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EQUILIBRIUM STUDIES OF MERCURY (II), LEAD (II) AND CADMIUM (II) IONS INVOLVING ASPARTIC ACID AND THYMINE

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ABSTRACT

Equilibrium studies of Hg (II), Pb (II) and Cd (II) ions with aspartic acid (X) and thymine (Y) ligands in aqueous solution have been investigated. Stability constants of the complexes and the complex formation equilibria at temperature 37 ± 1°C at the ionic strength I = 0.1 M ($NaNO_3$) have been determined by potentiometric method. Complexes of the type MXY (1:1:1) and $M_1 M_2 X Y$ (1 : 1 : 1 : 1) have been discussed.

Keywords: SCOGS, Aspartic acid, Thymine and Quaternary complexes.

INTRODUCTION

Human body contains many chelating agents such as amino acids, globins, proteins, enzymes, carboxylic acids and nucleic acid-bases, which form chelate compounds[1, 2] with the metal ion present in the living organism. Recent research results [3, 4, 5, 6, 7] have clearly demonstrated the need for comprehensive studies of metal ions and bio-ligand interaction as model systems. Multi metal-multiligand complexes studied gives clues to the roles of metal ions in many enzymic reactions[8, 9]. This paper deals with the investigation of Hg (II), Pb (II) and Cd (II) complexes with aspartic acid and thymine. The relevant stability constants have been calculated using SCOGS[10] computer program.

MATERIALS AND METHODS

All the reagents were of A.R. grade and their solution were prepared in double distilled CO_2-free water. Metal nitrate solutions were standardized by EDTA titration methods[11] combined with ion exchange and acid base titration[12]. For all the binary, ternary and quaternary systems, following solution mixture have been titrated against standardized NaOH (O.01M) solution, keeping the total volume 50.0 ml in each case:

(i) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + H_2O

(ii) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + 5ml X(0.01M) + H_2O

(iii) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + 5ml Y(0.01M) + H_2O

(iv) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + 5ml X(0.01M) + 5ml M_1(II)(0.01M) + H_2O

(v) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + 5ml X(0.01M) + 5ml M_1(II)(0.01M) + 5ml Y (0.01M) + H_2O

(vi) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) +5ml X(0.01M) + 5ml M_2(II)(0.01M) + 5ml Y (0.01M) + H_2O

(vii) 5ml $NaNO_3$(1.0M) + 5ml HNO_3(0.02M) + 5ml X(0.01M) + 5ml M_1(II)(0.01M) + 5ml Y (0.01M) + 5ml M_2(II)(0.01M) + H_2O

Where, M_1 (II) and M_2 (II) are Hg (II)/Pb (II) / Cd (II). X = Aspartic acid and Y =Thymine

Species distribution curves were obtained by plotting % concentration of the species obtained through SCOGS against pH. Complex formation equilibria were elucidated with the aid of the species distribution curve.

RESULTS AND DISCUSSIONS

The ligand aspartic acid is potentilly a tridentate ligand towards metal ions coordinating through a nitrogen and two carboxyl oxygen atoms. The secondary ligand thymine is chemically 2, 4-dioxo-5-methylpyrimidine.It has been concluded that in general, thymine acts as a bidentate ligand.[13]

Proton ligand stability constants obtained for both the ligands and other related stability constants are presented in table 1-5. Which are in good agreement with literature values [14]. The formation of quaternary complexes in an aqueous solution may be conveniently expressed by the equilibrium

$$pM_1 + qM_2 + rX + sY + t\,(OH) \rightleftharpoons (M_1)_p\,(M_2)_q\,(X)_r\,(Y)_s\,(OH)_t$$

The overall stability constant is given by

$$\beta_{pqrst} = \frac{[(M_1)_p\,(M_2)_q\,(X)_r\,(Y)_s\,(OH)_t\,]}{[M_1]^p\,[M_2]^q\,[X]^r\,[Y]^s\,[OH]^t}$$

Where the stoichiometric numbers p, q, r, s are either zero or positive integer and t is a negative integer for a protonated species, positive for a hydroxo or a deprotonated species and zero for a neutral species.

