Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2012, 4(4):2312-2316

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Kinetics Hydrolysis of Mono- 4-methyl-2-nitro aniline Phosphate via Conjugate Acid Species

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ABSTRACT

Kinetic study of the hydrolysis of mono-4-methyl-2-nitroaniline phosphate has been carried out in 0.1 to 7.0 M HCl at 50± 0.50^{0}C . The rate of hydrolysis increases with increase in acid molarity up to 4 M HCl and after that it decreases. The lowering of rates after 4 M HCl has been attributed to the effect of water activity. Rate data at constant ionic strength is used to identify reactive species and to determine theoretical rates. Hydrolysis of monoester via conjugate acid species has been assigned the bimolecularity of the reaction on the basis of Arrhenius parameters, Zucker- Hammett hypothesis and Bunnett & Bunnett –Olsen'sparameters. Solvent effect has been found to indicate the formation of a transition state in which charge dispertion occurs. Kinetic rate data and isokinetic relationship have been used to propose the probable bond fission.

Keywords Kinetics, Hydrolysis, Mono-4-methyl-2-nitroaniline phosphate, Hydrochloric acid.

INTRODUCTION

Phosphate mono, di and triester have important roles in living systems. Phosphorylation and hydrolysis reactions of phosphate monoesters play vital roles in protein function, energy regulation, metabolism signal transductionand many other processes [1-2]. Organophosphate is involved in many physiological functions including energy metabolism, activation of reactions of the metabolism of carbohydrates, lipids and proteins [3]. These compounds are important commercially because they are used as fertilizers [4], lubricants [5], flame retardants [6], plasticizers [7], smoke generation [8], corrosion inhibitors [9] and dispersionagents [10] in paints, primers and metal surface treatments. These are alsoused cancer chemotherapeutic agents [11]. Anti-tumor agents [12] as well as in the treatment of glaucoma [13].A phosphonoformate trianion (PFA) is effective as antiviral agent against AIDS chemotherapy under the names of Foscarnet and Foscavir [14]. Foscarnet is also active against herpes simplex virus (HSV) and AIDS related human cytomegalovirus [15]. Recently Di-2 ethylaniline phosphate [16] and other have investigated as an antimicrobial agent[17,18,19].

EXPERIMENTAL SECTION

Mono-4-methyl-2 nitro aniline phosphate (barium salt)has been prepared from 4-Methyl-2 nitro aniline and phosphorus pentaoxide by the method described earlier[20] .Inorganic phosphate produced during hydrolysis has been determined spectrophotomatrically by Allen's modified method[21]. All the reactions have been carried out at 50 ± 0.0 5^{o}C Employing5x10^{-4}M solution of the monoester in aqueous medium. The constant ionic strengths were maintained by using mixture of HCIandNaCl. All the chemicals used were of A.R. grade.

RESULTS AND DISCUSSION

Hydrolysis via Conjugate Acid Species

Hydrolysis of Mono-4-methyl-2 nitro aniline phosphate ester has been studied at 50 ± 0.5°C, in the region from 0.5 to 7.0 M HCI. Pseudo first order rate coefficients obtained are summarized in the Table-1 and illustrated in **Figure.1** The rate of hydrolysis increases with the rise in acid molarity up to 4.0 M and further rise in acid molarity decreases the rate as shown in **Figure.1**.The result of studies at different ionic strengths, 1.0, 2.0 and 3.0 µ, using an appropriate mixture of sodium chloride and hydrochloric acid. The rate constants are summarized in Table II and illustrated in**Figure.2.**shows that (a) each linear curve makes the positive slop with acid axis; hydrolysis is subjected to acid catalyzed at each ionic strength. (b) Curves meet at a point on the rate axis indicating the participation of neutral species is constant and independent of the influence of ionic strength.

