Kinetic Study of Catalytic Oxidation of Sugar by Potassium Permanganate in Acidic Medium

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Abstract: -- The kinetics of oxidation of sucrose with potassium permanganate is studied spectrophotometrically by using systronic visible Spectrophotometer-105 at 545 maximum wavelength. First order rate of reaction has been studied with respect to concentration of oxidant, substrate, H2SO4 in presence of Hg (II) . The effect of salt does not affect rate of the reaction in absence of catalyst . This result shows that molecular species are responsible for formation of final product in rate determining step. when concentration of sucrose increases then rate of reaction increases. Same result obtained in case of increasing the concentration of oxidant also it has been observed that rate of reaction increases by increasing the concentration of catalyst .Rate law of the reaction and suitable mechanism of the reaction is predicted for the current research work.

Keywords – Kinetics, oxidant, rate, sucrose.

I. INTRODUCTION

Carbohydrates are very essential for every living organisms and it is a part of a healthy and balanced diet. During digestion of sugar, it break down into smaller unit i.e. monosaccharide absorbed by intestine into the blood stream after the it travel to the cell and provide enrgy for cellular functions[2]. Oxidation reaction of sugars are responsible for the producing energy[3]. The kinetics of D-glucose and D-mannose, D-sorbitol and D-mannitol by potassium permanganate in NaHCO3/NaOH has been studied by Odebunmi and Murfu [4] Ruthenium (III) catalized oxidation of D-galactose and lactone by alkaline potassium bromated has been studied by Ashok and co-workers [5]. They reported Zero order rate with respect to sugar concentration and first order in [potassium bromated] and in [Ru(III)] and positive effectof salt [KCl] is shown. Rate law and suitable mechanism is proposed on the basis of experimental data. Oxidation of different monosaccharides and disaccharides has been investigated through many oxidants such as Ti (III) [6], V (V) [7], Cr(VI) [8], [9] have been studied.

Although, so many works has been investigated by using transition metals, organic and inorganic compopunds, enzymes, etc, in neutral , alkaline, buffera but less work has been done in acidic medium . So, current work is taken under investigation of sugar oxidation by $KMnO_4$ in sulphuric acid medium.

II.EXPERIMENTAL

Analytical grade chemicals sucrose, potassium permanganate, sulphuric acid, mercuric chloride, potassium chloride etc. has been taken for the kinetic study of the oxidation of sucrose and each stock solution is prepared by using doubly distilled water.

III.SPECTRAL MEASUREMENT

The absorption spectrum of different solution of potassium permanganate were recorded between 340-960nm by using Systyronic Vsible Spectrophotometer-105 and kinetic data is recorded at 545nm maximum wavelength.

IV. KINETIC MEASUREMENT

First order rate constant has been recorded with respect to oxidant and substrate. Appropriate volume of reactant solutions already placed in a thermostat water bath were mixed and drawn in the cuvette of the spectrophotometer. The oxidation reaction of sucrose were followed by measuring the decrease in absorbance at 545nm

V. RESULT AND DISCUSSSION

The first order rate constant were investigated by varying the initial concentration of sucrose from 1×10^{-1} mol dm^{-3} - 5×10^{-1} mol dm^{-3} while keeping constant other parameters were presented in Table-1.This result is

confirmed from the plot of k verses [sucrose] [fig. 1] and plot of log K verses log[sucrose][fig.2], which gives straight line with unity slope[4],[5].

The effect of variation of concentration of $KMnO_4$ were studied by changing its concentration from $1x10^{-4}$ mol dm^{-3} - $5x10^{-4}$ mol dm^{-3} . The first order rate of reaction is determined from a logarithmic plot of k verses [sucrose] [Table -2] and [fig.3][6].

The effect off variation of $[H_2SO_4]$ were determined by changing the concentration of sulphuric acid from $1x10^{-1}$ mol dm^{-3} - $5x10^{-1}$ mol dm^{-3} and straight line is obtained from the plot of logK verses $[H_2SO_4]$, which is in favor of first order rate of oxidation reaction[5],[6],[7].

The effect of concentration of salt potassium chloride does not alter the rate of reaction in both unanalyzed and catalyzed condition. The slope of the graph plotted between logk verses [KCl] gives zero slope. These results gives information about the formation of non-ionic or molecular species formed in the rate determining step of the oxidation of sucrose .

Table -1 Variation of rate constant (K) with [sucrose]

[sucrose] x 10^3 mol dm^{-3}	K x 10^4
1	2.2
2	3.2
3	5.7
4	7
5	8.1

$[KMNO_4]$ = $1x10^{-4}$ mol dm^{-3}, $[H_2SO_4]$ = $1x10^{-1}$ mol dm^{-3}, $[KCl]$ = $3x10^{-1}$ mol dm^{-3} , $[HgCl_2]$ = $1x10^{-4}$ mol dm^{-3}

