

ELECTROCHEMICAL STUDY OF METAL COMPLEXES

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Science

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DEPARTMENT OF CHEMISTRY

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of S. RAMYA (38030013) and M.SEYAD IJJAZ (38030014) who carried out the project entitled “**ELECTROCHEMICAL STUDY OF METAL COPMLEXES**” under my supervision from December 2020 to April 2021.

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EXTERNAL EXAMINER

DECLARATION

We **RAMYA .S** and **SEYAD IJJAZ .M**, hereby declare that the Project Report entitled **“ELECTROCHEMICAL STUDY OF METAL COMPLEXES”** done by us under the guidance of **Dr. S. SUPRIYA MSc., Ph.D.**, Associate Professor, Department of Chemistry, Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Science degree in Chemistry.

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S.RAMYA

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ABSTRACT

Cyclic voltammetry is a major technique in electrochemical analysis of metal complexes. Three metal complexes of DL-Methionine were prepared in aqueous medium and characterized by **CYCLIC VOLTAMMETRY**. With metal M(II) Methionine forms 1:2 complexes. The general empirical formula of complex is $[(C_5H_{10}NO_2S)_2M^{II}]$, Where $M^{II} = Mn(II), Cu(II), Cd(II)$.

The redox behavior of copper, cadmium and manganese in both coordinated and uncoordinated states were examined using Cyclic voltammetry technique.

The current potential data, peak separation and peak current ratio of (Mn, Cu, and Cd) complexes were examined in chloride buffer using cyclic voltammetry. The electrochemical behavior and redox behavior of metal complexes were observed by Cyclic Voltammetry.

The redox behavior of copper, manganese and cadmium were observed on Glassy carbon electrode (GCE) as working electrode, Ag/AgCl (standard KCL) as reference electrode and Pt wire as counter electrode.

The metal complexes $[Cu(C_5H_{10}NO_2S)_2]$, $[Cd(C_5H_{10}NO_2S)_2]$ and $[Mn(C_5H_{10}NO_2S)_2]$ were synthesized and characterized, hence corresponding voltammograms are produced.

The article explains the observations from the voltammograms of each complex, whether the electron transfer process is one step or two step process, Redox behaviour of the complex at different scan rates using their corresponding peaks.

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
CV	Cyclic Voltammetry
Cu	Copper
Cd	Cadmium
Mn	Manganese
GCE	Glassy Carbon Electrode
Ag/AgCl	Silver or Silver chloride
Pt	Platinum
i_{pc}	Cathodic current
i_{pa}	Anodic current
E_{pc}	Cathodic peak potential
E_{pa}	Anodic peak potential
CA	Reactant concentration
DA	Diffusion coefficient
Kf	Charge transfer rate constants
SQRT	Square Root

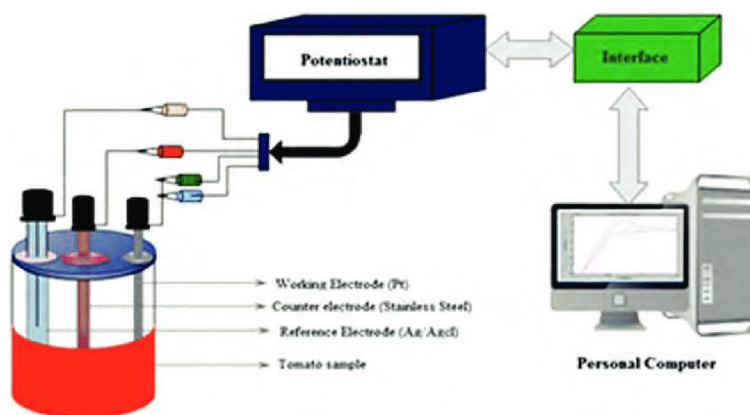
CHAPTER 1

INTRODUCTION

1.1 CYCLIC VOLTAMMETRY

The Electrochemical technique which measures the current that develops in an electrochemical cell under conditions where voltage is in excess of that predicted by the **Nernst equation** is called as CYCLIC VOLTAMMETRY (CV). By cycling the potential of a working electrode, CV is performed and the resulting current is measured. It is widely used in the study of Oxidation-Reduction reactions, detection of intermediates formed in the reaction and observation of following reactions. CV may use one full cycle or partial cycle or several cycles.