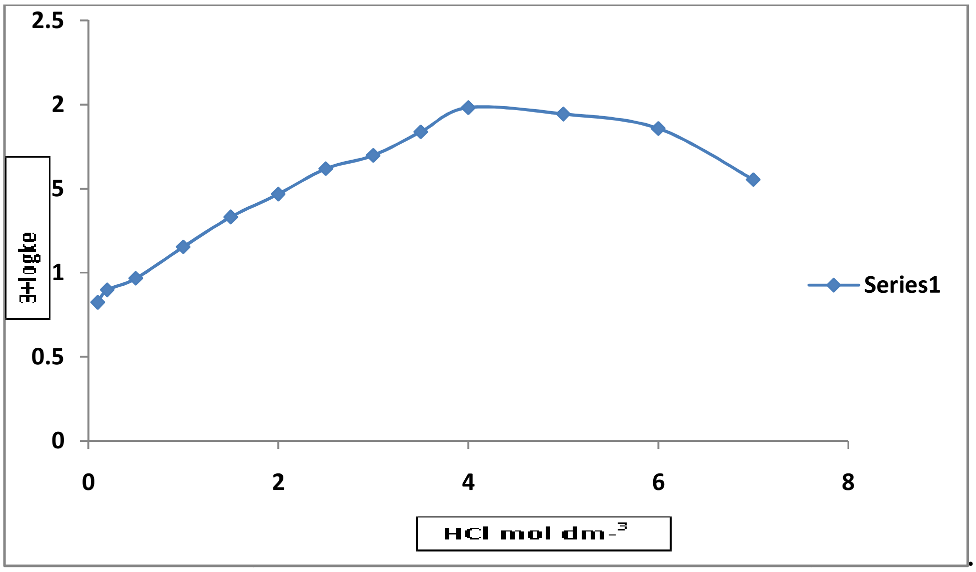


Figure1:- Plot 3+log ke versus HCl moldm-^{3} for acidic hydrolysis of Mono-4-methyl-2-nitroaniline Phosphate ester

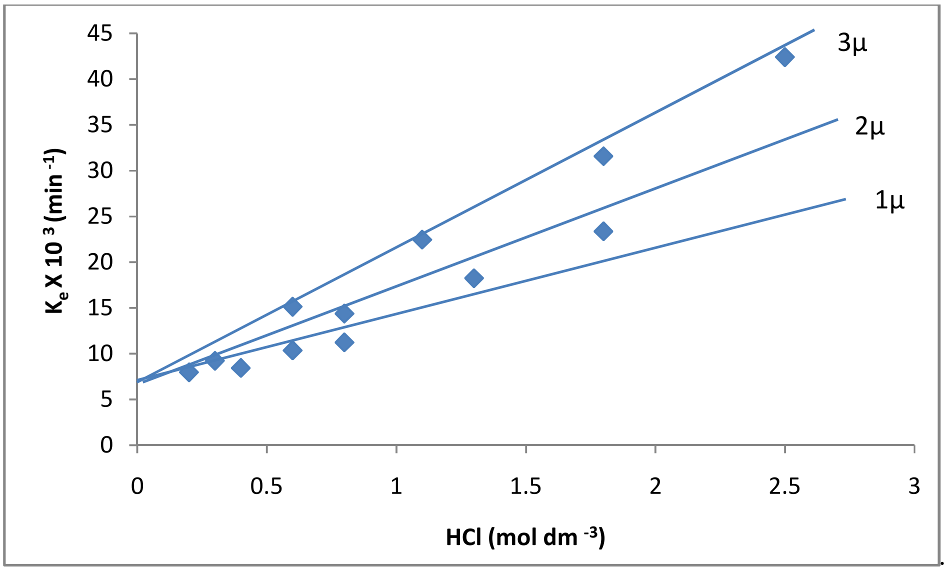


Figure-2 Plot of ke x 10-^{3}min-^{1} versus HClmol dm-^{3} for the acidic hydrolysis of mono-4-methyl--2 nitro aniline phosphate ester

