Kinetic study of surfactant catalysed oxidation of iso amyl alcohol by acidic permanganate spectrophotometrically

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ABSTRACT

A Kinetic investigation of oxidation of iso amyl alcohol by acidic permanganate in presence of surfactant as catalyst has been carried out spectrophotometrically. The reaction is double stage process in which first stage is followed by second fast stage process. The rate shows a first order dependence on each oxidant and substrate. The reaction is studied at different temperatures to evaluate usual kinetic and activation parameters such as rate constant, temperature coefficient, energy of activation.

Keywords: Surfactant, Catalysis, Rate constant, Kinetic parameters, Oxidation, Spectrophotometer.

1. INTRODUCTION

The study the oxidation of iso amyl alcohol by acidic permanganate in presence of anionic surfactant sodium lauryl shulphate was done spectroscopically.

The term oxidation was originally used to describe reactions in which an element combines with oxygen**.** Oxidation defined as the loss of at least one electron when two or more substances interact. Those substances may or may not include oxygen. In this experiment we oxidized iso amyl alcohol which is a primary alcohol primary. Primary alcohols can be oxidized to either aldehydes or carboxylic acid depending on the reaction conditions.The oxidising agent used in this reaction or experiment is Potassium permanganate which is acidified with sulphuric acid.

Potassium permanganate is an inorganic chemical compound with the formula $KMnO_4$. It is a salt consistingof $K^+$and MnO^{-4} ions. Formerly known as permanganate of potash or Condy's crystals, it is a strong oxidizing agent. It dissolves in water to give intensely pink or purple solutions, the evaporation of which leaves prismatic purplish-black glistening crystals. In 2000, worldwide production was estimated at 30,000 tonnes. In this compound, manganese is in the +7 oxidation state.

This reaction catalysed by the enzyme Sodium lauryl sulfate (NaLS) or sodium lauryl ether sulfate (SLES). Sodium lauryl sulfate (SLS) is an organic compound with the formula $CH_3(CH_2)_{11}OSO_3Na$. It is an anionic surfactant used in many cleaning and hygiene products. The salt is of an organosulfate consisting of a 12-carbon tail attached to a sulfate group, giving the material the amphiphilic properties required of a detergent. Being derived from inexpensive coconut and palm oils, it is a common component of many domestic cleaning products.
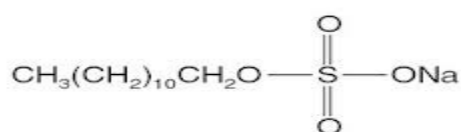

sodium lauryl sulphate

2. MATERIAL AND METHODS

2.1. Materials

The substrate used in this experiment is iso amyl alcohol. Iso amyl alcohol (also known as isopentyl alcohol) is a clear, colorless alcohol with the formula (CH3)2CHCH2CH2OH. Colorless liquid with a mild, choking alcohol odor less dense than water, soluble in water. Hence floats on water Produces an irritating vapor. Very high vapor concentrations irritate eyes and upper respiratory tract. Continued contact with skin may cause irritation.
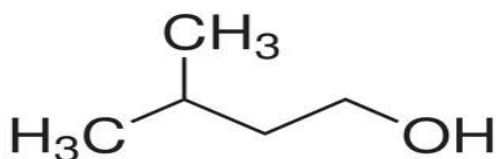
2.2. Method

The oxidation of Poly Vinyl Alcohol by permanganate ion in perchlorate solution was studied by Ishaaq.A.Jaffrany[1],Kinetics studies in the surfactant catalyzed oxidative deamination & decarboxylation of glycine by acidic permanganate explored by N.Bende[2], Kinetic studies in the surfactant catalyzed oxidative deamination and decarboxylation of L-Valine by permanganate in sulphuric acid medium observed by Kirti Yadav[3], Lewis-acid activated oxidation of alcohol by permanganate researched by Haojun Liang & coworkers[4],

Kinetics & Mechanism of the selective oxidation of primary aliphatic alcohols under phase transfer catalysis explored by K.Bijudas & T.D. Radhakrishnan Nair[5], Oxidation by Permangnate: synthetic & mechanistic aspects researched by Sukalyan Dash & coworkers[6], Kinetic studies in the surfactant catalyzed oxidative deamination and decarboxylation of L-Valine by permanganate in sulphuric acid medium observed by Maqsood Ahmad Malik & coworkers[7], Kinetics of the Oxidation of Benzhydrols with Permanganate under Phase Transfer Catalysis in Organic Solvents studied by Joy Joseph & coworkers[8], Kinetics of monohydric alcohol by acid permanganate investigated by Kalyan.K.Sengupta[9], Silica Sulfuric Acid/Potassium Permanganate/Wet SiO2 as an Efficient Heterogeneous Method for the Oxidation of Alcohols under Mild Conditions studied by Amin Zarei & coworkers[10], Investigations into the kinetics and mechanism of Cr (VI) oxidation of hexamethylpararosalinine chloride in aqeuous acidic medium studied by O.A.Komolafe & coworkers[11],