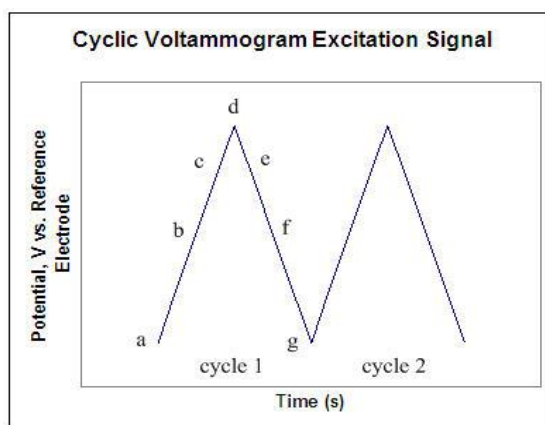
It consists of an electrolysis cell, a potentiostat, a current to voltage converter and data acquisition system. The electrolysis cell consists of three electrodes, a **working electrode**, **counter electrode** and **reference electrode** and an electrolytic solution. Working electrode potential is varied linearly with time as the reference electrode maintains a constant potential. Electricity was conducted from signal source to the working electrode by counter electrode. The necessity of providing ions to electrodes during oxidation and reduction. Potentiostat is an electronic device which uses DC power source which produce a potential which can be determined accurately and maintained. The current to voltage converter measures the resulting current and data acquisition system produce resulting voltammogram.



(Fig 1.1: CV Instrumentation)

1.2 CV- MECHANISM

The potential of working electrode is measured against a reference electrode which constitutes a constant potential, an excitation signal is produced from the resulting applied potential (**Fig- 1.1**). In forward scan, starting from greater potential (a) and ending and at lower potential (d), the potential first scans negatively. Potential extrema (d) is known as Switching potential, it is the point where the sufficient voltage is available to cause an Oxidation-Reduction reaction of an analyte. In reverse scan, the typical reduction occurs from (a) to (d) and oxidation occurs from (d) to (g), where the potential scans positively. Some analytes undergo oxidation first, in which the potential would first scans positive. The cycle is repeated by varying the scan rate. The slope from the excitation signal gives the scan rate provided.

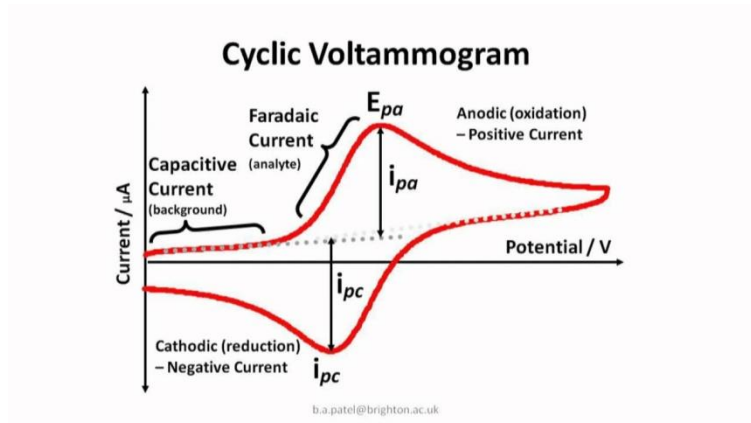


(Fig 1.2 : CV Excitation Signal)

In Cyclic Voltammetry experiment, triangular wave form excites the current response of a stationary electrode in an unstirred solution. The triangular wave form produces forward and reverse scan.

1.3 CYCLIC VOLTAMMOGRAM

By measuring the current at the working electrode during potential scans CYCLIC VOLTAMMOGRAM is obtained. A general Cyclic voltammogram was shown below (Fig 1.2);



(Fig 1.3 : Cyclic Voltammogram)

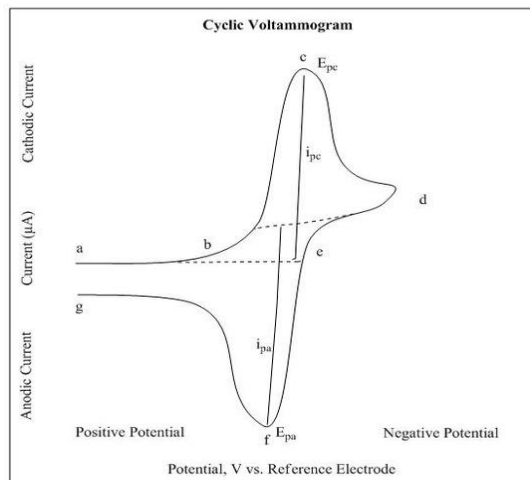
Where, i_{pc} -- Cathodic current

i_{pa} -- Anodic current

E_{pc} -- Cathodic peak potential

E_{pa} -- Anodic peak potential

Example : A reversible reaction $M^+ + e^- \rightleftharpoons M$



(Fig 1.4: Cyclic Voltammogram of single electron oxidation-Reduction)