Table-1: Kinetic Rate Data for the Acidic Hydrolysis of Mono-4-methyle-2- nitroaniline phosphate Ester

HClmol dm-^{3}	pH	Ke x10^3 (min-1)	3 +log k$_e$
0.5	0.30	6.713	0.966
1.0	0.00	14.256	1.153
1.5	-0.18	21.431	1.331
2.0	-0.30	29.314	1.467
2.5	-0.40	38.542	1.585
3.0	-0.48	46.613	1.681
3.5	-0.54	68.773	1.837
4.0	-0.60	95.826	1.981
5.0	-0.70	87.857	1.943
6.0	-0.78	72.033	1.878
7.0	-0.84	52.663	1.721

Table-2: Theoretical and Experimental Rate Data for the Acidic Hydrolysis of Mono-4-methyl-2-nitroaniline phosphate Ester

HCl (mol dm-^{3})	k$_H$+C$_H$+x10^3	k$_N$x 10^3	k$_e$ x10^3 (min^{-1})	Log(a$_{H2}$O)	k$_e$ x 10^3 (min^{-1})^a	k$_e$x10^3 (min^1)^b
						11.10
0.5	4.233	6.57	10.83		10.83	14.25
1.0	5.888	6.57	12.45		12.45	21.43
1.5	11.06	6.57	17.63		17.63	29.31
2.0	18.30	6.57	24.87		24.87	38.54
2.5	28.64	6.57	35.21		35.21	50.22
3.0	42.95	6.57	49.52		49.52	70.31
3.5	62.51	6.57	69.08		69.08	95.71
4.0	89.12	6.57	95.69		95.69	87.85
5.0	173.3	6.57	91.42	(0.155)2	91.42	72.03
6.0	321.8	6.57	81.97	(0.211)3	81.97	52.66
7.0	584.2	6.57	51.61	(0.279)4	51.61	

^{a}Theoretical rate ^{b}Experimental rate

Table -3: Arrhenius parameter on the Rate of Hydrolysis of Mono-4-methyl-2-nitro aniline phosphate

HCl (mol dm-^{3})	E (Kcal/mole)	Frequent Factor A (Sec-1)	-ΔS ≠
4.0	8.146	2.58 x 10^6	43.99
	9.609	1.82 10^6	31.022

Table-4: Solvent Effect Rate Data for the Hydrolysis of Mono-4-methyl-2-nitro aniline phosphate Ester

HCl (mol dm-^{3})	% of Dioxane (v/v)	k$_e$ x10^3 (min^{-1})	3 + log k$_e$
4.0	10.0	113.8	2.05
4.0	20.0	122.5	2.08
4.0	30.0	131.2	2.11

The overall rate of hydrolysis of the reaction may be represented as:

$$k_e = k_H+.C_H+ \qquad (1)$$

Where k_e, = k_H+and C_H+ are the experimental rate coefficients, specific acid catalyzed rate at ionic strength and concentrations of [H$^+$].Since the slopeof the linear plot increases with increase in ionic strength, hydrolysis is subjected to the positive effect of ionic strength. Specific acid catalyzed rates (k_H+) were then converted to acid rates (k_H+ .C_H+) as:

$$k_H+.C_H+ = k_{Ho} + C_H + \exp.\ b'_H+.\ \mu \qquad (2)$$

Where for HCl, µ and C_H+ are of the same value. The slope of the linear curve is b'_H+ ,which is equal to b'_H+/2.303 and intercept on log rate axis is 3 + log k_{Ho}+. It is seen that there is n agreement between theoretical and experimental rates in the acid region up to4.0 M HCI, while at the lower (0.1 M and 1.0 M) HCI as well as at higher (above 4.0 M) acid molarities the agreement between theoretical and experimental rates does not exist. At lower acidities disagreement may be due to incursion of neutral species. Disagreement between rates 5.0 to 7.0 M HCl has been found to be due to the incursion of water activity parameter. Rate estimated by equation (3) agree with the experimental rates.

$$k_H+.C_H+ = k_{Ho} + C_H+ \text{ exp. } b'_H+.\ \mu\ a_{H2}O\,(a_{H2}O)^n \qquad (3)$$

Where n is an integer and $a_{H2}O$ is water activity.

