

Influence of ionic strength of medium on the thermodynamic parameters of substituted heterocyclic drug with Ce (III), Gd (III) complexes

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Abstract

The metal-ligand and proton–ligand stability constant of Ce(III) and Gd(III) with substituted heterocyclic drug (Montelukast) were determined at various ionic strength by pH metric titration. NaClO₄ was used to maintain ionic strength of solution. The results obtained were, extrapolated to the zero ionic strength using an equation with one individual parameter. The thermodynamic stability constant of the complexes were also calculated.

Key word: Stability constant, ionic strength, substituted heterocyclic drug.

Introduction

The substituted heterocyclic drug is used for the treatment of asthma. It has seasonal anti- allergies properties.¹⁻² It forms complex with Ce(III) and Gd(III). Th. Saroda Devi³ *et.al.* have studied the stability constant of Co (III) with 1-Amidino-0-methylurea as primary ligand at different ionic strength. Agrawal⁴ *et.al.* have studied the influence of ionic strength of medium on complex equilibria. Meshram⁵ *et.al.* have studied the association and dissociation constant of Pr(III) complexes with 3-(2-hydroxy-3-Iodo-5-methyl phenyl)1,5 diphenyl pyrazoline at different ionic strength. Khorrami⁶ *et.al.* have studied the stability

constant of vanadium with glycine at various ionic strength by potentiometric titration technique. Majlesi⁷ *et.al.* have determined the stability constant of Mo (IV) with Iminodiacetic acid at different ionic strength maintain by using sodium per chlorate. Sharma⁸ *et.al.* have studied the effect of ionic strength and solvent effect on thermodynamic parameters. They have also studied the mechanism of protonation and complex formation of binary complexes of La (III), Ce (III), Pr (III) and Nd(III) with amino pyridines.

After review of literature survey, the detail study of complex under identical set of experimental condition is still lacking. It was thought of interest to study the effect of ionic

strength on thermodynamic parameters of complexes of substituted heterocyclic drug with Ce(III) and Gd(III) in 70% ethanol-water mixture by pH metrically.

Experimental

The pH measurements were carried out with equip-tronic EQ-610 pH meter (accuracy ± 0.01 units) using combine glass electrode at 208 K. Pure rare earth nitrates (99.9% Pure) were used. All metal nitrates available from Sigma Aldrich Chem. Co., U.S.A. Metal nitrate was prepared in triply distill water and concentration was estimated by standard method. The solution of drugs was prepared in solvent. The pH metric reading in 70% ethanol –water mixture were converted to [H⁺] value by applying the correction proposed by Van Uitert Haas. The ethanol was purified by the method described by Vogel⁹. The overall ionic strength of solution was constant maintains by adding NaClO₄. All the solutions were titrated with standard carbonate free NaOH (0.2N) solution at different ionic strength. The titration was carried out at ionic strength by adding NaClO₄ (0.02, 0.04, 0.06, 0.08, 0.1M).

The experimental procedure involved pH metric titrations of solutions of –

- 1) Free HClO₄ (A)
 - 2) Free HClO₄ + Ligand (A+L)
 - 3) Free HClO₄ +Ligand +Metal ion (A+L+M)
- Data obtained from each titration is plotted as pH Vs volume of NaOH added and corresponding volume at successive pH for each set is determined and calculated.

Result and Discussion

In the present investigation the

dependence of proton-ligand stability constant and metal-ligand stability constant on ionic strength of medium was examined by taking fix concentration of metal nitrates and ligand solution during pH metric titration. The system has been studied at 0.02, 0.04, 0.06, 0.08, 0.1M ionic strength by varying the concentration of sodium per chlorate. The total ionic strength of medium is calculated by equation.

$$\mu = \sum \frac{1}{2} C_i Z_i^2$$

C_i, Z_i are the concentration and valency of ith ion respectively.

The values of proton–ligand and metal ligand constant of Ce(III) and Gd(III) complexes at different ionic strength 0.02,0.04,0.06, 0.08 and 0.1M determined. These values determined by using Irving-Rossotties method. From table 1, it was seen that the values of proton–ligand stability constant (P^K) decreases with increasing ionic strength of medium. The metal-ligand stability constant (log^K) also decrease with increasing ionic strength. For determination of stability constant at zero ionic strength the Bronsted equation is used.

$$\log K = \log K^0 + A \sum \Delta Z^2 \sqrt{\mu}$$

$$pK = pK^0 - A \sum \Delta Z^2 \sqrt{\mu}$$

Where K⁰ is the formation constant at zero ionic strength, pK⁰ is proton-ligand stability constant at zero ionic strength, ‘A’ is the Debye-Huckel constant, ΔZ^2 is the difference in square of the changes of product and reactant ion.