From **(Fig 1.3)**, the reduction occurs from initial potential to switching potential (a) to (d). To cause reduction the potential is scanned negatively in this region. The resulting current is cathodic current (i_{pc}). The peak potential occurs at (c), called cathodic peak potential (E_{pc}). E_{pc} is reached when all the substrate at the surface of the electrode has been reduced. After reaching switching potential (d), the potential scans positive from (d) to (g). The resulting current is anodic current (i_{pa}) and to occur oxidation. The resulting peak potential at (f) is called the anodic peak potential (E_{pa}), E_{pa} is reached when all the substrate at the surface of the electrode has been oxidized.

1.4 ELECTRODE-CONCENTRATION PROFILES

In an unstirred solution, by diffusion alone mass transport of analyte to the electrode occurs. For mass transfer diffusion, Fick's law relates the distance from the electrode (x), time (t) and the reactant concentration (CA) to

the diffusion coefficient (DA). During reduction current increases until it reaches a peak, when all M^+ exposed to the surface of the electrode, M^+ is reduced to M . At this time additional M^+ to be reduced can travel by diffusion alone to the surface of the electrode. As the concentration of M increases, the distance of M^+ has to travel also increases. The current which has peaked during this process, begins to decline as smaller so, only smaller amounts of M^+ approach the electrode. Obtaining limiting currents is not practical, I_{pa} and I_{pc} in a system in which electrode is unstirred because the current continuously decrease with time.

A Nernst diffusion layer 10^{-2} cm thick, lies adjacent to the electrode surface in a stirred solution. There is laminar flow region followed by a turbulent flow region which contains bulk solution. As the diffusion is limited to the narrow Nernst region, the reacting analytes cannot diffuse into bulk solution, thus the Nernstian equilibrium is maintained, Diffusion controlled currents also obtained.

1.5 METAL COMPLEXES

A metal complex consists of a central metal atom (or) ion which is bonded to one or more ligands. Ligands are ions or molecules that contains one pair or more pairs of electron which can be shared with metal. Metal complex can be positive or negative or neutral. Metal ions can bind and then release ligand in some process and to oxidize-reduce in other processes because, they are ideal in nature.

The metal complexes $[Cu(C_5H_{10}NO_2S)_2]$, $[Cd(C_5H_{10}NO_2S)_2]$ and $[Mn(C_5H_{10}NO_2S)_2]$ were analysed using Cyclic voltammetry.

1.6 REDOX BEHAVIOUR OF METAL COMPLEXES

Commonly transition metals exhibit two or more stable oxidation states, accordingly they undergo oxidation-reduction reactions. It is the electron transfer between two complexes. Oxidation is the loss of electrons and corresponding increase in the oxidation state of a given reactant. Reduction is the gain of electrons and corresponding decrease in the oxidation state of a given reactant. Ligand effect is the major factor in modulation of redox potential of transition metal ion oxidation-reduction systems. The more reversible the redox couple, the shape of oxidation peak and reduction peak will be more similar. The electrochemical behavior and redox behavior of Cu, Cd and Mn was investigated by means of cyclic voltammetry.

1.7 APPLICATIONS-CYCLIC VOLTAMMETRY

It can be used to study qualitative information about electrochemical processes under various conditions, such as the reversibility of a reaction in the presence of intermediates in oxidation-reduction reactions.

Cyclic voltammetry can also be used to determine the electron stoichiometry of a system, the formal reduction potential and the diffusion coefficient of an analyte which can be used as an identification tool.

As the concentration is proportional to current in a reversible, Nernstian system, concentration of an unknown solution can be determined by developing a calibration curve of current vs concentration.

CV is used to calculate electron transfer rate constants.

Electron transfer plays a vital role in all reactions, particularly CV has an essential part in all aspects in areas of chemistry.

The various applications of cyclic voltammetry in different areas of chemistry are shown below (**Table 1.1**),

(Table 1.1): Applications- Cyclic voltammetry

AREAS OF CHEMISTRY	APPLICATIONS
Analytical chemistry	Preparation and synthesis, Analysis, Mechanism.
Organic chemistry	Synthesis, Analysis Characterization and Mechanism
Inorganic chemistry	Metal interactions and reactions Structure characterization and Analysis.
Physical chemistry	Thermodynamic studies, Theoretical equations, Kinetic Studies, Surface and Adsorption, Analysis.

