International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

Kinetics and Thermodynamics of Oxidation of Metformin Hydrochloride by Potassium Permanganate

Sayyed Hussain[1], Katapalle Ramdas[2], Surendra Takle[1], Vinod Mane[2]

[1]*P.G. Dept. of Chemistry, Sir Sayyed College of Arts, Commerce and Science, Aurangabad (M.S.) 431001, India.*
[2]*Late Shankarrao Gutte Gramin Mahavidyalaya, Dharmapuri, Dist. Beed (M.S.), India.*
[3]*Mahatma Gandhi College, Ahmedpur, Dist. Latur (M.S.), India.*

***Abstract*-- The Kinetic of oxidation of Metformin Hydrochloride by potassium permanganate has been studied in the presence of acidic medium. The reaction is first order with respect to $KMnO_4$ as well as Metformin Hydrochloride concentration. The reaction rate has been determined at different temperature and different thermodynamic parameters have been calculated which shows that the reaction rate increase with increase in temperature. With increase in the concentration of acid the reaction rate increases. A suitable mechanism has been proposed.**

***Keywords*- Kinetics, Mechanism, Oxidation, Metformin Hydrochloride, potassium permanganate, thermodynamic parameters, etc.**

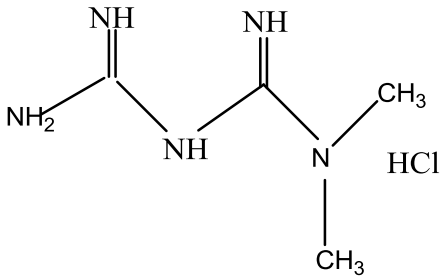
I. Introduction

In organic synthesis conversion of alcohols to aldehydes, ketones and carboxylic acids is widely used reaction. This reaction is done using different oxidizing agents. Among these chromium based oxidizing agents are extensively used. The teramethyl ammonium fluorochromate is one of the chromium based mild oxidizing agent. This compound has additional advantages over pyridine fluorochromate and pyridine chlorochromate with reference to lower acidity, ability to more selective oxidation under mild condition, higher solubility in non-aqueous solvents, etc. Teramethyl ammonium fluorochromate (TMAFC) is a complex of chromium trioxide and teramethyl ammonium fluoride. In this work we report the kinetic of oxidation of Metformin Hydrochloride by potassium permanganate[1].

Bunton *et al.*[2]found that acid catalysed hydrolysis occurs only when an electron attracting substituent is present in the aryl moiety, as in nitrophenyl phosphate monoester. 4-Chlorophenyl phosphate monoester[3] and 2, 6 dimethylphenyl phosphate monoester[4], showed only feeble acid catalysis, while 4-bromo-2, 6-dimethylphenyl phosphate monoester showed acid catalysis.

The change in the rate of chemical reaction in presence of surfactant has provoked great interest during three decades, since the study of micellar catalysed reactions might provide a basic model for the interpretation of some aspects of enzymatic catalysis[1-4].

Metformin hydrochloride (MET; 1, 1 dimethylbiguanide hydrochloride) comprises the biguanide group and is one of the most commonly used oral antihyperglycemic medicament to treat type II diabetes[5]. The chemistry of organic N-haloamines is of great interest owing to their diverse behaviour[6-7]. Sodium N-chloro-p-toluensulfonamide or chloromine-T and sodium N-chlorobenzenesufonamide or chloromine-B are the prominent members of this class of compounds. CAB is a stable compound with slightly higher active chlorine content than CAT[8-11]. Although sufficient reports are available about the kinetic and mechanism of oxidation of metformin hydrochloride by CAB[11-14] and other oxidising agents. But very little work is found on oxidation of metformin hydrochloride by potassium permanganate that is why I decided to use potassium permanganate as an oxidising agent.



$(C_4H_{11}N_5HCl)$

Metformin Hydrochloride

II. Material And Method

Chemical which are used in this experiment are highly purified and AR grade, the solutions were used in this study were prepared by using distilled acetic acid[15] and double distilled water. Solution of metformin hydrochloride were prepared by using double distilled water and this solution was used for kinetic studies. The reaction was carried out in glass stoppered Pyrex boiling tube. The Kinetics of reaction was followed in the temperature range $30^{\circ c}$ to $50^{\circ c}$.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

Kinetic Measurement:-

The kinetic of reaction were measured by using double beam spectrophotometer model No AU2100 of Systronic Company which is having inbuilt software. The Kinetic of reaction were measured at 520 nm wavelength up to the 85% completion of reaction.

