KINETIC INVESTIGATIONOF OXIDATION OF VOGLIBOSEBY DICHROMATE IN ACID MEDIUM

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ABSTRACT *Spectrophotometric study of kinetics of oxidation of voglibose using potassium dichromate as oxidizing agent in acid medium showed that rate of oxidation was first order with respect to potassium dichromate, vogliboseand acid. The rate of reaction increased with the rise in temperature. The rate of reaction had no effects on addition of different salts. The addition of acrylonitrile to reaction mixture has no effect indicating there was no polymerization reaction and hence no free radical formation during oxidation reaction. The stoichiometry of the reaction was found that one mole of oxidant is consumed for oxidation of onemole of voglibose and the product found is 1,2,3,4 – tetrahydroxy- 5 – [(1-hydroxy -3- oxopropan–2-yl) amino] cyclohexane carbaldehyde ($C_{10}H_{17}NO_7$). On the basis of results obtained, stoichiometry and product anaylsis suitable mechanism for the oxidation of voglibose was proposed. The activation parameters with respect to the slow step of the proposed reaction mechanism were calculated on the basis of results of the reaction at different temperatures.*

Keywords: *Kinetics, Oxidation, Voglibose, Potassium Dichromate*

INTRODUCTION:

Voglibose is an anti-diabetic medication used in the treatment of type 2 diabetes. It is used in addition to diet and exercise to improve blood sugar control in adults with type 2 diabetes. It inhibits the intestinal enzymes that cause breakdown of complex sugars into simple sugars such as glucose. This prevents blood glucose from rising very high after meals [1]. Oxidation of voglibose with potassium dichromate is studied kinetically and mechanistically.

Chromium, chromate, dichromate and permanganate ions in various forms are used as powerful oxidizing agent in organic and inorganic oxidation in the presence of polar solvent [2]. Chromate and dichromate has frequently and extensively been employed as an oxidizing agent both for analytical methods in chemistry [3][4]. Chromic acid, aqueous dichromate, chromyl chloride, chromyl acetate and other substituted chromates have been employed in oxidation of organic as well as inorganic compounds in aqueous acid and alkaline media[5] [6] [7] [8]. Hence the analytical chemists and kineticists are attracted to know more about such an interesting chemistry of this reagent. There is not work reported earlier by any worker for oxidation of voglibose with potassium dichromate as an oxidizing agent.Though R Ramchandrappa studied kinetics of oxidation of voglibose but he studied it using bromamine T in HCl as an oxidizing agent.

MATERIALS AND METHODS:

Potassium dichromate and voglibose is of analytical grade of purity supplied by local company. The stock solution of potassium dichromate was prepared by dissolving a known weight of it in double distilled water. The standard solution of voglibose was freshly prepared with double distilled water. The oxidation of voglibose by potassium dichromate was followed under pseudo-first order conditions where concentration of voglibose was excess over concentration of dichromate at 298K [9]. The reaction was initiated by mixing the required quantities of solutions of substrate and reagents with sulphuric acid. The unreacted dichromate was analyzed spectrophotometrically.

Stoichiometry and Product analysis:

Different reaction mixtures containing solutions of voglibosewith concentration from $1x10^{-2}$ to $6x10^{-2}$mol $dm^{-3}$with excess concentration of potassium dichromate in sulphuric acid were kept for 4-5 days for completion of reaction. The unreacted potassium dichromate was determined spectrophotometrically at 520nm. The stoichiometry of the reaction was found that one mole of oxidant is consumed for oxidation of one mole of voglibose. On the basis of stoichiometry following stoichiometric equation is confirmed for oxidation of voglibose.

$K_2Cr_2O_7 + H_2SO_{4(aq)} + C_{10}H_{21}NO_7 \rightarrow C_{10}H_{17}NO_7 + K_2SO_4 + 2H_2CrO_3 + H_2O$

The reaction mixture containing 0.1 mol dm^{-3},0.2 mol dm^{-3} potassium dichromate and 0.1 mol dm^{-3} sulphuric acid is used to confirm the reaction product. The reaction mixture was allowed to stand for 4-5 days for completion of the reaction. The reaction mixture was extracted with ether. The ether layer was neutralized using sodium bicarbonate and washed with distilled water. The ether layer was evaporated and dried to get product. The product was identified as 1,2,3,4 – tetrahydroxy- 5 – [(1-hydroxy -3- oxopropan–2-yl) amino] cyclohexane carbaldehyde ($C_{10}H_{17}NO_7$). It is confirmed by spot tests [10].