CHAPTER-2

LITERATURE SURVEY

Cyclic voltammetry is used in the study of electron transfer and its consequences. Three Metal complexes were synthesized and characterized by Cyclic voltammetry. Transition metal ions undergo oxidation-reduction reactions, resulting in corresponding cathodic and anodic peaks from which further analysis can be done.

DK Gosser-1993, Cyclic voltammetry has been the most important in the study of electron transfer and following reactions. With the CV method one can activate molecules by electron transfer and probe subsequent chemical reactions. The cyclic voltammogram curve provides information about electron kinetics and thermodynamic and also consequences of electron transfer.

Edmund JF Dickinson, has described that at a hemispherical electrode under conditions where the electric field is non zero and migration is significant to mass transport. The non linear set of differential equations formed by solving numerically the Nernst- Planck equation and Poisson equation, results in a zero field approximation at the electrode surface.

The following effects are noted from the observed voltammetry -electrode size, scan rate, diffusion coefficient of electroactive and supporting species and quantity of supporting electrolyte are noted.

X.-L. Wang, H.-Y. Lin, G.-C Liu, B.-K. Chen and H.-Y. Zhao, "Synthesis, structure, electrochemistry and electrocatalysis of two novel copper(II) complexes constructed with dipyrido[3,2-d:2',3'-f]quinoxaline," *Journal of organometallic Chemistry*.

X. Wang, H. Zhao, H. Lin, G. Liu, J. Fang, and B. Chen, “Renewable new copper complex bulk-modified carbon paste electrode , preparation, electrochemistry and electroanalysis and electrocatalysis.

CHAPTER- 3

AIM AND SCOPE

3.1 AIM

To synthesize three metal complexes of DL- Methionine and to study the electrochemical behavior of metal complexes using Cyclic Voltammetry.

3.2 SCOPE

Preparation of metal complexes $[\text{Cu}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$, $[\text{Cd}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$ and $[\text{Mn}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$.

Characterization of Cu(II), Cd(II) and Mn(II) complexes using Cyclic voltammetry.

Cyclic voltammetry was performed by using Glassy carbon electrode as working electrode, Ag/AgCl as reference electrode and Pt wire as counter electrode.

The cathodic peaks and anodic peaks were observed from the resulting Cyclic voltammogram.

Redox behavior of metal complexes were examined from corresponding cathodic and anodic peaks.

From the corresponding peaks, Cathodic peak potential and Anodic peak potential are noted.

Current potential data, Tafel slope, diffusion coefficient and charge transfer rate constant are calculated from cyclic voltammogram.

The electrochemical behaviour of metal complexes were studied using Cyclic voltammetry

CHAPTER- 4

MATERIALS AND METHODS

4.1 MATERIALS

Materials used in synthesis of metal complexes are, metal salts, chloride buffer, powdered alumina, N₂ gas dilute ammonia, methionine.

The three electrode electrochemical cell used in Cyclic voltammetry are Glassy carbon electrode (GCE), Ag/AgCl (Standard KCl) and Pt wire. The electrochemical cell is made up of borosilicate glass and Teflon cap.

4.2 CHARACTERIZATION TECHNIQUE

4.2.1 CV (CYCLIC VOLTAMMETRY)

Cyclic voltammetry is a technique in which the redox behaviour of metal complexes were observed. The metal complexes synthesized are characterized using CV.

Cyclic voltammogram is a data which is noted as Duck- shaped data provides data of cathodic and anodic peaks, thus we can relate the data and analyze the redox behaviour of metal complexes.



(Fig 4.1: CV- Interpretation)

4.3 SYNTHESIS OF METAL COMPLEXES

4.3.1 SYNTHESIS OF CU(II)

The metal complexes were prepared in aqueous medium.

Metal salt of about 0.6- 1.4 g was taken in a beaker and dil. Ammonia was added. The precipitate of metal hydroxide formed was filtered and washed thoroughly using deionized water until the precipitate was ammonia free. The precipitate was taken in a round bottom flask.

About 0.74 g of methionine was dissolved in 200ml of deionized water. The solution was mixed with precipitate in round bottom flask after filtered. The filtrate was taken in 500ml beaker and evaporated to decrease the volume of about 30ml and was kept undisturbed for crystallization.

The crystals were taken and washed with deionized water and dried at 50 °C in a heating oven for about 2 hrs and the product was taken and kept in a desiccator .