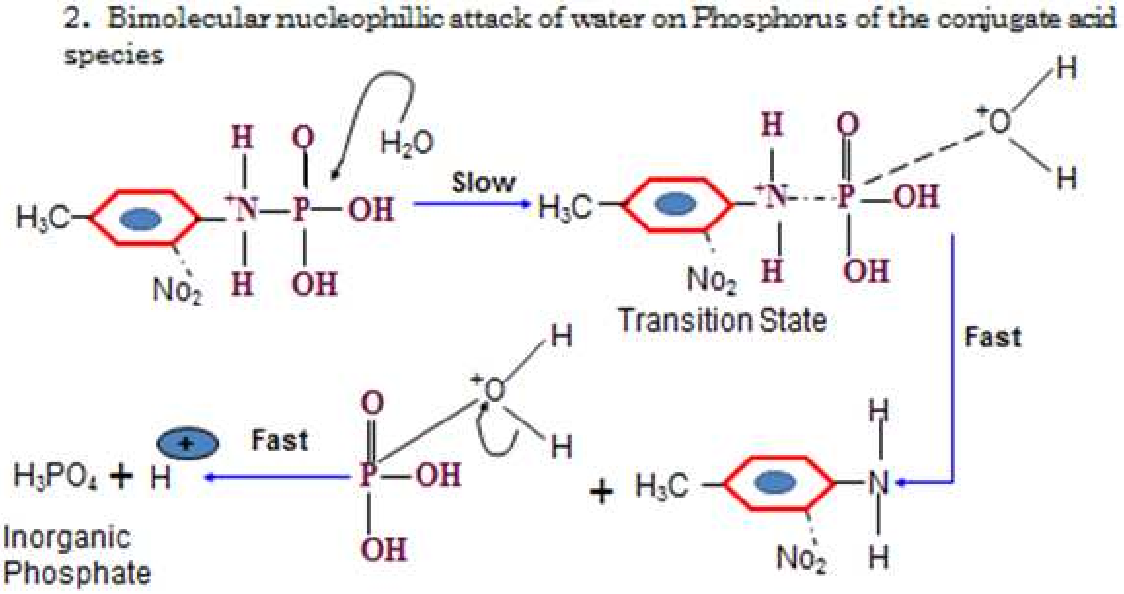
Arrhenius parameters determined for the hydrolysis at 4.0 M HCl are given as: E =8.146 Kcal/mol, A= 2.58 x 10^6 s-^{1}, $\Delta S^{\neq}$ = -43.994 e.u.Table-3

Magnitude of the Arrhenius parameters[22] fall in the range of bimolecular nature of the reaction. The slope of Zucker –Hammett [23]hypothesis is 1.64 which clearly indicates the bimolecularity of the reaction . Slope slightly greater than unit is due to positive salt effect. Dependence of rate on water activity is supported by Bunnett & Bunnett – Olsen's plot [24].The parameters w, w* and ϕ are 8.5, 2.3 and 1.15, respectively.

A change over from water to 30% aqueous dioxane (v/v) increases the rate of hydrolysis Table-4 indicates the formation of transition state in which charge is dispersed.

Mono-4- methyl-2 nitroaniline phosphate may undergo hydrolysis either by P-N or C-N bondfission. Summarizes comparative rate data for the hydrolysis of other monoesters studied kinetically shows isokinetic relationship **Figure not show**. The point of Mono-4-methyl-2nitroaniline phosphate lies on the linear curve of those monoesters which are known to undergo hydrolysis via P-N bond fission **Figure not show**. Thus P-N rather than C-N bond fission appears to be more likely.