The speciation curves indicate the formation of heterobinuclear complex species M_1M_2XY in the pH range —2.6-9.5, according to the following equilibria

$$M_1^{2+} + M_2^{2+} + [XH]^{2-} + YH \rightleftharpoons [M_1M_2XY] + 2H^+$$

It is clear from the speciation curves that formation of heterobimetallic complexes is preferred over the homometallic complexes.

the following species have been considered to exist in the equalibria Pb(II)-Cd(II)-X-Y (1:1:1:1)

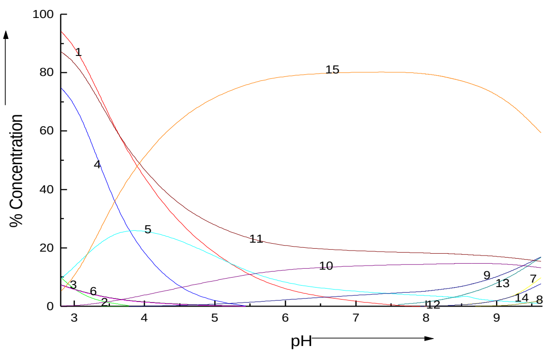


Fig. 1: Distribution Curves of 1:1:1:1 Pb (II)–Cd (II) –X-Y System (1) Cd^{2+}(II) (2) Pb^{2+}(II) (3) H_3X (4) H_2X (5) HX (6)YH(7)$Cd(OH)_2$ (8)$Cd(OH)^+$ (9)$Pb(OH)_2$ (10)CdY (11)PbX (12)PbY (13)CdXY (14) PbXY(15)PbCdXY

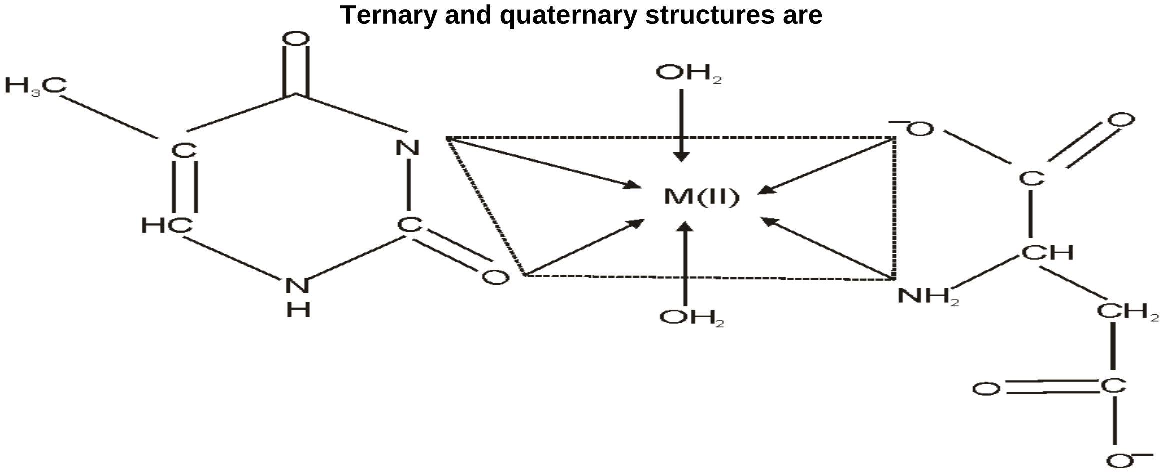
CONCLUSIONS

On the basis of experimental results we have to say that, ternary and quaternary complexes of mercury are more stable in comparison of lead and cadmium. The overall stability constants of ternary (MXY) and quaternary systems (M_1M_2XY) have been found to fallow the following order:

