

## Kinetics and Thermodynamics of Mandelic Acid Oxidation By Tripropylammonium Halochromates(X=F,Cl) In Micellar Medium

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**ABSTRACT**: Two new Versatile reagent Tripropylammonium Fluorochromate(TriPAFC) and Tripropylammonium Chlorochromate(TriPACC) has been employed for the oxidation of Mandelic acid. Rate of the réaction is catalysed by surfactant Sodium LaurylEther Sulphate(SLES). The Oxidation has been studied spectrophotometrically at room température in perchloric acid medium. Rate of TriPAFC and TriPACC oxidation of Mandelic acid has been followed under pseudo-first order condition. Rate constants were calculated by the integrated rate equation. The graph of logk versus time was linear and the slope is near to unity, rate constant calculated from graph also agreed with experimental value shows the first order rate dépendance on Mandelic acid. Product formed in this oxidation of Mandelic acid was analysed, polymerization test were carried to confirm that the reaction follows ionic mechanism and stoichiometric data has been accounted. Temperature of the substrate is varried and from the rate constant value, Thermodynamic parameters like Activation energy, Enthalpy change, Entropy change and change in Gibb's free energy is calculated using Arrhenius and Eyrings plot. All the kinetic runs were repeated and the rate constants were reproducible within  $\pm 2\%$  range.

**Keywords** : Mandelic acid, oxidation, perchloric acid, Sodium LaurylEther Sulphate, Temperature

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### I. Introduction

Chromium compounds have been widely used in aqueous and non- aqueous medium for the oxidation of a variety of organic compounds [1-3]. Chromium compounds especially Cr(VI) reagents have been proved to be versatile reagents capable of oxidizing almost all the oxidizable organic functional groups. The study of both very slow and very fast reactions can pose severe Experimental problems. The development of newer Cr(VI) reagents for the oxidation of organic substrates continues to be of interest.

The new reagent Tripropylammonium Fluorochromate(TriPAFC) and Tripropylammonium Chlorochromate (TriPACC) prepared is highly soluble in water, it is economic, stable, non-hygroscopic and easy to prepare in good yield (97%). It is reported to be highly toxic; there is a continued interest in this reagent for the selective and effective oxidation of the substrate under mild conditions. A number of new Cr (VI) reagents like Tripropylammonium fluorochromate<sup>[14]</sup>, Pyridinium fluorochromate<sup>[15]</sup>, Tetrabutylammonium chlorochromate<sup>[16]</sup> and tetraethyl ammonium chlorochromate<sup>[17]</sup> has been used to study the kinetics and mechanism of various organic compounds.

Rate of the reaction is determined at room temperature by spectrophotometrically. Oxidation of Mandelic acid is done in perchloric acid medium in presence of micelle SLES. Due to distribution of the substrate between aqueous and micelles phases, the rate of the reaction of the substrate are different. Basically, the rate effects can be attributed to electrostatic and hydrophobic interaction between the substrate and the surfactant aggregate and in some cases to change in structure of the surrounding water, on simple electrostatic consideration.

Rate is increased by increase in concentration of substrate, Perchloric acid and micelle. Decrease in Absorbance from 373nm for TriPAFC and 370.5nm for TriPACC is observed. Rate of the reaction also been determined at four different temperatures from 303K to 318K for Mandelic acid by keeping other reagents constant at constant temperature. Temperature is maintained using constant temperature bath. Activation parameters were calculated from the graph by plotting log ( $k_2$ ) versus (1/T) for Arrhenius plot is linear with negative slope.

### II. Materials And Methods

All the chemicals used are of Analytical grade. DL-Mandelic acid, 60% A.R.Perchloric acid were commercial products (E.Merck Ltd, Mumbai, India) and directly used. Tripropylamine, Sodium LaurylEther Sulphate (SLES) was purchased from SD fine chemicals, India. Double Distilled water was used as solvent. Perchloric acid was standardized using standard sodium carbonate (Merck, India) solution with methyl orange as Indicator.