The bimolecular hydrolysis with P-N bond fission of the conjugate acid species has been proposed as below:



CONCLUSION

Mono-4-methyl-2-nitroaniline phosphate ester in the region 0.5 to 7.0 M HCl the phosphate ester has been found to hydrolyze exclusively via conjugate acid species. The acid catalyzed hydrolysis is subjected to positive effect of ionic strength. Bimolecular nature of hydrolysis has been supported by different parameters such as Zucker-Hammett, Bunnett & Arrhenius (E, A &$\Delta S^{\neq}$). The bimolecular hydrolysis with P-N bond fission of the conjugate acid species has been proposed. The SN^2 (P) mechanism has been suggested for the hydrolysis via conjugate acid species.

Acknowledgement
The authors are thankful to Prof. K.S. Patel, Head, School of Studies in Chemistry, Pt. RavishankarShukla University, Raipur, India, for providing research facilities.

REFERENCES

[1] Hengge, A.C, Adv. *Phys. Org. Chem.***2005,** 40: 49.
[2] Weston, *J .Chem. Rev.***2005,** 105: 2151.
[3] Range K, Mayaan, E, Maher Iii. York, D.M, *Nucleic Acid Res.***2005,** 33:1257.
[4] Filippelli, G.M.; *Elements*,**2008,** 4:89.
[5] Mirci, L.E,Herdan, J.M, Boran, S, *J. Syn. Lubr.,***2006,** 21:13 .
[6] Moy, P.Y, *J. Vinyl and Additive Tech*., **2004,**22.
[7] Zhou, S. Wang, Z. Gui, Z. Hu, Y. *Fire and Materials,***2008,** 32: 307.
[8] Quin, L.D.A Guid to Organophosphorous Chemistry, *John Wiley and Sons. Inc., New York,* **2002**, 375:2.
[9] Moss, R.A. Morales, H.R,*J.Am. Chem. Soc.,***2001,** 123: 7457.
[10] Ceylan, A. Suvaci, E. Mandal, H, *Material Science Forum,* **2007,** 554: 71.
[11] Watkins, W.J. Chen, J.M. Cho, A. Chong, L. Collins, N. Fardis, M, Huang, W. Hung, M. Kirschberg, T. Li u, X. Thomas, W. Xu, J. Zeynalzadegan, A. Zhang, *J. Bioorg. Med. Chem. Lett.* **2006,** 16: 3479.
[12] Hongkang, S. Sinhababu, A.K. Cho, M.J., *Nucleotides and Nucleic Acids,* **1998,** 17:1089.
[13] Benzamin, T. buringham, TY. Wildanski, S., *J. Org. Chem.,* **2001,** 23:7561
[14] Oberg, B., *Pharmac. Ther*.**1989,** 213: 40.
[15] Colgan, R., Michocki, R. Greisman, L.*Am. Fam. Physician*, **2003,** 67: 757.
[16] Bhoite S.A., Banjara, R.A., Jadhav, S.K., *J. Chem. Pharm. Res.,* **2012** 4(1):648-652.
[17] Nerule MN, *J. Chem. Pharm. Res*., **2011**, 3 (3): 38-47,
[18] Shivananda MK, Shet P. M. *J. Chem. Pharm. Res.*, **2011**, 3 (5): 61-66.
[19] Shivanand MK. Shet Prakash M, *J. Chem Pharm. Res*. **2011**, 3(2): 303-307.
[20] Cavalier,*J. of Bull. Soc. Chem.France,* **1895**, 13:885.
[21] Allen, *R. j.L, Biochem* **1940,** 34:858.
[22] Arrhenius, S. *J.Phys. Chem***1889,** 4: 226.
[23] Zucker, L, Hammett, *L. P.J .Am Chem Soc***1939,** 61:2791.
[24] Bunnett, J.F, Olsen, F.F CVan, *J. Chem***1966,** 44:1917.