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Potentiometric study of vitamin C complexes with transition metal ions Co(II), Ni(II), Cu(II)& Zn(II)

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ABSTRACT

The stability constants of Vitamin C complexes with transition metal ions Co(II), Ni(II), Cu(II)& Zn(II) were determined pH metrically at temperature 298K in aqueous medium and an ionic strength 0.1M, 0.3M & 0.6M $NaClO_4$. The stability constants of vitamins and metals have been calculated.

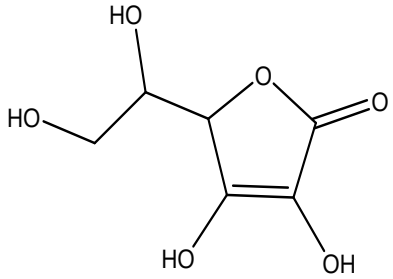
Keywords: Ascorbic acid, stability constants, binary complexes, transition metals.

INTRODUCTION

Vitamin C (Ascorbic Acid) is a water soluble antioxidant. It was first isolated in 1928 by the Hungarian biochemist and Noble prize winner Szent Gyorgyi. It is an unstable easily oxidized acid and can be destroyed by oxygen, alkali and at high temperature.

Unlike animals humans cannot synthesize vitamin C, rendering its ingestion from oxigeneous supplement or diet necessary of human inability to synthesize ascorbic acid is the absence of the active enzyme. 1–gulonolactone oxidase from the liver (Burns, 1959). Body requires vitamin C for normal physiological functions. It help in the metabolisms of tyrosin, folic acid and tryptophan.[1]. It helps to lower blood cholesterol and contributes to the synthesis of the amino acid carnitine and catecholamine that regulate nervous system. It is needed for tissue growth and wound healing. It helps in the formation of neurotransmitters and increases the absorption of iron in the gut. Being an oxidant, it protects the body from the harmful effects of free radicals & pollutants. Deficiency of this vitamin causes defective formation of the collagen fibers of connective tissue due to which the process of healing wounds retards and also causes disease scurvy.[2]. Vitamin C is essential for the process from bone formation to scar tissue repair[3]. In complexes of transition metals the formation of a coordination bond can be considered as a transfer of a lone electron pair from the coordinated group or ligand to the metal ion[4].These metal ligand chelates serves as suitable models for the valuable information in the elucidation of biological processes.[5-7]. The Literature survey reveals that no work has been reported on complex formation of vitamin C with transition metal ions in aqueous medium. Therefore in order to understand the complex formation behaviour of vitamin C at different ionic strength i.e. 0.1M, 0.3M and 0.6M $NaClO_4$ at constant temperature i.e. 298K is studied.

Vitamin C (Ascorbic Acid)



MATERIALS AND METHODS

Materials:

All chemical used were are A.R grade. Ligand sample of vitamin C (Ascorbic Acid) was obtained in pure form. $NaClO_4$ solution was prepared in carbon dioxide free double distilled water. Metal ions were used in the nitrate form (S.D.fine chem.) The sodium hydroxide 0.1M was standardized against oxalic acid. The ionic strength was maintained at 0.1M 0.3M and 0.6M by using $NaClO_4$ (B.D.H.).

The ligand solution and acid solution were transferred into 100 ml beaker and titrated against NaOH solution. The titration was performed first without addition of metal and then in its presence.

METHOD

The potentiometric titrations are performed by using an Elico model LI-120 digital pH meter in conjuction with an Elico combined glass electrode consisting of glass and reference electrode. The combined glass electrode was activated by immersing 24 hours in 0.1 N hydrochloric acid and then 12 hours immersed in glass distilled water. The precautions suggested by Bates[8],Albert and Sergent [9] were adopted for smooth handling of electrode. The combined glass electrode was connected to pH meter. By adopting standard procedure, all titrations were carried out under inert atmosphere by bubbling oxygen free nitrogen gas through an assembly.The buffer solution having the pH ranges 4.00 and 9.18 was used for the standardization of pH meter, before and after each titration. The ligand solution of ascorbic acid was prepared in aqueous medium which was used for further titrations i.e. without and with the transition metals Co(II), Ni(II), Cu(II), and Zn(II) maintaining ionic strength 0.1M, 0.3M and 0.6M $NaClO_4$ at constant temperature 298 K.