Stoichiometry of reaction:-

The Stoichiometry of the reaction were determined by envying out several sets of experimental with varying amount of oxidising agent potassium permanganate over Metformin Hydrochloride in acetic acid using in H_2SO_4. The remaining potassium permanganate was then analysed spectrophotometrically the result indicates that 1 mole of Metformin Hydrochloride react with 1 mole of potassium permanganate[16].

Product Analysis:

In the present study, the mechanism of metformin hydrochloride & potassium permanganate system in acidic medium has been kinetically studied. The reaction exhibits a first order dependence of rate each on $[KMnO_4]$ & $[C_4H_{11}N_5HCl]$.

The order of reaction respect to $[H_2SO_4]$ in first order. Activation parameters have been evaluated. Oxidation product is identified as metformin oxide[17]. Which is also confirmed by comparing its melting point.

III. Result And Discussion

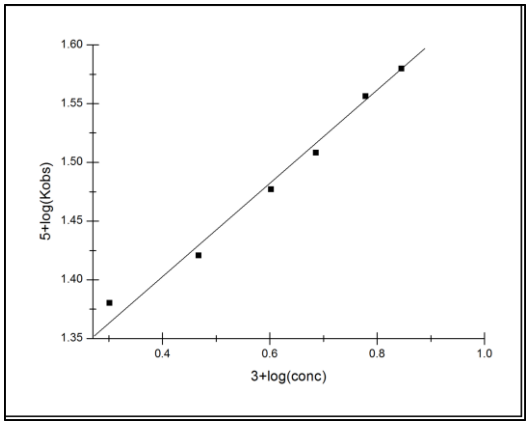
The results of various parameters is given in tabular form and presented with graphs.

1) Effect of variation of concentration of Metformin Hydrochloride :-

The oxidation of Metformin Hydrochloride with potassium permanganate in acetic acid in presence of sulphuric acid. By keeping constant concentration of potassium permanganate and H_2SO_4 and by changing the concentration of Metformin Hydrochloride increases the rate of reaction (Table-1) the plot of log of k_{obs} versus log concentration of Metformin Hydrochloride for different initial concentration of metal complex is linear with unit slop, which shows that the first order dependence of rate of reaction on Metformin Hydrochloride [18-20].

Table-1:
Effect of variation of concentration of Metformin Hydrochloride . Substrate

Concentration	Rate K_{obs}
0.001	0.00024
0.002	0.00024
0.003	0.00026
0.004	0.0003
0.005	0.00031
0.006	0.00036
0.007	0.00038



2) Effect of varing oxidising agent potassium permanganate:-

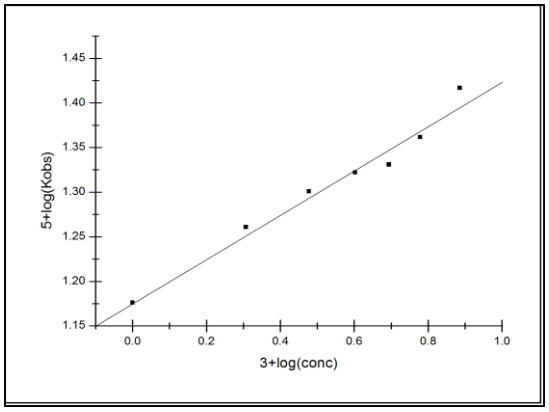
In this parameter studying the effect of variation of oxidising agent potassium permanganate on oxidation reaction of Metformin Hydrochloride by keeping constant concentration of Metformin Hydrochloride and concentration of H_2SO_4.

The Concentration of oxidising agent increases, increase the rate of reaction Table – 2 the plot of 1/log K_{obs} verses log $[KMnO_4]$ for different initial concentration of $[KMnO_4]$ is linear with unit slop presents the first order dependence of rate on $[KMnO_4]$.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

Table-2
Effect of variation of concentration of potassium permanganate.

Concentration	Rate K_{obs}
0.001	0.00015
0.002	0.00019
0.003	0.0002
0.004	0.00021
0.005	0.00021
0.006	0.00023
0.007	0.00027



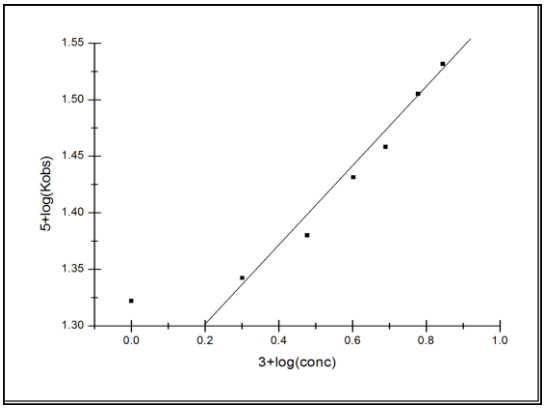
3) Effect of variation of concentration of sulphuric acid:-

In this factor there is study of variation of concentration of sulphuric acid on oxidation of Metformin Hydrochloride.