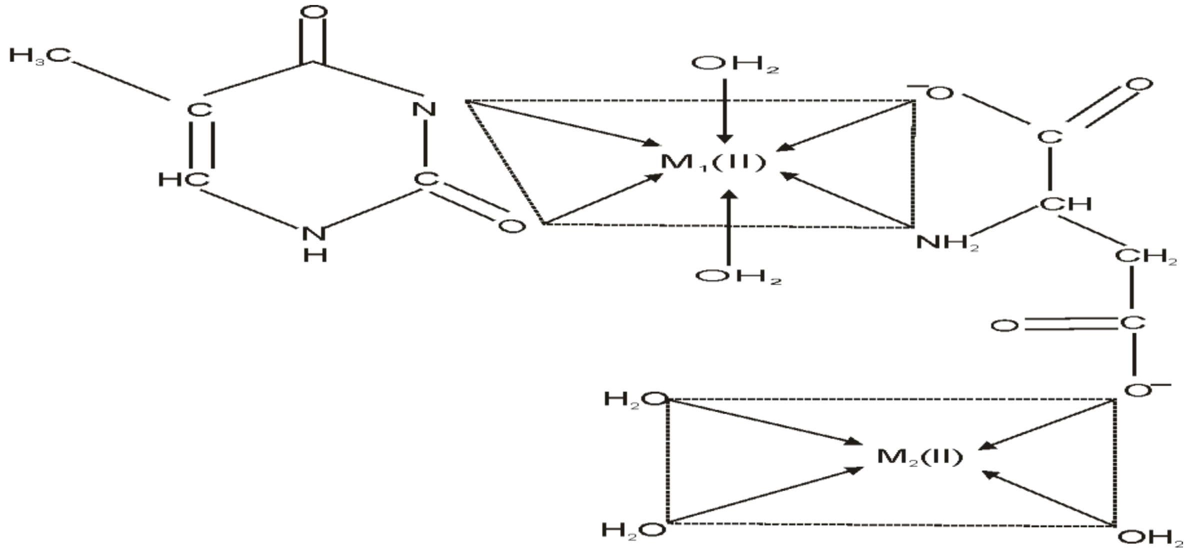
Ternary System: HgXY > PbXY >CdXY

Quaternary System: Hg-Pb-XY >Hg-Cd-XY >Cd-Pb-XY

Ternary and quaternary structures are



Structure 1: Ternary (MXY)



Structure 2: Quaternary (M_1M_2XY)

Table 1: Proton-ligand formation constant (log β_{00r0t}/ log β_{000st}) of Aspartic acid and Thymine at 37 $\pm$ 1^{0}C, I = 0.1 $NaNO_3$

Complex	log β_{00r0t}/ log β_{000st}
H_3X	15.26
H_2X	13.33
HX	9.63
YH	9.94

Table 2: Hydrolytic constants (log β_{p000t}/ log β_{0q00t}) M^{2+} (aq.) ions

Complex	Hg	Pb	Cd
$M(OH)^+$	-3.84	-9.84	-6.89
$M(OH)_2$	-6.38	-15.54	-14.35

Table 3: Metal-Ligand constants (log β_{p0r00}/ log β_{0qr00}/ log β_{po0s0}/ log β_{0q0s0}) Binary System

Complex	Hg	Pb	Cd
MX	13.08	11.60	4.38
MY	13.42	12.77	11.45

Table 4: Metal-Ligand constants (log β_{p0rs0}/ log β_{0qrs0}): Ternary System (1:1:1)

Complex	Hg	Pb	Cd
MXY	21.11	18.08	14.15

Table 5: Metal-Ligand constants (Log β_{pqrst}): Quaternary System (1:1:1:1)

Complex	Hg-Pb	Hg-Cd	Cd-Pb
M_1M_2XY	28.81	27.80	26.82

REFERENCES

1. Grvan FL. Chelating Agents and Metal Chelates (Ed. F.P. Dwyer and D.P. Mellor) Academic Press, New York. 1964;7:283.
2. Birch J. Handbook on Toxicity of inorganic compounds. Marcel Dekker, New York. 1988;383.
3. Tripathi NK and Krishna V. Journal of Ultra Chemistry. 2011;7(2):317-319.
4. Doja A and Roberts W. Immunizations and autism: a review of the literature. Can J Neural Sci. 2006;33(4):341-346.
5. Tripathi NK and Krishna V. Journal of Ultra Chemistry. 2013;9(1):83-86.
6. Kumar K and Tripathi NK. IJRANSS. 2018;6(3):129-136.
7. Shukla BK, Kumar R, Verma S and Krishna V. IJRPC. 2016;6(4):643-649.
8. Sigel H. Angew Chem Int Ed Engl. 1975;14:394.
9. Sigel H. Chemistry of Metals in Biological System. Journal of the European Science Foundation. 1991;24:16-17.
10. Sayce IG. Talanta. 1968;15:1397-1411.
11. Welcher FJ. The analytical uses of ethylene diamante tetraacetic acid, Van D. Nostarand Company, New York. 1957;169.
12. Kolthoff IM, Sandell EB, Meena EJ and Bruckenstein S. Quantitative chemical analysis. Macmilan, London. 1969;41.
13. Jonsson MJ. Rec Trav chim. 1957, 76:827.
14. Perrin DD. Stability Constants of Metal ion Complexes. Pergamon. New York. 1979.