M= Cu(II) was prepared using this method.

4.3.2 SYNTHESIS OF Mn(II) and Cd(II)

Methionine- 0.74 g and Na₂CO₃- 0.265 g were taken in a beaker containing about 200ml of water and heated to dissolve the mixture. The pH of solution was adjusted to 7.0 and filtered. M(II) salt of about 0.30- 0.55 g was dissolved in 50ml deionized water and filtered using filter paper. Both filtrate was mixed together and refluxed for about 1 hr. The filtration was done in hot condition in a 500ml beaker. The solution was then allowed to evaporate slowly and reduce the volume to about 30ml and kept undisturbed for crystallization after filtration. The crystals were taken and washed with deionized water and dried at 50 °C in an heating oven for about 2 hrs and the product was kept in a desiccator.

M= Mn(II), Cd(II) was prepared using this method

4.4 METHOD- CYCLIC VOLTAMMETRY

Redox behaviour of Copper, Cadmium and Manganese systems in coordinated and uncoordinated states were examined by Cyclic voltammetry. All solutions were freshly prepared in chloride buffer.

The working electrode surface was polished with powdered alumina and rinsed with deionized water before doing all process.

The system was deoxygenated by purging N_2 gas for about 30 min and by stirring with magnetic stirrer the system was homogenized.

The cyclic voltammograms of solution were recorded with respect to Ag/AgCl reference electrode.

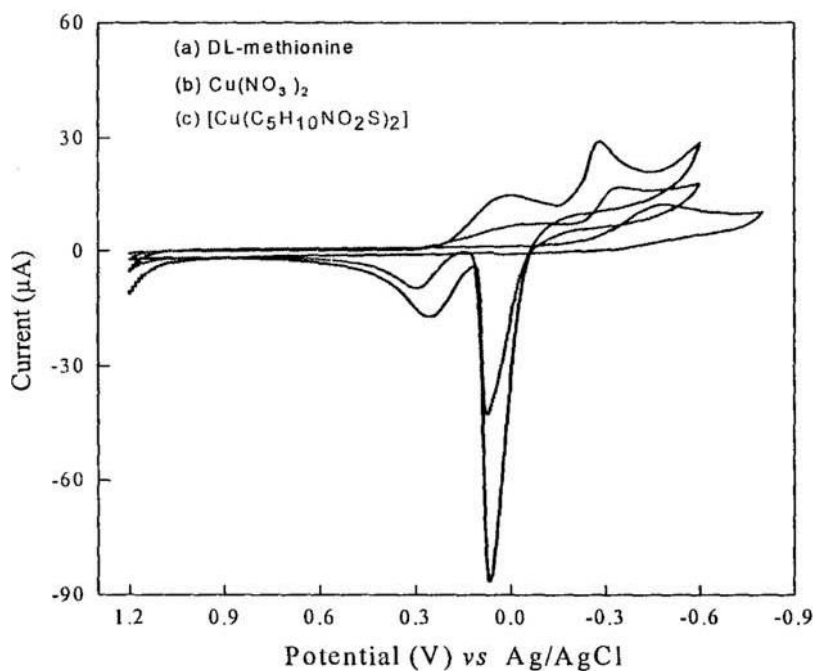
The heterogeneous charge transfer rate constant, k_f values for the electro active species were calculated from the experimental data.

CHAPTER- 5

RESULTS AND DISCUSSION

5.1 CV OF COPPER (Cu) SYSTEM

The redox behaviour of Cu in $[\text{Cu}^{\text{II}}(\text{C}_5\text{H}_{10}\text{NO}_2)_2]$ and in copper chloride was observed on glassy carbon electrode (GCE) with potential 1200 - -900 mV at room temperature.

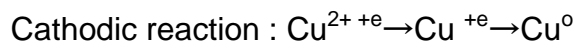


(Fig 5.1: Cyclic voltammogram of Copper system)

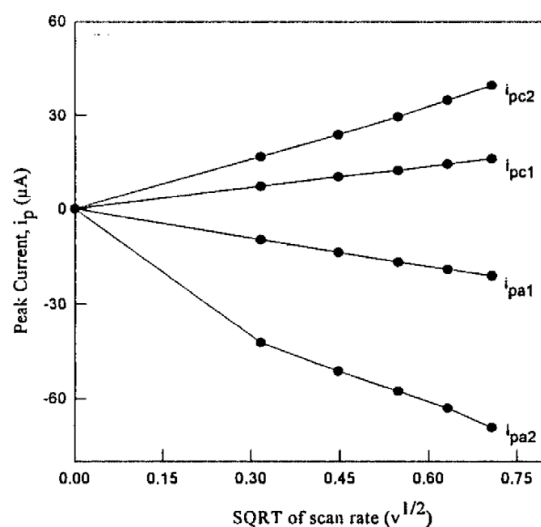
In metal complex (Fig 1.6), there are two cathodic peaks at the potentials -0.088 and -0.339 V and two anodic peaks at potentials 0.300 and 0.074 V. All the peaks are broader than those in metal salt.