By keeping constant concentration of oxidising agent and substrate changing the $[H_2SO_4]$ we find that the rate increases with increase in $[H_2SO_4]$ Table – 3 and plot of log k Vs log $[H^+]$ was linear with a unit slop indicating first order reaction on $[H^+]$. Fig – 3.

Table-3:
Effect of variation of concentration of sulphuric acid.

Concentration	Rate K_{obs}
0.001	0.00021
0.002	0.00022
0.003	0.00024
0.004	0.00027
0.005	0.00026
0.006	0.00032
0.007	0.00034



4) Effect of salts on reaction rate:-

The effect of salts on the reaction rate was studied by adding various concentration by salt. By keeping constant concentration by oxidising agent substrate and acid. It was observed that the rate of oxidation was not altered by the addition of salts.

Table-4:
Effect of salts on reaction rate

Concentration	Rate K_{obs}
1	0.0003
2	0.00022
3	0.00018
4	0.00023
5	0.00021
6	0.00023
7	0.00027

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

5) Effect of Temperature:-

The study of effect of temperature on rate of oxidation of Metformin Hydrochloride by potassium permanganate has been studied at different temperature by keeping all other factors constant concentration with changing temperature from 303K to 323K.

The rate constants are given in Table-5 as the temperature increases the values by rate constant also increases that shows rate of reaction depends of temperature the Arhenious plot 10gk Vs. 1/T were found to be linear fig – 4. The activation energy (Ea) were calculated from the clop of the plots from this values the thermodynamic parameters $\Delta H^{\#}$, $\Delta S^{\#}$ $\Delta G^{\#}$ was calculated Table – 6.

Table-5:
Effect of Temperature

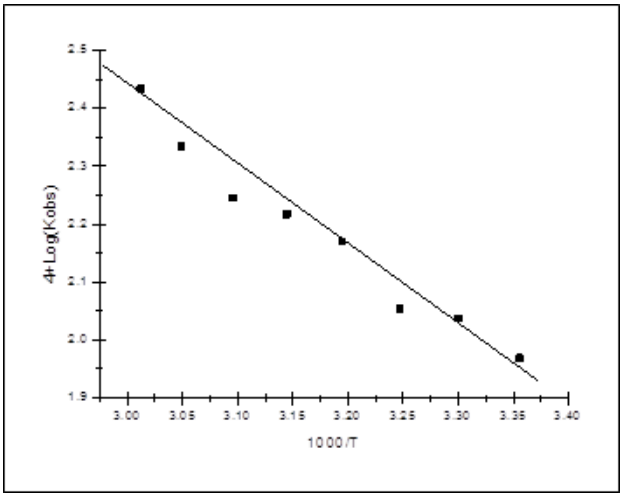
Sr.no	K	^{0}C	T^{0}K	1/T	logK	3+logK
1	0.0064	20	295	3.389831	-2.1938	1.80618
2	0.0093	25	298	3.355705	-2.0315	1.968483
3	0.0109	30	303	3.30033	-1.9625	2.037426
4	0.0113	35	308	3.246753	-1.9469	2.053078
5	0.0148	40	313	3.194888	-1.8297	2.170262
6	0.0165	45	318	3.144654	-1.7825	2.217484
7	0.0176	50	323	3.095975	-1.7544	2.245513
8	0.0216	55	328	3.04878	-1.6655	2.334454
9	0.0272	60	332	3.012048	-1.5654	2.434569

Table – 6:
Thermodynamic Parameter

Ea	14569
$\Delta H^{\#}$	11883
$\Delta S^{\#}$	-244
$\Delta G^{\#}$	90660

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

Fig:



IV. Conclusion

The oxidation of Fe (II) metal increases in acetic acid in acid medium shows that the oxidation of Metformin Hydrochloride of potassium permanganate is in presence of acidic medium with effect of oxidising agent, substrate an acid and temperature the reaction is first order dependence. The addition of salt does not alter the rate of oxidation reaction. The mechanism of the reaction were given with the activation parameters the negative value of $\Delta S^{\#}$ provides support to the formation of rigid transition state[21-22]. The overall mechanistic sequence described here is constituent with product and mechanistic study.