Oxidation of isopropyl alcohol by tripropylammonium fluorochromate: explored by Mazhar Farooqui & coworkers[12], kinetic and mechanistic study of oxidation of ester by KMnO4 researched by Sayyed Hussain & coworkers[13], co oxidation of oxalic acid and glutaric acid by chromic acid in presence of sulphuric acid observed by Mamta Mishara & coworkers[14], Oxidation of tyrosine by permanganate in presenceofcetyltrimethylammonium bromide researched by Malik MA & coworkers[15], N-Chloropyrazinamide Oxidation of Aliphatic Primary Alcohols: A Kinetic Study studied by S.Parimala Vaijayanthi[16], Kinetics and mechanistic oxidation of alcohols by butyl triphenyl phosphonium dichromate observed by Anita Kothari & coworkers[17].

Oxidation of Ethyl -2-Chloropropionate by Potassium permanganate in acidic Media studied by Shaikh Quadeer & coworkers[18] while kinetic and mechanistic study of oxidation of ester by potassium permanganate investigated by B.R.Agrawal & coworkers[19], Oxidation of chemical compounds studied by B.S. Dhobal & coworkers[20], Oxidation of Cyclic Alcohols by Hexacyanoferrate(III) in Alkaline Medium in the Presence of Rhodium(III) Chloride as a Homogeneous Catalyst researched by Praveen.K. Tandon & coworkers[21].

Kinetic model for sulfate/hydroxyl radical oxidation of methylene blue in a thermally-activated persulfate system explored by Chen Ju Liang & Shun Chin Huang[22], kinetics and mechanism of oxidation of 2,5-diamino-1,3,4-thiadiazole metal complex in acid medium observed by Takale Surendra & Sayyed Hussain[23], Nickel Porphyrin Hybrid Material Based on Functionalised Silica for the Selective Oxidation of Benzyl Alcohol investigated by Farook Adam & Ooi Wan-Ting[24], Transition metal-free catalytic oxidation of aromatic alcohols with molecular oxygen in the presence of a catalytic amount of *N*-bromosuccinimide studied by Xinli Tong & coworkers[25] .

Kinetics and Mechanism of Oxidation of Methyl Cellulose Polysaccharide by Permanganate Ion observed by Refat Hassan, Ahmed Fawzy & coworkers[26], Kinetics and mechanism of oxidation of sugar and sugar alcohols by KMnO4 explored by H.K.Okro & O.Odebunmi[27], Effect of metal ion on reaction velocity of surfactant catalysed oxidation of some amino acids by acidic permanganate researched by A. Fadnis & coworkers[28], Kinetics of oxidation of fructose, sucrose & maltose by potassium permanganate in NaHCO3 observed by S.A.Iwarere[29], Kinetics and Mechanism of Oxidation of Nicotine by

Permanganate Ion in Acid Perchlorate Solutions explored by Ishaaq.A.Jaffrany[30].

3. RESULTS AND DISCUSSION

3.1. Nature of the reaction

The oxidation of alcohols has been investigated by various scientists to study the reaction rates. As I performed it on iso-amyl alcohol it observed that the reaction is double stage process i.e. first slow reaction followed by fast reaction. The kinetics studies suggest that the reaction is first order. The reaction is studied till completion when the color of the permanganate ion disappears from the reaction mixture (Figure 1).
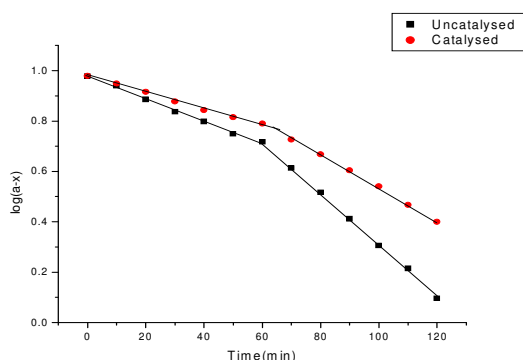

Figure -1: Typical run.

3.2. Substrate variation

The oxidation of iso-amyl alcohol has been studied by changing the substrate concentration from 0.05 to 0.20 N.

It was found that the order of the reaction remains same i.e. first order but the rate changes greatly. As the amount of substrate in the reaction mixture increases the rate of the reaction enhances greatly (Table 1 and Figure 2). The substrate concentration found to be directly proportional to the rate of the reaction.

Table - 1: oxidation of iso-amyl alcohol has been studied by changing the substrate concentration from 0.05 to 0.20 N.