RESULT & DISCUSSIONS:

To study the effect of concentration change of voglibose, potassium dichromate and sulphuric acid on oxidation at room temperature using UV-Visible spectrophotometer different concentrations of these substances were used and results were analyzed to calculate kinetic parameters.

Effect of voglibose concentration:

In this study the concentration of voglibose was varied from 1x10^{-2} to 6x10^{-2}mol dm^{-3} keeping concentration of potassium dichromate and sulphuric acid and all other conditions constant. Figure 1 represents plot of log[VBS]versuslog$k_{obs.}$ The linear graph indicates first order rate of the reaction [11].

[VBS] mol dm\\$^{-3}$	001	0.02	0.03	0.04	0.05	0.06
k_{obs} x 10^{-4}	6.3	6.6	6.8	7.0	7.3	7.6

Table 1: [VBS]mol dm^{-3}and k_{obs}

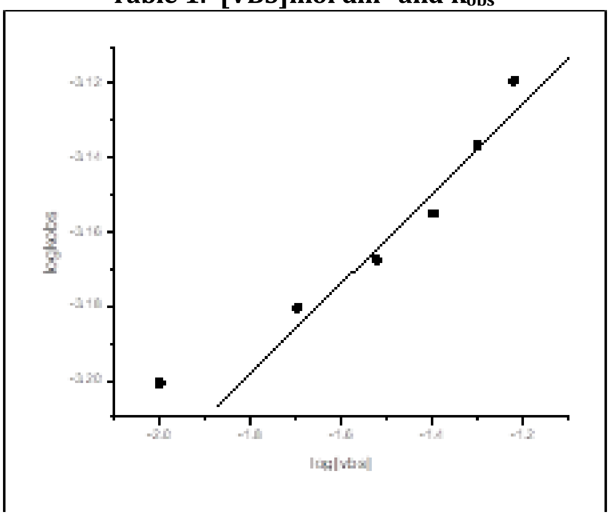


Figure 1 : Graph of log[VBS]versuslog k_{obs} of voglibose

Effect of Potassium Dichromate concentration:

Concentration of potassium dichromate was varied from 1x10^{-3} to 6x10^{-3}mol dm^{-3} keeping concentration of voglibose, sulphuric acid and all other conditions constant. The k_{obs} values showed a sharp increase with the increase in concentration of potassium dichromate. The graph of log[PD] versus log k_{obs} gives a straight line showing first order dependence of the rate of the reaction on concentration of potassium dichromate.

[PD] mol dm^{-3}	0.001	0.002	0.003	0.004	0.005	0.006
k_{obs} x 10^{-4}	6.1	6.4	6.9	7.5	8.0	8.6

Table 2 : [PDF] mol dm^{-3}and k_{obs}

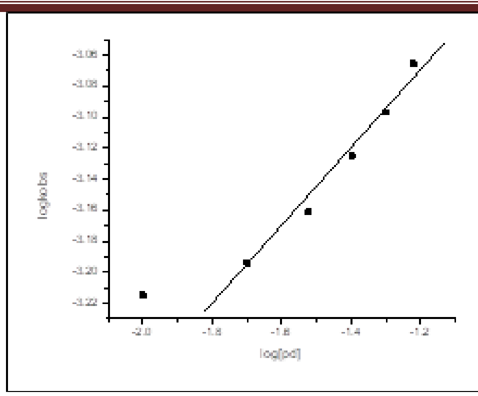


Figure 2 : Graph of log[PD]versuslog k_{obs} of potassium dichromate

Effect of Temperature:

Variation of temperature change on the rate of oxidation of voglibose was studied by conducting kinetic runs at different temperatures ranging from 298K,303K,308K,313K and 318K keeping concentrations of potassium dichromate, voglibose and sulphuric acid all other experimental conditions constant. The result shows increase in rate of reaction with the increase in temperature table 3. From the linear Arrhenius plots of 1/Tversuslog$k_{obs}$and 1/Tversuslogk_{obs}/Tactivation parameters were calculated and tabulated in table 4.