Table-2 Variation of rate constant (K) with $[KMnO_4]$

$[KMnO_4]$ x 10^4 mol dm^{-3}	K x 10^4
1	4.3
2	5
3	7.8
4	9
5	9.9

[sucrose] = $4x10^{-3}$ mol dm^{-3}, $[H_2SO_4]$ = $1x10^{-1}$ mol dm^{-3}, $[KCl]$ = $3x10^{-1}$ mol dm^{-3} , $[HgCl_2]$ = $1x10^{-4}$ mol dm^{-3}
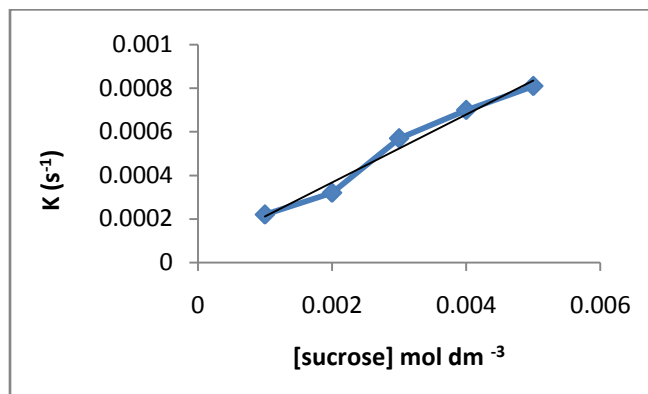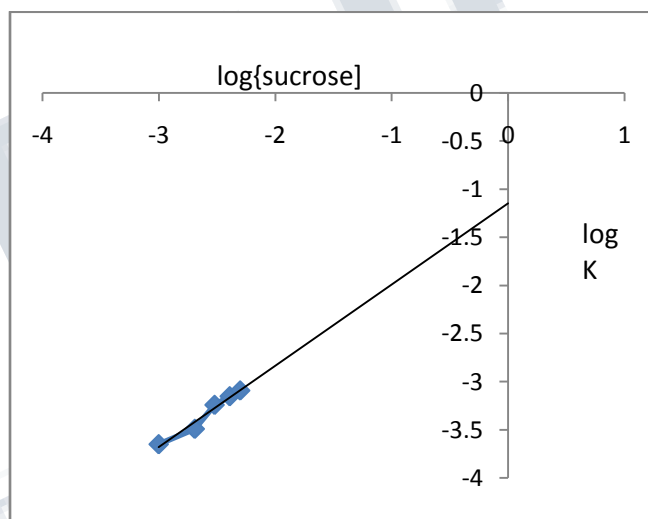

Fig.1 A plot of K verses [sucrose]
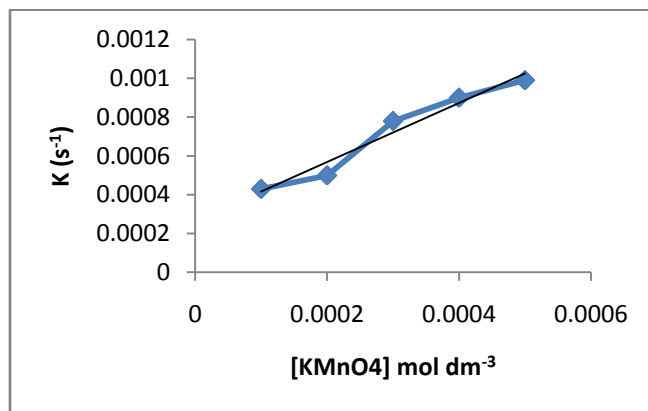

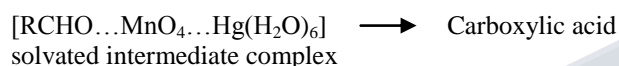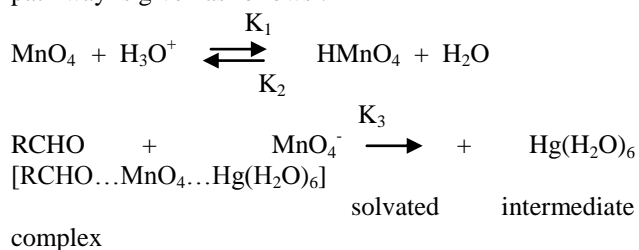*Fig.2 A plot of logK verses Log[sucrose]*

Fig.3 A plot of K verses $[KMnO_4]$

VI. MECHANISM OF THE REACTION AND RATE LAW

One molecule iof sucrose is made by the glycosidic linkage between one molecule of glucose and one molecule of fructose. On the basis of experimental data during the oxidation reaction, solvated intermediate complex is formed[8] . This intermediate complex break down into final product of the oxidation reaction with carboxylic acid functional group. The possible reaction path way is given as follows :

$$MnO_4 + H_3O^+ \underset{K_2}{\overset{K_1}{\rightleftharpoons}} HMnO_4 + H_2O$$

$$RCHO + MnO_4^- \overset{K_3}{\longrightarrow} + Hg(H_2O)_6$$
$$[RCHO…MnO_4…Hg(H_2O)_6]$$

solvated   intermediate

complex

$$[RCHO…MnO_4…Hg(H_2O)_6] \longrightarrow Carboxylic\ acid$$
solvated intermediate complex

Hence, on the basis of literature and experimental data following rate law is predicted for present research work.

$$\frac{-d[oxidant]}{dt} = K^{'}\ [sucrose]\ [oxidant]$$

Where,

$$K^{'} = K_1 K_3 / (K_2 + K_3)$$

VII. ACKNOLEGEMENT

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