## 2.1. Kinetic methods and Rate Measurements

Elico UV-Visible (FL244) Spectrophotometer has been used to study the oxidation of Mandelic acid by TriPAFC and TriPACC in presence of Micellar catalyst. The solution of temperature pre-equilibrated. The rate measurement was carried out on  $30 \pm 0.2^\circ \text{C}$  in 100% aqueous medium. The Temperature was controlled by electrically operated thermostat. The total volume of reaction mixture in the spectrophotometric cell was kept as 2.5ml in each kinetic run. The reactions were carried out under pseudo-first order conditions, keeping the substrate concentration always in excess. The pseudo-first order rate constant of each kinetic run was evaluated from the slope of the linear plot of  $\log(a-x)$  versus time, according to the first order rate equation by the method of least square.

$$k = (2.303/t) \cdot \log(a/(a-x)) \quad \text{---- (1)}$$

$k_1 = 2.303 \times \text{slope}$  expressed in  $\text{sec}^{-1}$  where  $k_1$  is the pseudo-first order rate constant, 't' is the time in sec. and 'a' and (a-x) denote the initial concentration and concentration at time 't' respectively of oxidant.

## 2.3. Thermodynamic methods

Time is a variable in kinetics but not in thermodynamics; rates dealt with in the latter are with respect to temperature, pressure, etc., but not with respect to time; equilibrium is a time independent state. Thermodynamic parameters such as Activation Energy, Frequency factor, Enthalpy of Activation, Entropy of Activation and free energy of Activation has been calculated at four different temperatures from the equations given below. From Arrhenius Equation the speed of the chemical reaction increases exponentially with temperature.

$$k = A \cdot \exp[-E_a/RT] \quad \text{----- (2)}$$

$$\log A = \log k_2 + [E_a/2.303RT] \quad \text{----- (3)}$$

The equation is in accordance with empirical fact that for most of reactions plot of  $3 + \log k$  versus  $10^3/T$  is a Arrhenius plot which gives a straight line and slope is  $-E_a/2.303R$ ,  $E_a$  calculated in this way is called Arrhenius activation energy. Intercept gives the value of  $\log A$ .

$$\Delta H = E_a - RT \quad \text{---- (4)}$$

$$\Delta S = 2.303 R (\log A - \log \exp [k_B T/h]) \quad \text{---- (5)}$$

$$\Delta G = \Delta H - T\Delta S \quad \text{----- (6)}$$

Two oxidants TriPAFC and TriPACC were synthesized by the given procedure

## 2.4. Preparation of Tripropylammonium Fluorochromate TriPAFC, $(\text{C}_3\text{H}_7)_3\text{NH} [\text{CrO}_3\text{F}]$

Tripropylammonium Fluorochromate TriPAFC by the reported procedure<sup>[15]</sup> Chromium (VI) oxide (10g, 10 mmol) and 9.0 mL (20 mmol) 40 % hydrofluoric acid were added to 20 mL of water in a 100 mL polyethylene beaker with stirring at  $0^\circ\text{C}$ . To the resultant orange solution, Tripropylamine (14ml, 20mmol) was added drop wise and stirring was continued over a period of half an hour. The precipitated solid was isolated by filtration and washed with petroleum ether and dried under vacuum for 2 hours. Yield: 45.8(98%); mp  $142^\circ\text{C}$ . IR spectral data shows peak at  $904, 647, 949 \text{ cm}^{-1}$ . Electronic absorption occurs at  $22321 \text{ cm}^{-1}$ . UV/Visible and  $^1\text{H-NMR}$  and  $^{19}\text{F-NMR}$  was all consistent with the TriPAFC structure. The pH of 0.01 M solution of TriPAFC in water was 3.3. Purity of the oxidant was checked by Iodimetric procedure.

