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Study of [Pb(II) Dicarboxylic Acids-Propylenediamine] System as a Tool in Removal of Excess Lead from Human Blood: A Polarographic Approach

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The mixed ligand complexes of propylenediamine (pn) and malonate (mal^{2-}) or maleate ($male^{2-}$), with Pb(II) have been studied polarographically at constant ionic strength, μ = 1.5 M ($NaNO_3$) and pH 7.3 at 25.0 ± 0.1 ºC. The reduction of the complexes at d.m.e. is reversible and diffusion-controlled. One mixed complex [Pb(mal)(pn)] and [Pb(male)(pn)] is formed in each case and the stability constant at 25 ºC are log β_{11} = 8.99 and 8.90, respectively.

Key Words: Polarography, Pb(II) dicarboxylic acids, Propylenediamine, Lead removal, Human blood.

INTRODUCTION

The excess of lead in the human blood is extremely dangerous for their health as it can cause brain damage too. Lead pollution is caused chiefly by interior decoration, PVC water pipes carrying water to the houses, paints, vehicles and industrial wastes as well as by cheap Chinese jewellery and children's toys. Chinese manufacturers are suspected of recycling lead from discarded computers for use in cheap jewellery and some kinds of toys. Hence it is imperative that the excess amount of lead in the human blood be excreted by means of complexes which make lead soluble and excreted it through urine.

The present study is aimed at presenting complexes which makes excess lead soluble. From the survey of literature[1-11] it appears that polarographic studies of mixed complexes of Pb(II) with propylene diamine and malonate, maleate are still lacking from this point of view. The communication deals with the studies of mixed ligand complexes of Pb(II) with propylene diamine and malonate or maleate.

EXPERIMENTAL

All reagents were analytical grade and their solutions were prepared in conductivity water. The ionic strength was maintained constant at μ = 1.5 M using $NaNO_3$ as supporting electrolyte. The concentration of Pb(II) was maintained at 1 × 10^{-3} M. $NaNO_3$ was used as supporting electrolyte and also to maintain a constant ionic strength (μ = 1.5 M). Triton-X-100 (2 × 10^{-3} %) was used as a maximum suppressor. Polarograms were obtained by means of a manual polarograph (Toshniwal CL 02) in conjunction with Toshniwal polyflex galvanometer (PL 50). All the measurements were made at 25 ± 0.1 ºC and pH 7.3. A saturated calomel electrode (SCE) was used as reference electrode. The d.m.e. had the following characteristics (in 0.1 M $NaNO_3$, open circuit): μ = 2.219 mg/s, t = 3.5 s, $m^{2/3} t^{1/6}$ = 2.10 $mg^{2/3} s^{-½}$, h_{corr} = 40 cm.

The simple system of Pb(II) with propylenediamine (0.05 × 10^{-5} M to 0.5 × 10^{-5} M) and malonate or maleate were studied at different concentrations from 0.025 M to 0.30 M separately prior to the study of mixed system. In case of mixed systems malonate and maleate concentration was varied from 0.05 M to 0.30M and that of propylene diamine (pn) was kept constant at 0.2 × 10^{-5} M. The system was repeated at another concentration of propylene diamine at (0.4 × 10^{-5} M).

RESULTS AND DISCUSSION

The reduction of Pb(II) in propylenediamine and malonate or maleate was found to be reversible and diffusion controlled. The same was true for the mixed system. The slops of linear plots of log i/id-i *vs.* $E_{d.m.e.}$ were in the range 30-33 mv and the plots of id *vs.* $h^{½}_{corr}$ were linear and passed through the origin with the addition of increasing amounts of malonate (mal) or maleate (male), it is seen that $E_{1/2}$ of Pb(II) is shifted, in each case, to more negative values there was showing the formation of complexes. The plots of $E_{1/2}$ *vs.* log [mal] and log [male] and log [pn] are smooth curves thereby indicating the formation of successive complexes[12,13]. The composition and stability constants of the simple complexes have been determined by DeFord and Hume's method[14]. The results are detailed below:

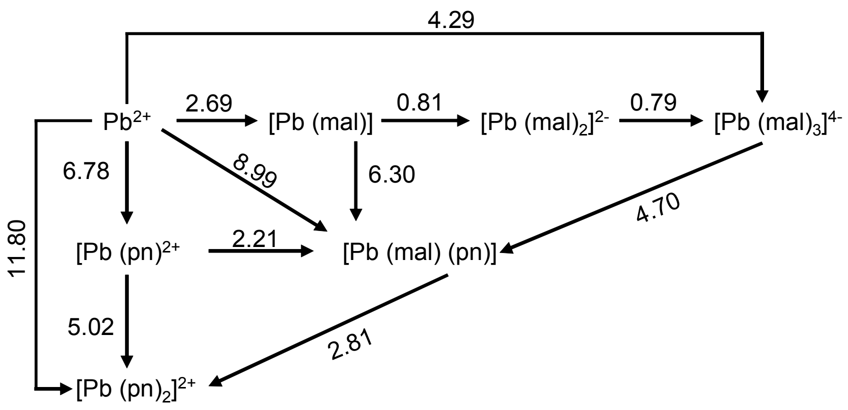
System	Complex species	Stability constants
Pb(II)-pn	$[Pb(pn)]^{2+}$	log β_1 = 7.490
	$[Pb(pn)_2]^{2+}$	log β_2 = 13.400
Pb(II)-mal	[Pb(mal)]	log β_1 = 2.690
	$[Pb(mal)_2]^{2-}$	log β_2 = 3.500
	$[Pb(mal)_3]^{4-}$	log β_3 = 4.290
Pb(II)-male	[Pb(male)]	log β_1 = 1.113
	$[Pb(male)_2]^{2-}$	log β_2 = 1.778
	$[Pb(male)_3]^{4-}$	log β_3 = 4.060

The method of Schaap and McMaster[15] was used to determine the values of the stability constants of mixed complexes. One mixed complex are formed in each system. The results are presented as below:

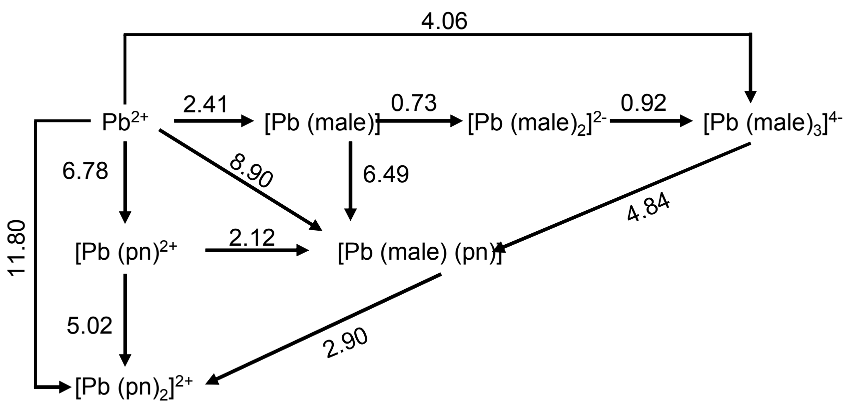
Pb(II)-Malonate-propylenediamine system: [Pb(mal)(pn)] : log β_{11} = 8.99

Pb(II)- Maleate-ethylenediamine system: [Pb(male)(pn)] : log β_{11} = 8.90

The overall results of the present study are summerized in the following diagrams (**Schemes I** and **II**), where the numerical values shown are the logarithms of the equilibrium constants for the reactions indicated:



Scheme-I: Pb(II)-malonate-propylenediamine system



Scheme-II: Pb(II)-maleate-propylenediamine system

The mixing constant K_M (equilibrium constant) for the reactions:

$$½[Pb(mal)_2]^{2+} + ½[Pb(pn)_2]^{2+} \rightleftharpoons [Pb(mal)(pn)] \quad (1)$$

$$½[Pb(male)_2]^{2-} + ½[Pb(pn)_2]^{2+} \rightleftharpoons [Pb(male)(pn)] \quad (2)$$

is given by relation

$$\log K_M = \log \beta_{11} - ½ (\log \beta_{20} + \log \beta_{02})$$

This works out to be +1.34 and +1.43 for the reactions 1 and 2, respectively. The positive values shows that the mixed complexes [Pb(mal)(pn)] and [Pb(male(pn)] are more stable than simple complexes.

This study clearly shows that the binary and ternary complexes of lead with propylene diamine and malonate or maleate are stable as well as soluble in water. Thus it can be concluded that lead can be excreted as soluble mixed complexes -Pb(mal)(pn) and Pb(male)(pn) as well as simple soluble [Pb(mal)], $[Pb(mal)_2]^{2-}$, $[Pb(mal)_3]^{4-}$, Pb(male), $[Pb(male)_2]^{2-}$ and $[Pb(male)_3]^{4-}$ complexes.

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