

THE STUDY OF STABILITY CONSTANT, KINETIC AND THERMODYNAMIC PARAMETERS OF LANTHANIDE METAL COMPLEXES OF INDOLE-3-PROPIONIC ACID

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ABSTRACT

The action of metals plant auxins has been a controversial subject of metal complexes, which have the wide spectrum of applications beginning with analytical chemistry and ending with medicinal chemistry. Chauhan, and Co-workers [1-11] have studied the affinity of metals to plant Auxins (IPA) highlighting their solution chemistry, synthesis, decomposition mechanism and kinetics. In the light of controversy still hanging on the subject mode of action of plant auxins it has been felt to pursue and continue studies on metal-plant auxin interaction in solution and solid state. The study of thermodynamic and stability constant etc. to be carried out potentiometrically applying the concept of Henderson Hasselback for Proton-ligand stability constant of plant auxin (IPA) and Bjerrum for the stability constants of metal-ligand systems. This paper reports on an extension of these studies on the interaction of the metal Ce (III) and Pr (III) with plant Auxins (IPA) in solution.

Keywords: Auxin, Biologists, Interaction, Thermodynamic, Kinetic, Compositional.

Introduction

Biologist are faced with nature of interaction of plant auxins with metal ions present in soil. They have been confused for a long time. The first comment on the subject came from Koepfli, Themann and Went [12]. The conclusion based upon the investigation on the number of compounds had tally with the presence of a ring system. In the side chain of the ring carboxylic group present which contain double bond between carbon and oxygen of the carboxylic group, and there being at least one carbon atom between the ring and carboxylic groups in an active growth substance. The subsequent results collected by Health and Clark [13] were to the contrary. Highlight of the work oata and coworkers [14] are the action patterns of 3-Indole propionic acetic acid, similar to those reported for agents that chelate both Cu (II) and Fe (III) Fe (III).

Solanki and his associates (15,16) worked on the compositional and conformational aspects of the metal complexes of IAA and IBA with La (III), Nd (III) etc. The different aspects other than their affinity to metals and allied areas of the plant auxins have been exhaustively studied and looked into by different researchers and Botanists (17). This time IPA and trivalent metal Ce, Pr have been taken as model studies under thermodynamic conditions.

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Experimental

All Chemical used were of analytical grade.

Reagents

HNO ₃	:	0.1 M(aq)
Ligand	:	(IPA)
KNO ₃	:	M(aq)
Solvent	:	50% Dioxane
NaOH	:	0.1 M(aq)
Metal Salts	:	X(NO ₃) ₃ .6H ₂ O (X=Ce, Pr)

Apparatus

Digital pH Meter : Model Li-120 with glass and Calomel electrodes was used.

Results and Discussion

The whole study was done in 50% Dioxane in water and constant ionic strength (0.01M KNO₃). All experiments were performed at near infinite dilution so that the activity coefficient of species in solution were reduced to unity and thereby, the conditions were thermodynamically true. The protonation constants (P^{K^H}) of IPA were calculated for two different temperatures using the equation of Henderson and Hasselback (18): 5.45 (25°C) and 4.80 (35°C). The value of \bar{n} was approximately 3 for the Ce (III)-IPA and Pr (III)-IPA systems, as a result the complexes formation takes place by stepwise in 1:1, 1:2 and 1:3 in solution form.

The metals (Ce, Pr) -plant auxin (IPA) Stability constants (k_1 , k_2 , k_3 and β_3) could be worked out, the $\log k_1/k_2$, values for the systems were for less than 2.5, signaling deviation from the basic requirements ($\log k_1/k_2 \geq (2.5)$) to apply Bjerrum half Integral method for the determination of stepwise formation constants. The table 1 are shown the stability data on Ce (III), Pr(III) -IPA systems. The values of $\log k_1$, k_2 and $\log k_3$ given in table 1 according graphical method.

Further, it is clear from table 1 that the low temperature favours the intersection in solution between Ce/Pr and IPA which could be safely based upon the decreasing trend of the logarithmic values of stepwise formation constant ($\log k_1$, $\log k_2$ and $\log k_3$): this is in all probability is due to the decrease in the number of collisions with the decrease in kinetic energy of the molecules involved in the reaction. The interaction between Ce/Pr, Eu/Gd, and IPA in solution is spontaneous as indicated by the (ΔG) Values at high temperature (35), Increased. The observed. ΔH values for the reaction suggested this reaction are accompanied by an increase of entropy ($+\Delta S$) and tend to be a spontaneous.