Due to the complexation of Cu(II) with DL-methionine, the positions of cathodic peaks and the anodic peaks in the complex were shifted significantly compared to those of metal salts.

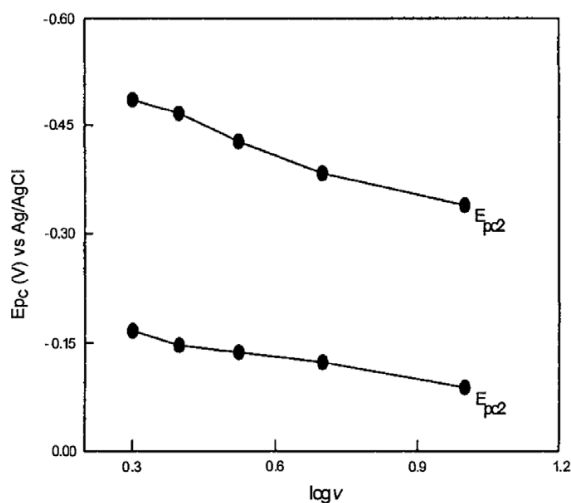
Cyclic voltammogram (Fig 1.60) indicates that there are two one-electron transfer process taking place,



The current-potential data, peak separation, peak current ratio of voltammogram at different scan rates are recorded.



(Fig 5.2: Variation of peak current with square root of scan rate)



(Fig 5.3: Effect of scan rate on peak potential of 1mM)

The observations from the voltammograms are,

According to the voltammogram data metal complex at different scan rates shows the peak current of both the cathodic and anodic peaks increase in increase with scan rates.

In (Fig 1.7), a plot of peak potential i_{pc} (μA) vs SQRT of scan rate for the copper complex is shown. The plot indicates that the i_p , value increases with increase of scan rate v .

In (Fig 1.8), a plot of cathodic peak potential, E_{pc} (vs) Ag/Agcl (vs) $\log v$ for metal complex express that the slope of the tafel plot is not zero which implies that the redox process is **not reversible**. It also indicates that E_{pc} is shifted towards the positive potential with increase of $\log v$.

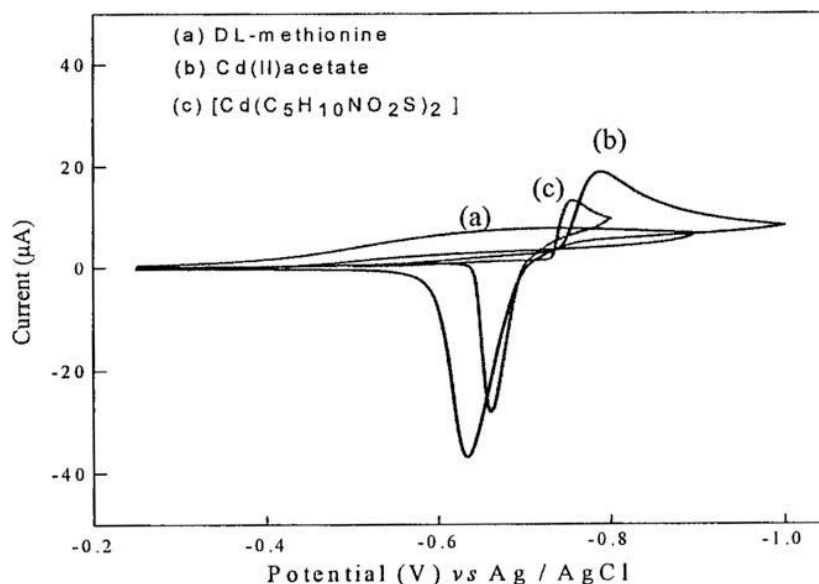
Hence the electrochemical process is **irreversible**.

