



Formation of binary and ternary complex of Cu (II) with tridentate schiff base and dipeptide as primary and secondary ligand

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Abstract

The stability of 1:1:1 ternary chelates of bivalent Cu(II) metal ion with Schiff base 4-hydroxy-3-(1-{2(4-fluoroenzylideneamino)phenylimino}ethyl)-6-methyl-2H-pyran-2-one MF: C₂₁H₁₇N₂O₃F) as primary ligand(L) and DL-Alanyl-Glycyl as secondary ligand (R) have been carried out in 60% (v/v) THF-Water medium pH metrically at 30° C and 0.1 MNaClO₄ ionic strength. The stability constants of ternary complexes ML and MR are also determined under similar experimental conditions. The stability constants of ternary complexes are evaluated and their relative stabilities compared to the corresponding binary complexes are evaluated and their relative stabilities compared to the corresponding binary complexes are expressed in terms of statistical parameter $\Delta \log k$, K_R , K_L and K_T values. The species distribution curves are used to explain the variation in concentration of these as function of pH. The pH have been discussed by Irving-Rossotti technique and evaluated by using the computer SCOGS program.

Keywords: ternary complex, dipeptides, schiff base, potentiometry, tridentate ligand

Introduction

Mixed chelation occurs commonly in biological fluids, as millions of potential ligands are likely to compete for metal ions found *in vivo* i.e. sodium, potassium, magnesium, calcium, manganese, iron, cobalt, copper, zinc and molybdenum.¹ Ternary coordination lay an important role in biological processes^[2-8].

Schiff Bases shows complexing properties with metals. This complexing property is due to presence of electron donor imines, diazo and hydroxyl sites, which acts as coordinating sites^[9, 10]. These metal complexes have wide range of applications as an anti-inflammatory, antipyretic, analgesic, antidiabetic, antibacterial, anticancer^[11-14]. The ternary complex formation equilibria of tetradentate Schiff base with 4-hydroxy-3-(1-{2-[(4-chlorobenzylideneamino)phenylimino]ethyl)-6-methyl-2H-Pyran-2-one as primary ligand and DL-Alanyl Glycyl (R₁), Glycyl-DL-Valine(R₂) dipeptides as secondary ligands with Cu, reported earlier^[15, 16]. In the present work here report about ternary complex formation of Cu(II) metal with tridentate Schiff base 4-hydroxy-3-(1-{2(4-fluoroenzylideneamino)phenylimino}ethyl)-6-methyl-2H-pyran-2-one as primary ligand(L) and DL-Alanyl-DL-Valine as secondary ligand (R). In continuation of our earlier work^[17] we have prepared tri dentate Schiff base with known method.

Experimental

All the reagents used were of AR grade. Schiff Base was found insoluble in water there for 60% (THF: Water) used as a solvent in present investigation. AR grade THF used further purified by Known literature method^[17]. Ligand was synthesized by known method of ligand reported. The ligand solution (0.1M) was prepared in distilled THF. A standard 0.2N NaOH solution was used for titrations

prepared in distilled water. Standard solutions of AR grade HClO₄, NaClO₄ (1.0 M) were prepared in distilled water and standardized by known methods.¹⁷ Experimental procedure by potentiometric titration technique performed in inert atmosphere (nitrogen) at ionic strength of 0.1 M (NaClO₄). The potentiometric technique for study of the mixed ligand complexes include following titrations.

1. 2ml HClO₄ (0.2N) + 5 ml NaClO₄ (1M) + 13(ml) Water + 30ml THF (A).
2. 2ml HClO₄ (0.2N) + 5 ml NaClO₄ (1M) + 10ml Ligand 13 ml (0.1M) + 20ml THF (A+R).
3. 2ml HClO₄(0.2N) + 5 ml NaClO₄(1M) + 10 ml ligand + 2 ml Metal solution(0.01M) + 11ml Water + 20 ml THF (A+R+M).
4. 2ml HClO₄(0.2N) + 5 ml NaClO₄(1M) + 10 ml ligand (L)+ 10ml secondary Ligand (R) (+2 ml Metal solution(0.01M) + 11ml Water + 10 ml THF (A+R+M).