Table No.1 Proton ligand stability constants of vitamin C (Ascorbic acid) at different ionic Strengths

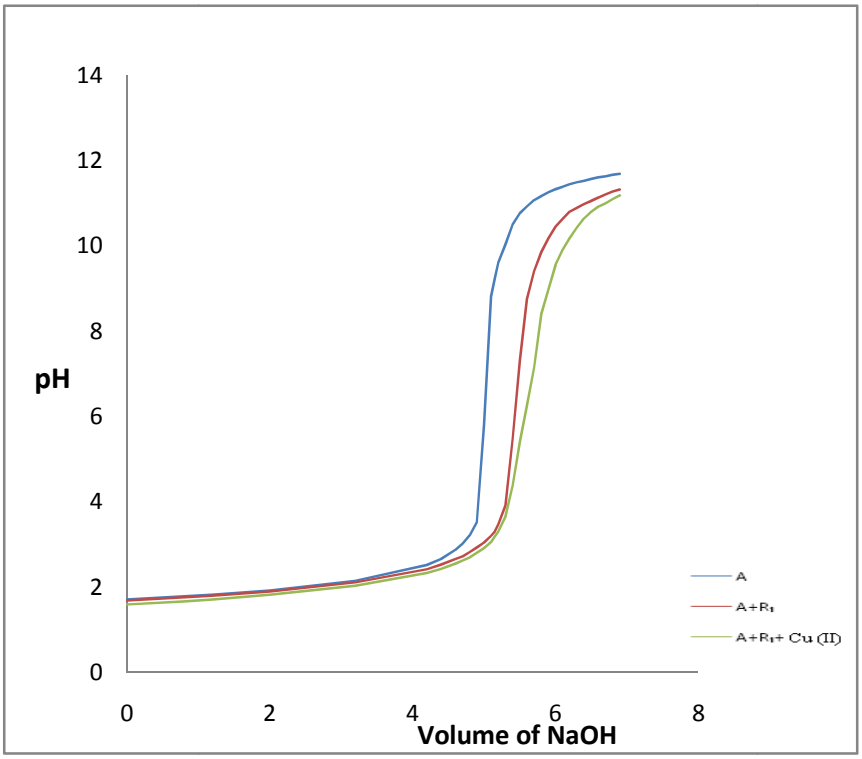
Medium – Water *Temperature- 298K*

Proton Ligand stability constants	Ionic Strengths		
	0.1	**0.3**	**0.6**
pK_1	4.16	4.08	4.02
pK_2	11.54	11.31	11.10

Table No. 2 Metal ligand stability constants of vitamin C (Ascorbic acid) at different ionic Strengths

Transition Metals	Metal Ligand stability constants	Ionic strengths		
		0.1	**0.3**	**0.6**
Co(II)	$logK_1$	7.97	6.57	6.36
	$logK_2$	6.24	5.74	5.63
Ni(II)	$logK_1$	10.83	9.16	8.31
	$logK_2$	6.72	6.40	5.60
Cu(II)	$logK_1$	9.06	8.64	7.25
	$logK_2$	7.99	6.19	6.15
Zn(II)	$logK_1$	8.89	8.25	8.23
	$logK_2$	6.95	6.87	6.75

Fig.1. Potentometric titration curve of ascorbic acid with Cu(II) at μ=0.1M



RESULTS AND DISCUSSION

The proton ligand and metal ligand stability constant of ascorbic acid with transition metal ions $Co^{++,}$ Ni^{++}, Cu^{++},Zn^{++} at ionic strengths 0.1M,0.3M and 0.6M $NaClO_4$ in aqueous medium is given in table 1 and 2 .The temperature was maintained constant ie 298K. In ascorbic acid two pK values are obtained. This are attributed to the dissociation of two enolic-OH groups. The first pK values is 4.16 which is due to dissociation of –OH at fourth position and more acidic than second –OH (3) and second pK value is 11.54 which is higher than first pK value it is due to the dissociation of –OH at third position.

Ascorbic acid can be co-related with Lactone i.e. γ-Butyrolecton. The pk value of γ-Butyrolecton is 4.5. the observed pk value of Ascorbic acid is 4.16 which is less than pk value of γ-Butyrolecton . Which indicates decrease in basisity of ascorbic acid.

The effect of increase of ionic strength from 0.1M, 0.3M to 0.6 M decreases the pK value This decrease in pK values is according to Debye-Huckel theory the –COOH and –OH group decreases the pK value by increasing the ionic strength.

In case of metal ligand stability constants as ionic strength increases metal ligand stability constant decreases.

The order of stability constant of Ascorbic acid for 0.1M $NaClO_4$ is

Ni > Cu > Zn > Co
For 0.3M $NaClO_4$ is
Ni > Cu > Zn > Co
For 0.6M $NaClO_4$ is
Ni > Zn > Cu > Co

All the above order of stabilities of the metal complexes with all the ligands show good agreement with the stability order shown by workers[10,11]and others[12,13.]

CONCLUSION

In the present work pH metric study was performed to determine stability constants and to asses binary species for ascorbic acid with transition metals in aqueous medium pH range 1.98 to 11.95. The following conclusions have been drawn.

1) Ascorbic acid forms complexes with transition metal ions in the pH range 1.98 to 11.95.
2) The two pK values of ascorbic acid are due to presence of enolic groups in it. The order of pK values in varying ionic strength is 0.1M > 0.3M > 0.6M.
3) The order for logK values for transition metals are 0.1M > 0.3M > 0.6M.

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