Temperature K	298	303	308	313	318
k_{obs} x 10^{-4}	5.8	6.0	6.3	6.7	7.3

Table 3:k_{obs} at different temperatures

Activation Parameters	**Ea**	**ΔH**	**ΔS**	**ΔG**
	9.156 $kJmol^{-1}$	**6.553 $kJmol^{-1}$**	**-286.03 $JK^{-1}mol^{-1}$**	**96.096 $kJmol^{-1}$**

Table 4 : Activation Parameters

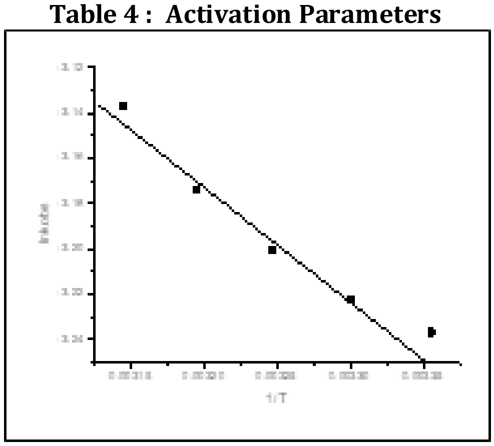


Figure 3 : Graph of 1/T versuslog k_{obs}

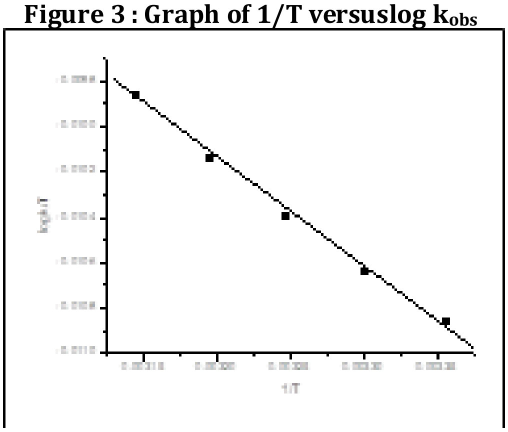


Figure 4 : Graph of 1/T versus log k_{obs}/T

Effect of acid concentration:

The oxidation of voglibose with potassium dichromate was studied with different concentrations of sulphuric acid keeping concentration of potassium dichromate, voglibose and all other conditions of the reaction constant. There is no significant change in the rate constant with increasing sulphuric acid concentrations i.e. rate of the reaction is not depending on concentration of acid.

Free radical test: Free radical test is conducted with addition of aqueous solution of acrylonitrile to the reaction mixture was added. There is no initiation of polymerization reaction indicating non-involvement of free radical in the reaction sequences [12].

Effect of Salts added

Different salts were added to study the effect of salt on the rate of oxidation of pregabalin with potassium dichromate. Sodium chloride (NaCl), potassium chloride (KCl), potassium bromide (KBr) and magnesium chloride ($MgCl_2$) these salts were added to the oxidation reaction at 298K. It is found that the added salt has no effect on the rate of oxidation of voglibose and so there is no interaction of charged species during the reaction.

Mechanism of the oxidation of voglibose:

$H_2CrO_4 + H^+ \overset{K1}{\leftrightarrows} H_3CrO_4^+$ (I fast)

VBS + $H_3CrO_4^+ \overset{K2}{\leftrightarrows} C$ ***(II fast)***

$C \xrightarrow{k} C^/$ (III slow)

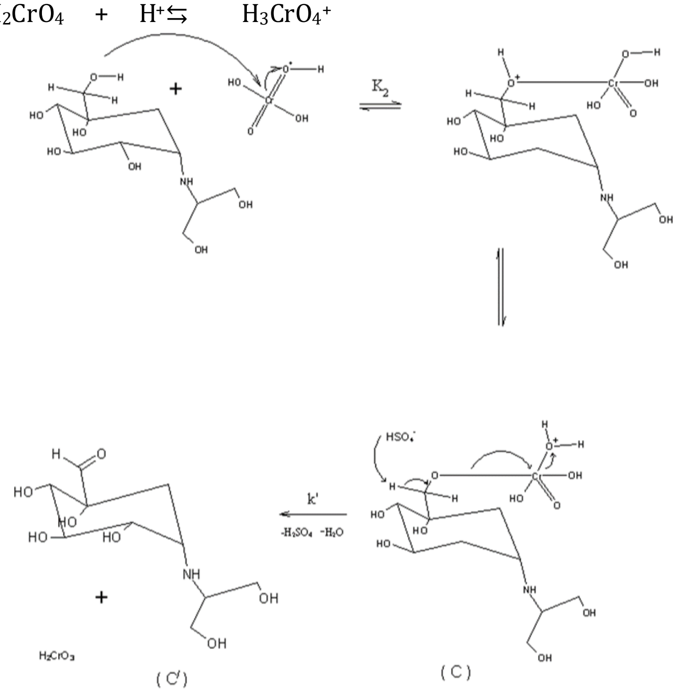
$C^/ \overset{K3}{\leftrightarrows} C^{//}$ (IV fast)