The solutions were titrated pH metrically against (0.2N) NaOH. All other solvents used during the entire research work were of AR grade

Apparatus

The titrations were carried out using Elico digital pH meter (model LI-127) equipped with a CL-51B combined electrode for pH measurements. Before titrations pH meter was calibrated against standard buffers (pH 4.02 and 9.18) readings were corrected for THF: water media. The pH and volume of NaOH piloted to determine protonation constants and stability constants of the Schiff bases and their complexes were determined. Throughout the experimental work glass distilled water was used. This was obtained by double distillation of deionised water in presence of crystals of potassium permagnate and potassium hydroxide pallets. For synthesis of Schiff bases, ethanol and methanol were

used as commercial solvents. Structure of Ligand is as follow.

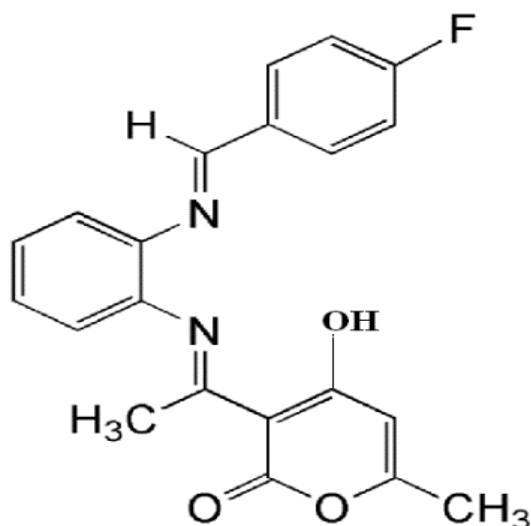


Fig 1: 4-hydroxy-3-(1-(2-(4-fluorophenyl)imino)phenylimino)ethyl)-6-methyl-2H-pyran-2-one

Potentiometric Measurement

Stock solutions of ligand (0.1M) was prepared in THF. The protonation constants of primary ligand (L) and secondary ligands DL- Alanly Glycyl (R) with Cu ions determined in 60% (v/v) THF: Water medium. The Irving-Rossetti technique was used after appropriate pH corrections determined by using method suggested by Van Uitert.¹⁸ The protonation constant and metal- ligand stability constant of ligands is given in the (Table 1). The pH values of titrations were found in between pH 3 to 11 from pH metric data the stoichiometry, deprotonation and stability constants were calculated. Primary and secondary ligands form both 1:1 and 1:2 complexes with Cu(II) ions. Here two systems are represented in the above work. The Concentration of various species HL, L, R, Cu L, Cu R, Cu LR, at different pH were obtained by using SCOGS computer programme.^{19,20} The concentration of these species were plotted against pH values to study complexing equilibria and predominance of mixed ligand complexes over binary complexes. Equilibrium constant β_{111} for the reaction



Result and Discussion

Binary Metal Complexes

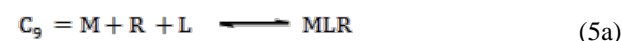
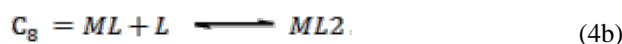
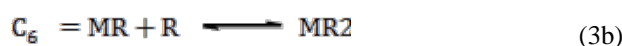
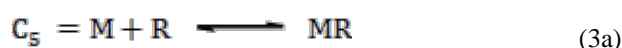
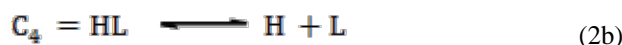
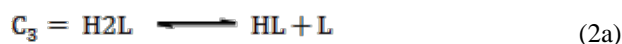
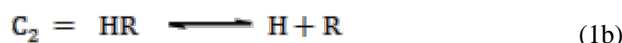
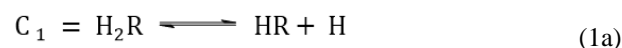
Proton ligand constants of primary ligand (L) and Secondary ligand (R) determined by Irving-Rossetti technique. Primary and Secondary ligand form both 1:1 and 1:2 complexation with Cu(II). The values of P^k , $\log k_1$, $\log k_2$ are presented in Table 1.