Table 1: The Equilibrium, Kinetic and Thermodynamic Stability Constant Parameters of the Ce (III)- IPA and Pr (III)- IPA Complexes

Systems	Temp. °C	log					ΔG	ΔH	ΔS
		K_1	K_2	K_1/K_2	K_3	β_3			
Ce (III)-IPA	25	3.72 (3.69)	3.23 (3.22)	0.46	2.99 (2.98)	9.92 (9.88)	-13.52	-2.54	
	35	3.73 (3.69)	3.20 (3.19)	0.51	2.98 (2.96)	9.89 (9.84)	-13.49		+36.55
Pr (III)- IPA	25	3.70 (3.79)	3.20 (3.18)	0.48	2.98 (2.94)	9.88 (9.92)	-13.54	-1.26	
	35	3.74 (3.72)	3.22 (3.20)	0.52	2.95 (2.99)	9.95 (9.94)	-13.56		+39.84

a value in parenthesis is obtained due to graphical method ΔG and ΔH in KCal.mol⁻¹; ΔS in Cal.m^{mol}-oC-1

The data obtained in the above table 1 not fulfill the necessary conditions of the Bjerrum method [19] and not applied to calculate the bond strengths and not satisfy the basic conditions of the method ($\log k_1/k_2 \geq 2.5$). Evidence of the spontaneity of the reactions could be found in the negative ΔG^0 values which become less negative at high temperatures in the Ce (III) IPA and Pr (III) IPA systems making the formation of these systems less feasible with increasing temperatures. The negative ΔH^0 values show that the reaction are endothermic in nature, and signaled further the presence of Covalency in metal-plant auxin complexes. All the reactions are accompanied by an increase of entropy ($+\Delta S^0$) of the Ce (III)-IPA and Pr (III)-IPA Systems implies spontaneity of the reaction.

References

1. S. S. Sawhney, Gambhir Singh Chauhan and Naresh Chandra, Thermochemical, 144(1989), 173-175.
2. S. S. Sawhney, N. C. Chandra, Thermochemical, 115 (1987) 375-380.
3. S. S. Sawhney, and N. C. Sharma and N. K. Arora, Thermochemical, 126(1988), 393-395.
4. S. S. Sawhney, Gambhir Singh Chauhan and Mohd. Aslam, Thermochemical, 204(1992) 321-327.
5. H. Irvin and H. Rossotti, J. Chem. Soc., (953), 3397, (1954), 2904.
6. G. S. Chauhan, IJARCMSS, 03 (2020), PP 327-332.
7. G. S. Chauhan, IJEMASS, 02(2020), PP77-83.
8. S. S. Sawhney and G. S. Chauhan, Thermochemical, 158(1990) 385-388.
9. S. S. Sawhney, Gambhir Singh Chauhan, Thermochem. Acta, (1992) 477-481.
10. Gambhir Singh Chauhan, IJSIRS, Vol (9), No. 7 July, 2021.
11. Gambhir Singh Chauhan, IJSIRS, Vol (10), No.1Jan, 2022.
12. J.B. Koepfli, K. V. Thiemann and F. W. Went, J. Biol. Chem., 122(1938) > 63.
13. O.V.S. Health and J.E. Clark, Nature, 197 (1957) 1118, 178(1956), 600; 183(1959) 1177.
14. Yukito Oata, Takaliko Tsudzulki, Plant Cell Physiol., 12(4) (1971).
15. K. Solanki and A. M. Bhandari, J. Inorg. Nucl. Che., 12(4) (1971).
16. K. Solanki, K. R. Mehar and A. M. Bhandari, Synth. React. Inorg. Met. Org. Che., 8(4) (1978) 335.
17. P. Collection, M. Esposito, S. Meloni and M. Oddone, J. Radioanal. Nucl. Chem. 112(2) (1987) 473-9; Cremaster., 107(1987) 173533g.
18. V. P. Kudesia and S. S. Sawhney, Instrumental Methods of chemical Analysis, Pragati Prakashan, Meerut, 1983.
19. J. Bjerrum, Metal Amonine Formation in Aqueous Solution, P. Hasse and San, Copenhagen, 1941, p. 298.