## 2.5. Preparation of Tripropylammonium Chlorochromate TriPACC, $(\text{C}_3\text{H}_7)_3\text{NH} [\text{CrO}_3\text{Cl}]$

Tripropylammonium Chlorochromate TriPACC by the reported procedure<sup>[16]</sup> Chromium (VI) oxide (10g, 10m mol) and 2.5 mL (15 mmol) 40 % hydrofluoric acid were added to 20 mL of water in a 100 mL polyethylene beaker with stirring at  $0^\circ\text{C}$ . To the resultant orange solution, Tripropylamine (15ml, 15mmol) was added drop wise and stirring was continued over a period of half an hour. The precipitated solid was isolated by filtration and washed with petroleum ether and dried under vacuum for 2 hours. Yield: 45.8(95%); mp  $135^\circ\text{C}$ . IR spectral data shows peak at  $901, 432, 949 \text{ cm}^{-1}$ . Electronic absorption occurs at  $22123 \text{ cm}^{-1}$ . UV/Visible and  $^1\text{H-NMR}$  and  $^{13}\text{C-NMR}$  was all consistent with the TriPAFC structure. The pH of 0.01 M solution TriPACC in water was 2.9. Purity of the oxidant was checked by Iodimetric procedure

## 2.6. Product Analysis

The carbonyl compound formed during the oxidation of Mandelic acid by both TriPAFC and TriPACC was analyzed by the following general procedure. The reaction mixture, after 9 half lives was neutralized to  $\text{pH} = 6.0$  by the addition of saturated  $\text{KHCO}_3$  solution and the resultant solution are filtered off. The filtrate was extracted with diethyl ether several times and the ether extracts were made up to known volume. The amount of Benzaldehyde formed was determined by measuring the absorbance at 280nm. Benzaldehyde formed was analyzed as 2, 4-dinitrophenyl-hydrazone derivative (b.pt- $178^\circ\text{C}$ ).

### 2.6. Stoichiometry and polymerization test

The stoichiometric studies for the oxidation of Mandelic acid by both TriPAFC and TriPACC in the presence of micelle SLES were carried out at  $30 \pm 0.2^\circ\text{C}$ . The Stoichiometry was calculated from the ratio between reacted [oxidant] and [substrate]. Polymerization test with acrylonitrile was carried out to check the formation of intermediate radicals during the oxidation of Mandelic acid by both TriPAFC and TriPACC in perchloric acid medium.

### III. Result And Discussion

The kinetics of both TriPAFC and TriPACC oxidation of Mandelic acid at room temperature  $30 \pm 0.2^\circ\text{C}$  in perchloric acid medium in presence of micelles is attempted.

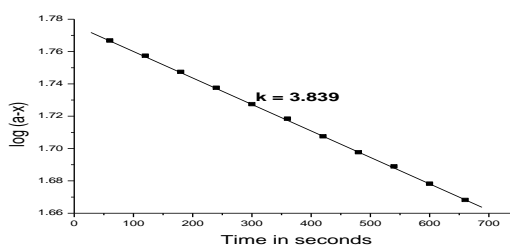
#### 3.1. Rate Dependence on varying TRIPAFc and TRIPACC concentration

The rate of TriPAFC and TriPACC oxidation of Mandelic acid has been followed under pseudo first order condition by keeping excess of the Mandelic acid concentration than the reagent. The rate constants were calculated by the integrated rate equation. The graph of  $\log k$  versus time was linear and the rate constants calculated from the slope of the graph agreed with the experimental value, which shows first order dependence. The rate of **TriPAFC** was given in Table – 1, Fig.1 and rate of **TriPACC** was given in Table – 2 and Fig.2. All the kinetic runs were repeated and the rate constants were reproducible within  $\pm 2\%$  range. Concentration of TriPAFC and TriPACC varied at  $1.0 \times 10^{-2}$ ,  $2.0 \times 10^{-2}$ ,  $3.0 \times 10^{-2}$ ,  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>, keeping other concentrations of Mandelic acid, perchloric acid and temperature constant.

$$-d[\text{Mandelic acid}] / dt = k_1 [\text{Mandelic acid}] \text{ ----- (11)}$$