Ternary Complexation

The pH titration curves for systems Cu (II)-L-R is represented in (Fig.2). The possible equilibria in the ternary chelation was done by analyzing the graph. The precipitation pH of mixed ligand complex was about 7.2. The mixed ligand curves coincide with A+L curve at pH 1.4 and then deviates. The mixed ligand curve from the theoretical composite curve towards left indicate the

formation of ternary complex. The mixed ligand curve did not coincide with A+L+M and A+R+M metal complex titration curves, indicates the formation of 1:1:1 complex by a simultaneous equilibria.

The species distribution curves as a function of pH were generated using SCOGS computer programme. The initial percentage of free metal at pH = 3.2 is very less i.e. 3.6 which indicates the maximum consumption of metal ions in the complex formation at this pH. It sharply decreases up to pH 5.2 after which the concentration remains constant indicating the maximum complexation in the pH- range 3.2 to 5.2. The percentage of free ligands L and R₁, though extremely low (~0.03%) found to increase with increasing pH. The percentage of F_L and F_R reaches to 6 and 0.64 percent respectively at pH 5.5 and then remains constant. Due to the dissociation of excess ligands present in the system increase in free ligand concentrations. The values of β_{111} , β_{20} , β_{02} , K_L , K_R , K_f and $\Delta \log K$ are presented in (Table. 2). These values express relative stabilities of binary and ternary complexes. The comparative study of β_{111} with the product of β_{20} and β_{02} i.e. K_R of the system confirm formation of ternary complexes over binary complexes of primary as well as secondary ligands. Since they show positive value. Relatively higher positive value of K_R than K_L reveals greater stability of ternary complexes with respect to the binary complexes of secondary ligand than that of primary ligand.



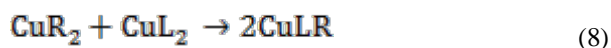
To understand mechanism and extent of ternary complex formation at different pH the species distribution curves are most useful. The speciation diagram obtained for Cu(II)LR is presented in Figure 2. From C₉ curve it can be observed that initially ternary species is near about 52% at pH 3.2 it increases sharply upto 96% at pH 5.4 then after it remains constant thus more than 96% metal ion is present in the form of ternary complex at pH 5.4.

The reaction 1b and 2b represent formation of R(C₂) and L(C₄) their continuous decrease in pH indicate the formation of Cu LR by reaction 5a(C₉). It can be seen that concentration of HL and HR at initial pH 3.2 are 13 % and 30% respectively which sharply decreases up to pH 5.4 and then remains constant. The formation of ternary complex also takes place to maximum extent i.e. 95% in the same pH

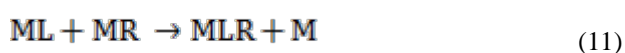
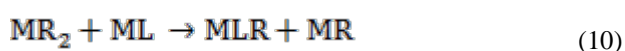
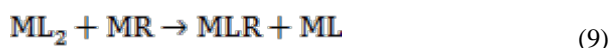
range which support possibility of C_9 . The possibility of formation of $CuLR$ in the present investigation is also possible by following equilibria



The other way of characterizing the ternary complexes is by following disproportionation reactions.



This reaction is possible if both ligands form 1:1 and 1:2 complexes individually with the metal ion. Otherwise disproportionation reactions are