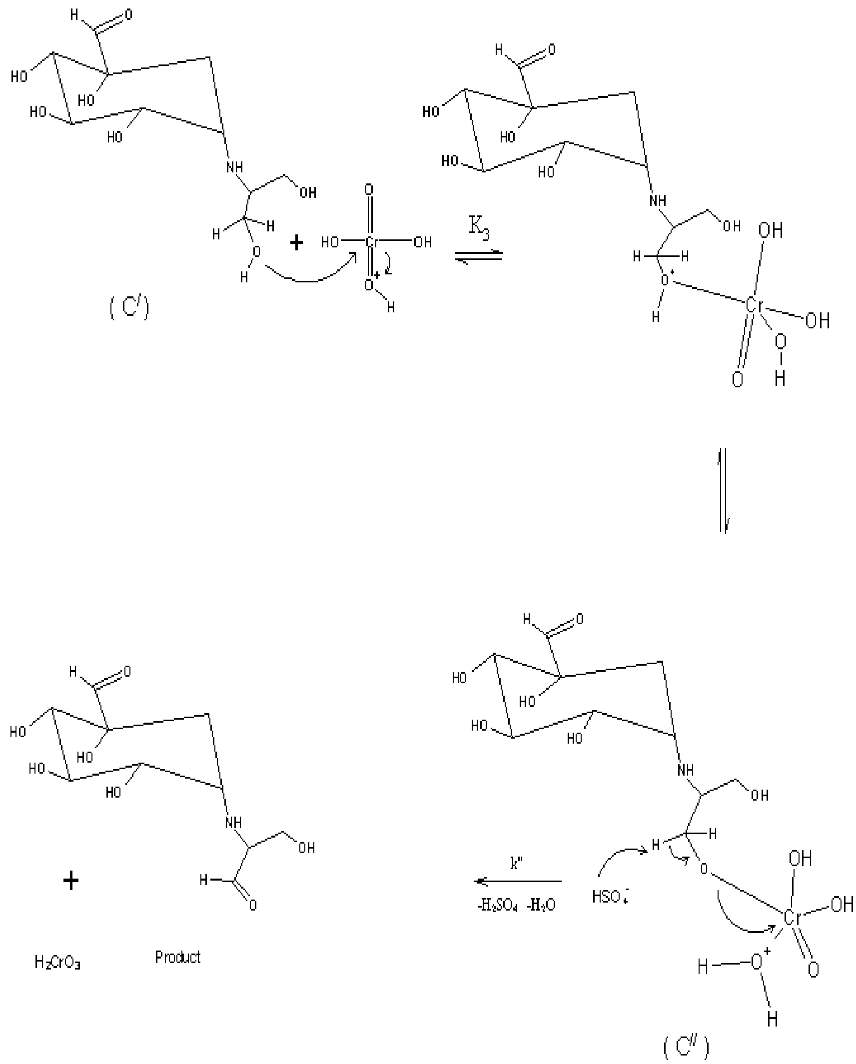
$C^{//} \rightarrow$ Product (V fast)

Scheme-1

Inscheme-1 in the first step the dichromate is protonated in the presence of aqueous sulphuric acid which reacts with the substrate to give intermediate chromate ester (C). The intermediate chromate ester (C) in third step gives another compound ($C^/$) in which C1 of the ring get an aldehydic group after oxidation. The compound ($C^/$) in fourth step reacts with second molecule of protonated chromic acid molecule to give another chromate ester ($C^{//}$) as an intermediate which finally gets converted to product. The structures of these intermediates are shown in scheme-2.

$H_2CrO_4 + H^+ \overset{K1}{\leftrightarrows} H_3CrO_4^+$





CONCLUSION:
On the basis of results obtained the following mechanism is proposed in scheme-1. It has a fast intermediate complex formation between the substrate and the kinetically active protonated chromic acid. The formation of intermediate complex is also confirmed by the plot of 1/[VBS] versus 1/k_{obs} which gives a straight line with an intercept[12]. The intermediate complex gets decomposed in the rate determining step to give rise to the final product.