(Table 5.1)- Current potential data, peak potential separation, peak current ratio of the voltammograms of $[\text{Cu}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$ in chloride buffer at different scan rates :

Scan rate (v) (V s^{-1})	Anod ^c peak potential E_{pa} (V)	Cath ^c peak potential E_{pc} V (-)	Anod ^c peak curr ^t i_{pa} A (-)	Cathd ^c peak curr ^t i_{pa1} (A)	Peak sep ⁿ $\Delta E = (E_{pa} - E_{pc})$ V	Peak curr ^t ratio i_{pa}/i_{pc}
0.100	0.300	0.088	9.74	7.15	0.388	1.36
0.200	0.310	0.123	13.79	10.19	0.433	1.35
0.300	0.315	0.137	16.83	12.22	0.452	1.38
0.400	0.315	0.147	19.20	14.24	0.462	1.35
0.500	0.320	0.167	21.22	15.93	0.487	1.33
2nd pair						
0.100	0.074	0.339	42.17	16.61	0.413	2.54
0.200	0.074	0.383	51.29	23.70	0.457	2.16
0.300	0.064	0.427	57.71	29.45	0.491	1.96
0.400	0.064	0.467	63.11	34.85	0.531	1.81
0.500	0.059	0.486	69.20	39.58	0.545	1.75

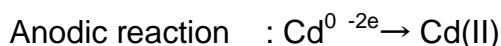
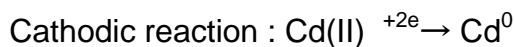
5.2 CV OF CADMIUM (Cd) SYSTEM

Redox behaviour of Cd (II) in Cd(II) acetate and in $[\text{Cd}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$ were examined in chloride buffer using cyclic voltammetry on glassy carbon electrode at the scan rate 100 mVs^{-1} within potentials -200 to -1000 mV at room temperature.



(Fig 5.4: Cyclic voltammogram of cadmium system)

In (Fig 1.9), the cathodic peak at potential -0.784 and the anodic peak at potential -0.575 V is shown. The CV of both electroactive species indicates that there is a two electron process,



The cathodic and anodic peak current in the voltammogram of the complex is significantly lower than that of metal salt. The cathodic peak of the complex is shifted towards the left (towards positive potential) and anodic peak to the right (towards negative potential).

From metal complex, $[\text{Cd}^{\text{II}}(\text{C}_5\text{H}_{10}\text{NO}_2\text{S})_2]$ the cathodic peak is at potential -0.833 V and an anodic peak is at potential -0.605 V.

The observations from the voltammograms are,

According to the voltammogram data, The cathodic and anodic peak currents in the voltammogram of the complex is lower than that of metal salt.

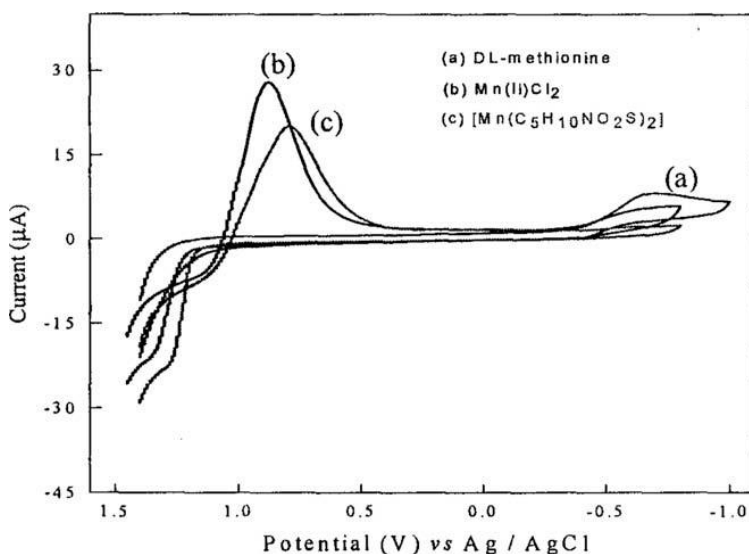
On the other hand , compared to the metal salt positions of the cathodic peak in the complex has also shifted.

The plot indicates that the i_p value increases with increase of SQRT of scan rate v . The cathodic peak potential, E_{pc} vs $\log v$ (Tafel plot) for metal complex shows that the slope of the plot is not zero.

Hence the electrochemical process is **irreversible**.

5.3 CV of MANGANESE (Mn) System

Redox behaviour of 1 mM DL- Methionine, 1mM $MnCl_2$ and 1 mM of $[Mn(C_5H_{10}NO_2S)_2]$ in chloride buffer were examined using Cyclic voltammetry.