The pK⁰ and logK⁰ values were calculated by plotting the graph of pK, logK₁, logK₂ versus $\sqrt{\mu}$

Table 1. Proton–ligand (p^K) and metal–ligand stability constant (Log^K) values for Ce (III) and Gd (III) with Montelukast at various ionic strength (μ)

μ	$\sqrt{\mu}$	$1+\sqrt{\mu}$	$\sqrt{\mu}/1+\sqrt{\mu}$	$[\sqrt{\mu}/1+\sqrt{\mu}]-0.3\sqrt{\mu}$	p^K	$\text{Log}K_1$	$\text{Log}K_2$
Montelukast Ce(III)							
0.02	0.1414	1.1414	0.1239	0.0815	9.80	6.93	4.06
0.04	0.2000	1.2000	0.1667	0.1067	9.50	6.19	3.90
0.06	0.2449	1.2449	0.1968	0.1233	9.15	6.05	3.84
0.08	0.2828	1.2828	0.2205	0.1357	8.80	5.99	3.49
0.10	0.3162	1.3162	0.2403	0.1454	8.50	5.56	2.95
Montelukast Gd(III)							
0.02	0.1414	1.1414	0.1239	0.0815	9.80	7.26	4.15
0.04	0.2000	1.2	0.1667	0.1067	9.50	6.98	4.14
0.06	0.2449	1.2449	0.1968	0.1233	9.15	6.60	3.89
0.08	0.2828	1.2828	0.2205	0.1357	8.80	6.52	3.68
0.10	0.3162	1.3162	0.2403	0.1454	8.50	5.77	3.19

Table 2. Thermodynamic stability constant (pK^0 and $\text{Log} K^0$) values for Ce (III) and Gd (III) with Montelukast.

Plots	Montelukast Ce(III)			Montelukast Gd(III)		
	pK^0	$\log K_1^0$	$\log K_2^0$	pK^0	$\log K_1^0$	$\log K_2^0$
p^K Vs $\sqrt{\mu}$	10.93	----	----	10.93	----	----
p^K Vs $\sqrt{\mu}/1+\sqrt{\mu}$	11.28	----	----	11.28	----	----
p^K Vs $[\sqrt{\mu}/1+\sqrt{\mu}]-0.3\sqrt{\mu}$	11.55	----	----	11.55	----	----
$\text{Log}K_1$ Vs $\sqrt{\mu}$	----	7.782	----	----	8.460	----
$\text{Log}K_1$ Vs $\sqrt{\mu}/1+\sqrt{\mu}$	----	8.121	----	----	8.803	----
$\text{Log}K_1$ Vs $[\sqrt{\mu}/1+\sqrt{\mu}]-0.3\sqrt{\mu}$	----	8.398	----	----	9.073	----
$\text{Log}K_2$ Vs $\sqrt{\mu}$	----	----	5.020	----	----	5.050
$\text{Log}K_2$ Vs $\sqrt{\mu}/1+\sqrt{\mu}$	----	----	5.264	----	----	5.269
$\text{Log}K_2$ Vs $[\sqrt{\mu}/1+\sqrt{\mu}]-0.3\sqrt{\mu}$	----	----	5.452	----	----	5.438

Table 3. Values of ΔZ^2 determined from the plots of P^K Vs μ

Reaction Equilibria	System	ΔZ^2 Expected	Slope	ΔZ^2 Observed
$HL \rightarrow H^+ + L^-$	Montelukast + Gd(III)	2.00	-7.528	-14.5864
$L^- + M^{+3} \rightarrow ML^{+2}$		-6.00	-6.910	-13.3889
$ML^{+2} + L^- \rightarrow ML_2^{+1}$		-4.00	-5.790	-11.2188
$HL \rightarrow H^+ + L^-$	Montelukast + Gd(III)	2.00	-7.528	-14.5864
$L^- + M^{+3} \rightarrow ML^{+2}$		-6.00	-7.737	-14.9913
$ML^{+2} + L^- \rightarrow ML_2^{+1}$		-4.00	-5.233	-10.1396

From table 2, it was seen that the good agreement among thermodynamic constant obtained from different plots. The plots p^K , $\log K_1$, $\log K_2$ versus $\sqrt{\mu}$ gives straight line over the entire range of ionic strength for both systems. It shows that the bronsted relationship is valid for dissociation equilibrium. Fazlur Rahman¹⁰ *et. al.* have determined similar results of stability constant of different metal complexes with substituted acetophenone oxime at 0.1, 0.05, and 0.01M ionic strength in 70% dioxane.

The values of ΔZ^2 were calculated from the slope of plots P^K Vs $\sqrt{\mu}$, $\log K_1$ Vs $\sqrt{\mu}$, $\log K_2$ Vs $\sqrt{\mu}$. The value of 'A' was taken equal to 0.5161.¹¹ The value of ΔZ^2 given in table 3. The observed value of ΔZ^2 is different than the expected value. These values do not give conclusive evidence regarding the magnitude of the charge of reacting species. This discrepancy may be due to the limited applicability of Bronsted equation. Narwade¹², Sathe and meshram⁴ also recorded same discrepancy.

Conclusion

The calculated values of stability constant at various ionic strength are high. From data the conclusion is, the complexes of Montelukast with Ce (III) and Gd (III) is quite stable at over all range of ionic strength. The values of thermodynamic parameters are nearly same from all plots was good agreement of results.

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