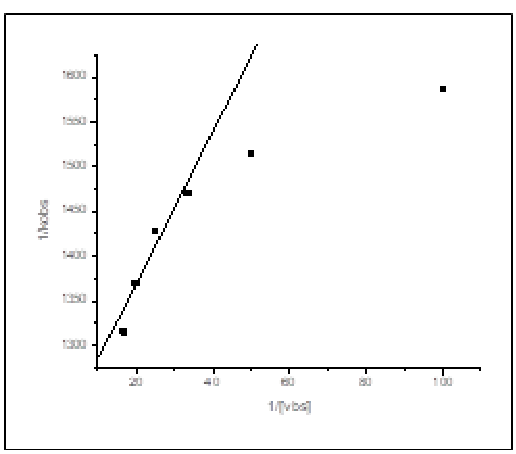


Figure 5: Graph of 1/[VBS] versus 1/k_{obs}

In the present investigation of kinetic study of oxidation of voglibose with potassium dichromatevoglibose undergoes oxidation in acid medium in which the C1 having CH_2OHgets oxidized firstto give 5-[(1,3-dihydroxypropan-2-yl)amino]-1,2,3,4-tetrahydroxycyclohexanecarbaldehyde which undergoes oxidation to yield 1,2,3,4-tetrahydroxy-5-[(1-hydroxy-3-oxopropan-2-yl)amino]cyclohexanecarbaldehydeas the main product. The rate of the reaction is first order with respect to voglibose and potassium dicchromate but it is not depending on the concentration of sulphuric acid.In the reaction the chromium(VI) exists in acid media as chromic acid H_2CrO_4. It is indicated in the first step in scheme-1[13] [14] [15] [16]. The negative value of entropy of activation indicates formation of rigid transition state. It can be concluded from kinetic data the overall mechanistic sequence described is consistent with product and scheme-1.

REFERENCES:

1. https://www.1mg.com/generics/voglibose-210910
2. Lee D.G. Oxidation of organic compounds by permanganate, Fe ion and hexavalent chromium, Open Court : La Sale :1980
3. SayyedHussain, et al, "Kinetic and mechanistic study of oxidation of ester by K2Cr2O7, 2011;Vol. 2, (2):8-10
4. Chimatadar, S.A., Madawale, S.V., &Nandibewoor, S.T. "Mechanism of oxidation of hexamine by quinolinium dichromate in aqueous perchloric acid" Ind.J. Chem. Tech., 2007; 14: 459-465.
5. Signorella, S.R. et al, "Kinetics and mechanisms of chromium (VI) and chromium (V) by lactobionic acid", Can.J.Chem.,1994; Vol. 72:398-402.
6. Bijudas K, Kinetics and mechanism of the selective oxidation of benzyl alcohols by acidified dichromate in aqueous acetic acid medium, Oriental J. Chem., 2014; 30 (3): 1391-1396.
7. Fiester, L., Fiester, M. Reagents for organic synthesis, Wiley, New York, 1984.
8. Das, A.K., "Micellar effect on the kinetics and mechanism of chromium (VI) oxidation of organic substrates" Coordination Chemistry Reviews, 2004, 248, 81-99.
9. Wiberg K.B., Oxidation in organic chemistry, Academic Press, London and New York, 1965.
10. F. Feigl, Spot tests in organic analysis, Elsevier, New York, NY, USA, 1957.
11. Joseph, Basheer, K.M., Radhakrishnan Nair T.D., "Effects of substituents on the kinetics of the oxidation of benzyl chloride using acid dichromate, Asian J. Chem., 2007; 19(6): 4733-4738
12. Vogel, AI, Text book of practical organic chemistry, Longman, London, 1967.
13. Michaelis L, Menton M.L. "The kinetics of invertase action", Biochem Z, 1913, 49, 333-369
14. Laidler K. Chemical Kinetics, McGraw Hill, New York, USA, 1965.
15. Bailey N, Carrington A, Lott KAK, Symons MCR "Structure and reactivity of the oxyanions of transition metals". Part VIII. Acidities and spectra of protonated oxyanions. J ChemSoc,1960: 290-297.
16. Sasake Y Equilibrium studies on polyanions. 9. The first steps of acidification of chromate ion in 3M $Na(ClO_4)$ Medium at 25^{o}C. ActaChem Scand,1962;16: 719-734.
17. Chimatadar, S.A., Madawale, S.V. &Nandibewoor, S. T. "Mechanism of oxidation of hexamine by quonolinium dichromate in aqueous perchloric acid" Indian Journal of Chemical Technology, 2007,14, 459-465.