrow 2H_2O + I_2$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

**Table – 1 Reaction kinetics (without catalyst):**

Reaction of : $K_2S_2O_8$ + KI + Methanol

Concentration : (0.0227M) (0.0227M) --

Volume : 50ml 50ml 10ml ($t_\infty$ =113.5 ml)

| Time t (min.) | Burette reading x (ml) | k = 1/at * x/(a-x) (lit.mol$^{-1}$ min$^{-1}$ |
|---|---|---|
| 5 | 3.2 | 4.20 X $10^{-5}$ |
| 10 | 3.7 | 2.44 X $10^{-5}$ |
| 15 | 4.1 | 1.80 X $10^{-5}$ |
| 20 | 4.6 | 1.52 X $10^{-5}$ |
| 25 | 5.0 | 1.33 X $10^{-5}$ |
| 30 | 5.5 | 1.22 X $10^{-5}$ |

**average k = 2.085 x $10^{-5}$**

a=b=initial concentrations of reactants =0.0227M

**Table – 2 Reaction kinetics table without catalyst**

Reaction of : $KBrO_3$ + KI + HCl + Methanol

Concentration : (0.0096M) (0.0096M) --

Volume : 25ml 25ml 10ml ($t\infty$ =25ml)

| Time t (min.) | Burette reading x (ml) | k= 1/at * x/(a-x) (lit.mol$^{-1}$ min$^{-1}$ |
|---|---|---|
| 5 | 6.9 | 3.04 X $10^{-3}$ |
| 10 | 7.4 | 1.68 X $10^{-3}$ |
| 15 | 7.7 | 1.18 X $10^{-3}$ |
| 20 | 8.6 | 1.04 X $10^{-3}$ |
| 25 | 9.0 | 0.9 X $10^{-3}$ |
| 30 | 9.5 | 0.81 X $10^{-3}$ |

**average k = 1.44 X $10^{-3}$**

a=b=initial concentrations of reactants=0.0227M

**Table – 3 Reaction kinetics table without catalyst**

Reaction of : $H_2O_2$ + KI + $H_2SO_4$ + Methanol

Concentration : (0.0091M) (0.0091M) --

Volume : 10ml 10ml 10ml ($t\infty$ =50ml)

| Time t (min.) | Burette reading x (ml) | k = 1/at * x/(a-x) (lit.$mol^{-1}$ $min^{-1}$ |
|---|---|---|
| 5 | 1.2 | 9.8 X $10^{-5}$ |
| 10 | 1.7 | 7.03 X $10^{-5}$ |
| 15 | 2.3 | 6.42 X $10^{-5}$ |
| 20 | 2.9 | 6.15 X $10^{-5}$ |
| 25 | 3.4 | 5.83 X $10^{-5}$ |
| 30 | 3.8 | 5.48 X $10^{-5}$ |

**average k = 6.78 X $10^{-5}$**

a=b=initial concentrations of reactants =0.0227M

**Table:- 4 Common Reaction Kinetics- experimental Set ups with Catalyst**

| | | |
|---|---|---|
| **Reactions (I)** | **$K_2S_2O_8$ + KI + Ir-KYNA in 10 ml methanol (0.0227M) (0.0227M) (1 % MW)** | **$t\infty$ = 113.5 ml a=b= 0.0227M** |
| **Reactions (II)** | **$KBrO_3$ + HI + Ir -KYNA in 10 ml methanol (0.0091M) (0.0091M) (1 % MW)** | **$t\infty$ = 25 ml a=b= 0.0227M** |
| **Reactions (III)** | **$H_2O_2$ + HI + Ir -KYNA in 10 ml methanol (0.0091M) (0.0091M) (1 % MW)** | **$t\infty$ = 50 ml a=b= 0.0227M** |

**Table:- 5 Kinetic experiments with Iridium metal Complex**

| Reactions | k without Complexes | k with Ir –KYNA (1%) | % Increase reaction rate at T = 300K Ir - KYNA |
|---|---|---|---|
| $K_2S_2O_8$ + KI | 2.085 X $10^{-5}$ | 3.82X $10^{-5}$ | 83.21 % |
| $KBrO_3$ + HI | 1.44 X $10^{-3}$ | 2.19 X $10^{-2}$ | 1420.83 % |
| $H_2O_2$ + HI | 6.78 X $10^{-5}$ | 2.05 X $10^{-4}$ | 202.35 % |