The reaction 9 and 10 are possible when both ligands forms 1:1 and 1:2 binary complexes. The reaction 11 indicates ligand which form only 1:1 binary complex with metal ion. From species distribution curve it shows that initial

concentration of primary C_4 and secondary ligands C_5 decreases sharply up to pH 4.2 and 5.4. The percentage distribution curves of free metal (F_M), free primary ligand (F_L) and free Secondary Ligand (F_R) are shown in Figure (3-5). The initial percentage of free metal is 0.09 at pH 3.2 which indicates the maximum consumption of metal ions in the complex formation at this pH. Concentration of free metal sharply decreases up to pH 4.4 then after it remains constant this indicates the maximum complexation in the pH range of 3.2 to 5. The percentage of free ligand F_L and F_R initially is very low near about 0.01% and increases with increase in pH. The percentage of free primary ligand (F_L) and free secondary ligand (F_R) reaches to 0.3 and 3.2 respectively at pH 5 and 4.4 and then remains constant. This increase in free ligand concentration may be due to the dissociation of excess of ligands present in the system. The relative stabilities of the binary and ternary complexes are expressed in terms of β_{111} , β_{20} , β_{02} , K_L , K_R , K_r and $\Delta \log K$ are presented in (Table. 2). These values express relative stabilities of binary and ternary complexes. The K_L value more than K_R indicates that ternary complexes with respect to binary complexes of secondary ligand than binary complex of primary ligand. The negative value of $\Delta \log k$ complex indicates that the ternary complex is less stable than binary complexes of primary and secondary ligand and also due to reduced number of coordinating sites. From ternary complex curve.

Table 1: pK and log k values of Cu (II) chelates of ligand and dipeptide in 60 % (v/v) THF-water medium at Temp: 30 °C and ionic strength $\mu = 0.1$ M NaClO₄

Ligands(L) / peptide(R)	pK ₁	pK ₂	logk ₁	Logk ₂	logβ
Ligand (L)	3.01	9.98	9.39	8.84	18.23
DL-Alanyl Glycyl(R ₁)	4.13	8.45	6.05	-	6.05

Table 2: Parameters of formations of mixed ligand complexes of Cu (II) with primary Ligand (L) and dipeptides (R)

Dipeptides	logβ ₂₀	β ₀₂	β ₁₁	k _L	k _R	k _r	Δlogk
DL-Alanyl glycine(R ₁)	5.2785	7.5555	9.7271	6.9573	2.1716	-	-0.5982

Conclusion

Present investigation include the study of - Ternary complex formation equilibria of Cu (II) metal involving tri dentate Schiff base ligand (L) 4-hydroxy-3-(1-(2(4-fluoroenzylideneamino)phenylimino)ethyl)--6-methyl-2H-pyran-2-one MF:C₂₁H₁₇N₂O₃F) as primary ligand(L) and DL-Alanyl-Glycyl as secondary ligand (R). The stability of ternary complex is mainly governed by characterisation of approaching secondary ligand the stability therefore depends on ring size which is offsets the overall basicity the secondary ligand. From graph it is observed that at initial stage at pH 3.2 ternary complexation is near about 52%, at this pH primary and secondary ligand concentration is about 30% and 13% and it decreases sharply upto pH 5.2 where ternary complex formation is near about 93% at pH 7.2. This indicate involvement of both primary and secondary ligand involved in in Ternary Complexation.