(Fig 5.5: Cyclic voltammogram of Manganese System)

From (Fig 1.10), In the metal complex , there is a cathodic peak at potential 0.793 V and anodic peak at 1.280 V. From the cyclic voltammogram it is observed that the electron transfer is one a step process.

Cathodic reaction : $\text{Mn(II)}^{+2} \rightarrow \text{Mn(II)}$

Anodic reaction : $\text{Mn}^0 - 2e^- \rightarrow \text{Mn(II)}$

The observations from the voltammograms are,

The peak current of cathodic peak of the complex is lower than that of metal salt.

Peak currents of both anodic and cathodic peaks increase with the increase of scan rate in the voltammogram of the complex. The first cathodic peaks are shifted towards right.

The value of ΔE increases with the increase of scan rate.

Plot of peak current i_{pc} (μA) vs. SQRT of scan rates (Randles-Sevcick plot) for the metal complex shows the i_{pc} value increases with the increase of SQRT of scan rate v .

Plot of cathodic peak potential, E_p vs. $\log v$ (Tafel plot) for metal complex shows that the slope of the plot is non zero.

Hence the electrochemical process is **irreversible** for this system.

5.4 OBSERVATION- CV DATA

(Table 5.2)- CV- Data Observation:

Sample ID	Cath ^c peak poten ^l E_{pc} V (-)	Cath ^c peak current i_{pc} (A)	Tafel slope $b = 2.303 RT/\alpha n_a (F)$	Diff ⁿ coeff. $D \times 10^{11} \text{ cm}^{-2} \text{ s}^{-1}$	$-\log k_f$ (cm s^{-1})	Charge transfer rate constant $k_f \times 10^6 (\text{cm s}^{-1})$
Cu(NO ₃) ₂	0.236	23.11	0.2602	2.63	5.2832	5.21
[Cu(C ₅ H ₁₀ NO ₂ S) ₂]	0.334	17.49	0.3367	1.95	5.4041	3.94
Cd(II) acetate	0.758	69.11	0.1377	12.40	4.8076	15.6
[Cd(C ₅ H ₁₀ NO ₂ S) ₂]	0.805	34.28	0.0306	0.07	5.1119	7.7
MnCl ₂	0.878	27.08	0.2372	6.58	5.0640	8.63
[Mn(C ₅ H ₁₀ NO ₂ S) ₂]	0.793	17.97	0.2295	28.05	5.242	5.73

$T = 298 \text{ K}$, $n = \text{no. of electron transferred} = 2$, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$, $F = 96,500 \text{ C}$, $A = \text{surface area of the electrode} = 0.05 \text{ cm}^2$.

The current potential data, Tafel slope b , diffusion coefficient, D and charge-transfer rate constant, k_f calculated from the voltammograms of 1.0 mM metal salts and metal complexes in chloride buffer at 100mVs^{-1} and at ambient temperature were observed.

From **(Table 5.2)**, the very high peak separation potential for the metal complexes confirms that the system is irreversible. The anodic and cathodic peak current ratio for electroactive species are slightly deviated from the unity, which also confirms the system is irreversible **(David k. and Gosser Jr.,1993)**.

Peak heights of cathodic and anodic signals increases positively with scan rate, so that the electrochemical system supports the process to be diffusion controlled (Bard and Faulkner, 1980).

The k_f value of the metal complex system is lower than metal salt system. The charge transfer rate constant (k_f) for metal complexes lower than respective metal salts at an identical experimental conditions.

CHAPTER-6

SUMMARY AND CONCLUSION

Three metal complexes of DL- Methionine complexes were synthesized in aqueous medium. The general molecular formula of the complex is $[M^{II}(C_5H_{10}NO_2S)_2]$, where M^{II} = Cu(II), Cd(II), Mn(II). All the solutions and the complexes were freshly prepared in chloride buffer (pH 2.2).

The complexes synthesized were characterized using Cyclic voltammetry (CV) technique, which is the forefront in the electrochemical study of metal complexes. Cyclic voltammograms of each metal complex shows the cathodic and anodic peaks at different scan rates resulting in their electrochemical , redox behaviour of the complex. It describes whether the system is single step electron transfer or double step electron transfer and the system is reversible or irreversible system.

Voltammogram data were obtained for each system using CV. In Copper system there are two one-electron transfer taking place, In Cadmium system there are two electron transfer process, In Manganese system there is one step electron transfer process. The Tafel plot for all the three system was not zero, hence the Cu, Cd and Mn systems are irreversible.

CHAPTER-7

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