**k = reaction rate constant for the second order reaction, 1% complex = 1 % molecular weight of the complex**

**1 % MW of complex of Ir-KYNA= 0.0435 % of mole of $K_2S_2O_8$ ,**

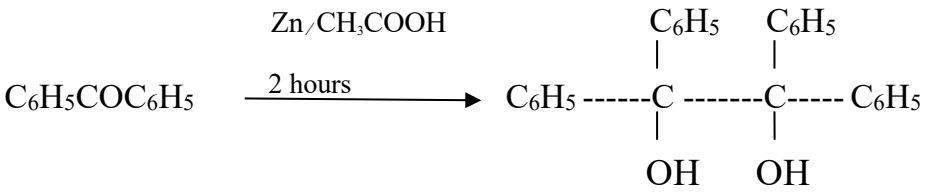
**1 % MW of complex of Ir -KYNA = 0.104 % of mole of $KBrO_3$**

**1 % MW of complex of Ir -KYNA = 0.11 % of mole of $H_2O_2$**

## Catalysis of Organic Reaction:- Synthesis of Benzpinacol from Benzophenone

A mixture containing benzophenone (7.5 g, 0.041 mol), zinc dust (4 g), glacial acetic acid (110 mL), and water (22 mL) was refluxed for 2 hours. After completion of the reaction, the mixture was filtered (if necessary) to remove unreacted zinc or insoluble impurities and then allowed to cool. The crude product, benzpinacol, precipitated upon cooling and was collected by filtration. The solid was recrystallized from glacial acetic acid to obtain purified benzpinacol. [8-12]

The final yield was 4.5 g (30%), and the melting point of the purified product was recorded as 188–189 °C, consistent with literature values [13-14].




**Benzophenone** **Benzpinacol**

**Table:- 11 % yield of without catalyst for different temperature**

| Sr. No | Temperature | % yield without catalyst (for 4 hours reaction) | % yield without catalyst (for 3 hours reaction) | % yield without catalyst (for 2 hours reaction) |
|---|---|---|---|---|
| 1 | 368 K | 64.44% | 55.55% | 30.00 % |

**Table :-12 percentage yield with catalyst metal complexes for 2 hours Temperature = 368 K**

| Complexes | For 1 % catalyst, yield obtained | For 5 % catalyst, yield obtained | For 10 % catalyst, yield obtained |
|---|---|---|---|
| **Ir-KYNA** | **25%** | **30%** | **52%** |

***1% MW of complex = 0.0243 % of mole of benzophenone***
***5% MW of complex = 0.121 % of mole of benzophenone***
***10% MW of complex = 0.243 % of mole of benzophenone***

**Results and Discussion: -**

It was apparent that rates of all the redox reactions selected were increased by the addition of catalytic amounts of individual complexes. An increase of 83% was possible for reaction (i) $K_2S_2O_8$ + KI and for reactions (ii) $KBrO_3$ + KI + Hl and (iii) $H_2O_2$ + HI, a profound increase from 200% to 1420% was possible. Thus a significant increase in reaction rates could be achieved with help of two complexes and hence application of these complexes as catalyst is certainly of immense significance.

**Catalytic Role of Lanthanide Complexes in Reductive Coupling: Synthesis of Benzpinacol**

The synthesis of benzpinacol from benzophenone represents a classic example of reductive coupling, wherein the carbonyl group is reduced by zinc dust, and two benzophenone units couple to form a new central carbon–carbon bond. This transformation, involving both reduction and C–C bond formation, presents a valuable model for investigating the catalytic potential of coordination compounds. Owing to this dual mechanistic nature, the reaction was selected to explore the application of lanthanide complexes as homogeneous catalysts [15-20].

The reaction was conducted under identical experimental conditions both with and without the addition of catalysts. Among the synthesized complexes, Ir-KYNA (Iridium complex of kynurenic acid) demonstrated effective homogeneous catalytic activity. The presence of catalytic amounts of the lanthanide complexes significantly reduced the reaction time and led to a notable increase in product yield, highlighting their potential as efficient catalysts for reductive coupling reactions [15-20].

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