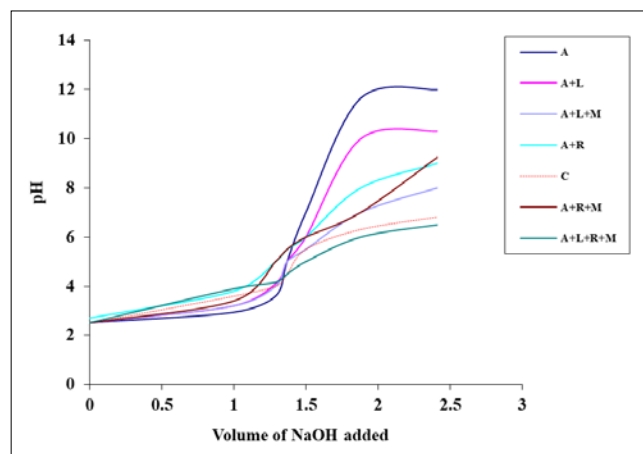


Fig 1: Potentiometric titration curve in Cu LR system

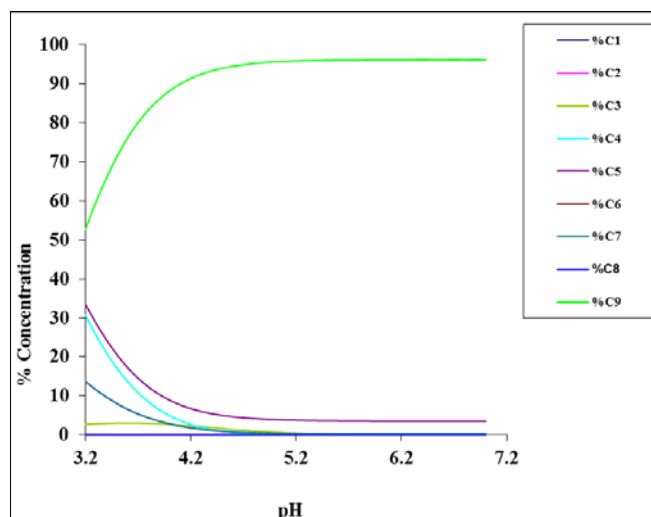


Fig 2: Species distribution diagram in Cu LR system

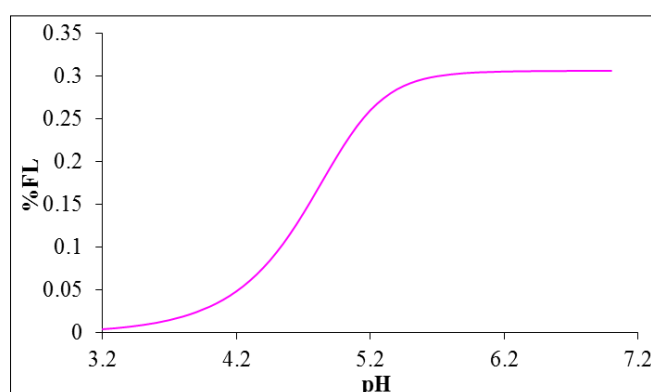


Fig 3: Percentage distribution curve of F_L in Cu LR

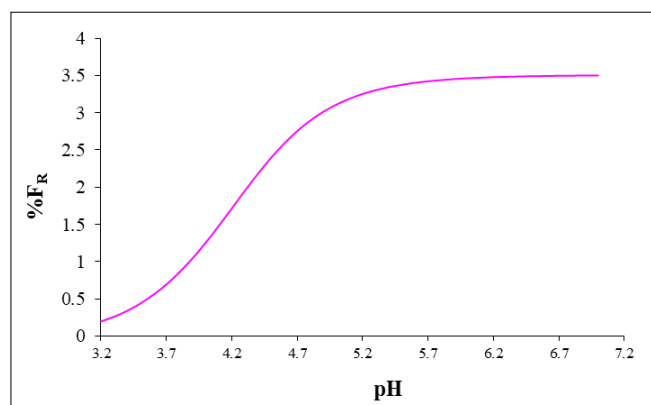


Fig 4: Percentage distribution curve of F_R in Cu LR

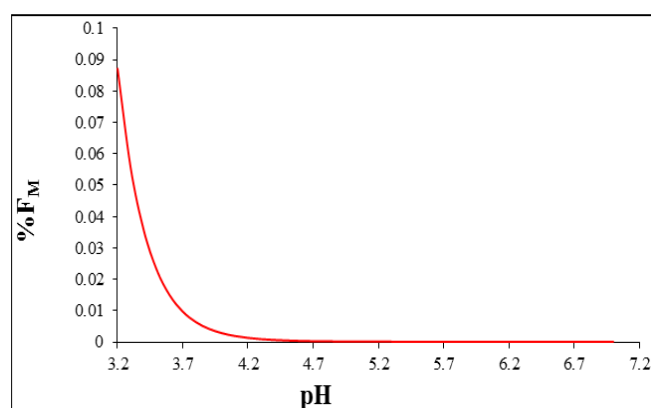


Fig 5: Percentage distribution curve of F_M in Cu LR

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