[Iso Amyl alcohol] N	$k_1 \times 10^{-3}$ min^{-1}	$k_1^{l} \times 10^{-3}$ min^{-1}
0.05N without NaLS	2.7533	18.5473
0.05	4.5333	17.5969
0.10	5.5119	16.9686
0.15	7.4164	12.4909
0.20	9.5440	16.0597
[NaLS]= 1x10^{-4} mole/dm^2; [H$_2$SO$_4$]=3N; Temp.=35°C		

3.3. Michaelis menten plot

The graph between logK and 1/[iso amyl alcohol] i.e. Michaelis menten plot have straight line showing that the reaction is first order with respect to each stages and also confirms that there is no any intermediate complex formation, if there any complex is formed, its formation constant should be very small (Figure 3).
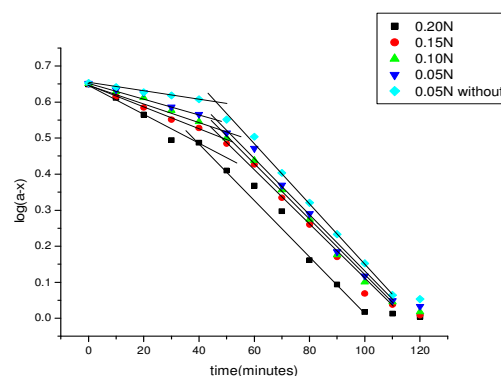

Figure -2: Oxidation of iso-amyl alcohol has been studied by changing the substrate concentration from 0.05 to 0.20 N.
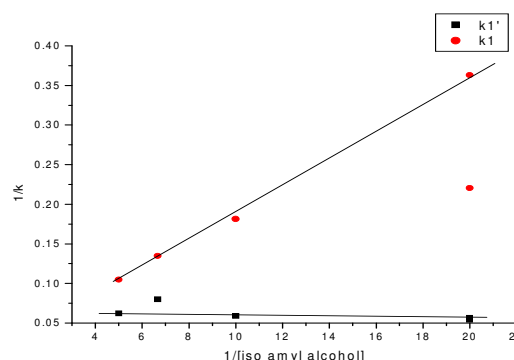

Figure - 3: Michaelis menten plot

Table - 2: Different temperature to study the effect of energy on the reaction

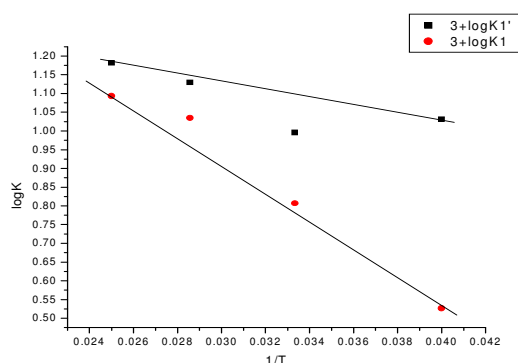| Temperature (°C)	$K_1 \times 10^{-3}$ min^{-1}	$K_1' \times 10^{-3}$ min^{-1}
25	0.3361	1.1935
30	0.6411	1.0914
35	1.0834	1.3475
40	1.2398	1.5441
Temperature Range(K)	**Temperature coefficient for K_1**	**Temperature coefficient for K_1'**
298-308	4.2234	2.1290
303-313	2.9338	2.4147
[NaLS]= 1x10^{-4} mole/dm^2; [H$_2$SO$_4$]=3N; [Iso Amyl alcohol]=0.05N		

3.4. Temperature variation

Figure - 4: Arrhenius plot

The reaction has been studied at different temperature to study the effect of energy on the reaction and to calculate some physical parameters. The activation energy has been calculated by temperature coefficient whose value is given in the table 2 and figure 4.

4. CONCLUSION

In this experiment we oxidized iso amyl alcohol by $KMnO_4$ in the presence of an enzyme which is sodium lauryl sulphate in acidic medium and we calculated some thermodynamic parameters ie. Temperature coefficient and activation energy. In this experiment, we focused on three major points nature of the reaction, substrate variation, and temperature variation. By substrate variation we obtained Michaelis Menten plot and by temperature variation we obtained Arrhenius plot.

Table - 3: Thermodynamic Parameter		
	$K_1 X 10^{-3}$ min^{-1}	$K_1' X 10^{-3}$ min^{-1}
Thermodynamic Parameter	**Calculated**	**Calculated**
$\Delta Ea(KCalmol^{-1})$ (298-308)	26.2754	13.7845
$\Delta Ea(KCalmol^{-1})$ (303-313)	20.2843	16.6128
[NaLS]= $1x10^{-4}$ mole/dm³; [H_2SO_4]=3N; [Iso Amyl alcohol]=0.05N [$KMnO_4$]=$1x10^{-3}$ mol dm-3		

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