- Mechanism of oxidation of Metformin Hydrochloride by potassium permanganate.

$$H^{+} + Mno_4^{-} \longrightarrow HMnO_4$$

This point has been also confirmed by previous researchers. Hence Mn (VII) could be considered as the reactive specie and this probably exists to a certain extent as $HMnO_4$.

As the concentration is increased the formation of $HMnO_4$ is favoured and hence increases the oxidation may be assumed to be taking place by Mn (VII) in the form of either MnO_4 or $HMnO_4$ or both depending on the acid concentration. The linear plot of log k Vs log (H_2SO_4) and log k Vs. Ho indicates that the reactions are acid catalysed, but none of the above plots gives an ideal slope for unity[23-24].

Derivation of Rate Law

$$Mno_4 + H^{+} \underset{}{\overset{K_1}{\rightleftharpoons}} HMnO_4$$

$$\text{Metformin Hydrochloride} + HMnO_4 \overset{K_2}{\rightleftharpoons} C$$

$$C \longrightarrow \text{Product}$$

$$[MnO_4] = [MnO_4^{-}] + [HMnO_4]$$

$$= [MnO_4^{-}] + k_1 [MnO_4^{-}] [H^{+}]$$

$$= [MnO_4^{-}] + [1+k_1 [H^{+}]]$$

$$\text{Rate} = \frac{k\, k_2 [MnO_4^{-}] [\text{Metformin Hydrochloride}]}{1+k_1 [H^{+}]}$$

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

$$\frac{\text{Rate}}{[MnO_4][\text{Metformin Hydrochloride}]} = \frac{K K_2}{1+k_1[H^+]}$$

$$K_{obs} = \frac{k k_2}{1+k_1[H^+]}$$

$$\frac{1}{K_{obs}} = \frac{1}{k K_2} + \frac{k_1[H^+]}{K K_2}$$

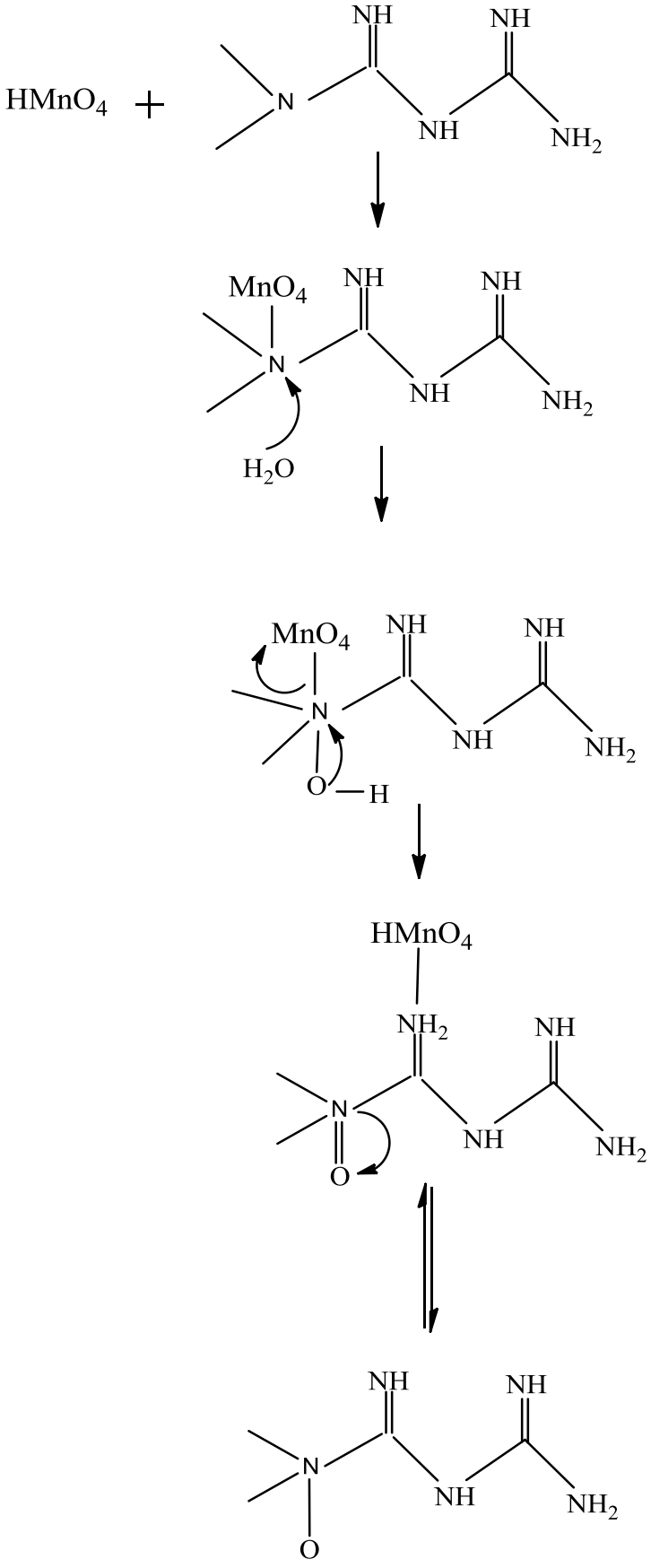
Mechanism of oxidation of metal complexes:-

$$Mno_4^- + H^+ \underset{}{\overset{K_1}{\rightleftharpoons}} HMnO_4$$

$$H_2SO_4 \rightleftharpoons H^+ + HSO_4$$

$$H^+ + MnO_4 \longrightarrow HMnO_4$$

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)



International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 1, January 2017)

Metformin Oxide

Compound (III) being highly unstable disproportionate to give acid and the corresponding oxide.

The rate law can be expressed by equation (1).

$$\frac{-d[Mn(VII)]}{dt} = k\,[\text{Metformin Hydrochloride}]\,[MnO_4]_{\text{Total}}$$

The effect of temperature on reaction rate was studied which shows the increase in reaction rate with increase in temperature[25] (Table 5 and 6).

REFERENCES

[1] Gharib, F,; Zare, K.; Ghammami, S.; Ebrahimi, R. Russ. Chem Bull. 54,462,2005.

[2] P.W.C. Barnard, C.A. Bunton, D.Killerman, M.M. Mahala, B. Silver, C.A. Vernon and V.A. Welch, J. Chem. Soc., B, 227 (1966).

[3] M.D. Patwardhan, Hydrolysis of Organic Phosphate, Ph.D. Thesis, Jiwaji University, Gwalior (1967).

[4] S. David, Ph.D. Thesis, Dr. B.R. Ambedkar University, Agra (2001).

[5] Powers A C, Kasper D L, Braunwald E, Fausi A S Hauser S l, Longo DL & Jamson J L, Harrisons Principles of internal medicine, (MC Graw-Hill Companies, New York) 2005, p. 2152.

[6] Campbell M M & Johnson G, Chem Rev, 78 (1978)65.

[7] Banerji K K, Jayaram B & Mahadevappa D S, J Scient Ind Res, 46(1987) 65.

[8] Kolvari E, Ghorbani-Choghamarani A, Salehi P, Shirni F & Zolfigol M A, J Iran Chem Soc, 4(2007)126.s

[9] Aggarwal M C & Upadhyay S K, J Scient Ind Res, 49(1990)13.

[10] Sayyed Hussain, et. Al. IJERA 2 (1) 558-561, 2012

[11] Neerja Gupta and Monal Singh, Essentials of bio-inorganic chemistry, 1-2, 2009.

[12] Dilsha K.M., Kothari Seema, Prog. Rec.Kinet. Res. 2007, 32, 119

[13] Kothari Seema, Goyal A., Banerji K. K. J. Chem Res. (S) 2002, 363 (M), 863.

[14] Kothari Seema, Kothari A., Banerji K. K., Indian J. Chem, 2000, 39 (A) 734

[15] Kothari Seema, Kothari A., Baanerji K.K. Oxidn. Commun. 2000, 23, 93.

[16] Subbarao P.V.Z., Phy Chem., 19 246, (1971), 352.

[17] Nirmala Vaz, A. S. Manjunatha & Puttaswamy, Indian Journal of Chemistry, vol. 54A, 2015, pp. 484-488

[18] Sayyed Hussain, Takale Surendra, Orient J. Chem 27 (4), 1729-1734, 2011.

[19] Kinetic and mechanistic study of Oxidation of ester by K2Cr207, Sayyed Hussain et. al, Der Chemica Sinica, 2 (1), 2011, 61-65.

[20] Kinetic and mechanistic study of Oxidation of ester by by KMnO4, Sayyed Hussain et a;. Asian J. Research Che, 4 (4), 2011, 607-610.

[21] V. Surendra Rao and workers, Ind. J. Chem. 1979, 18 (A), 37.

[22] Steward R, Oxidation in organic chemistry, edit by wibera (Academic press, London) 1965, 2, 48, 57).

[23] Mohajer D., tangetaninejad S., Tetrahrdron Lett. 1994, 35, 845.

[24] Narayan, Kutty and M.V. Bhat, TettLett. 1979. 2121.

[25] Banerji K.K., Indian J. Chem. 1973, 11, 242.