**TABLE – 1**  
 [TriPAFC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>      [HClO<sub>4</sub>] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>  
 [Mandelic acid] =  $4.0 \times 10^{-1}$  mol dm<sup>-3</sup>    [SLES] =  $1.0 \times 10^{-3}$  mol dm<sup>-3</sup>

Time(Sec)	(a – x) mol dm <sup>-3</sup>	10 <sup>3</sup> k <sub>1</sub> s <sup>-1</sup>
60	0.5846	3.78
120	0.572	3.7
180	0.559	3.7
240	0.5465	3.76
300	0.5339	3.78
360	0.523	3.72
420	0.51	3.79
480	0.4986	3.78
540	0.4886	3.7
600	0.4768	3.78
660	0.4658	3.79
Experimental value		<b>3.76</b>
Graphical value		<b>3.839</b>



**Fig.1: Pseudo first order plot of logk versus time rate dependence for TriPAFC**

**TABLE – 2**  
 [TriPACC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>      [HClO<sub>4</sub>] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>  
 [Mandelic acid] =  $4.0 \times 10^{-1}$  mol dm<sup>-3</sup>    [SLES] =  $1.0 \times 10^{-3}$  mol dm<sup>-3</sup>

Time(Sec)	(a – x) mol dm <sup>-3</sup>	10 <sup>4</sup> k <sub>1</sub> s <sup>-1</sup>
60	0.662	1.984
120	0.602	1.978
180	0.544	1.980
240	0.491	1.989
300	0.431	1.971
360	0.371	1.989
420	0.311	1.982
480	0.245	1.975
540	0.172	1.977
600	0.099	1.974
Experimental value		<b>1.979</b>
Graphical value		<b>1.980</b>

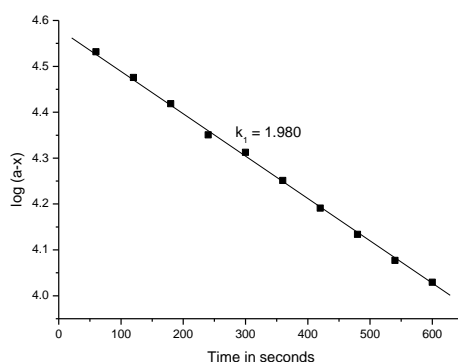


Fig.2: Pseudo first order plot of logk versus time rate dependence for TriPACC

3.2. Rate Dependence on varying Mandelic acid concentration

On increasing the concentration of Mandelic acid at  $1.0 \times 10^{-1}$  to  $4.0 \times 10^{-1}$  mol dm<sup>-3</sup> and by keeping other constituents constants, the rate increases proportionately. The plot of  $4+\log k$  versus  $2+\log$  [Mandelic acid] is a linear with slope nearness to Unity shows the first order rate dependence of Mandelic acid. The rate is compared for the both the absence and presence of micelle. The rate of TriPAFC was given in Table – 3, Fig.3 and rate of TriPACC was given in Table – 4 and Fig.4.

TABLE – 3  
 [TriPAFC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>    [HClO<sub>4</sub>] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>  
 [Temperature] =  $30 \pm 0.2^\circ\text{C}$     [SLES] =  $1.0 \times 10^{-3}$  mol dm<sup>-3</sup>

Mandelic acid	$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	SLES	
			$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
1.0	2.413	2.413	2.895	2.895
2.0	4.846	2.423	5.804	2.902
3.0	7.339	2.446	8.694	2.898
4.0	9.662	2.416	11.601	2.900

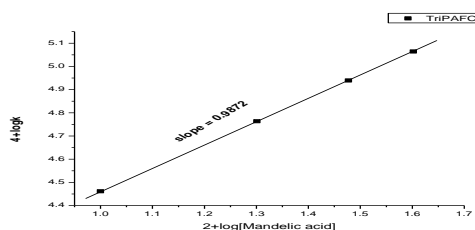


Fig.3: Rate dependence of Mandelic acid in presence of micelle

TABLE – 4  
 [TriPACC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>    [HClO<sub>4</sub>] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>  
 [Temperature] =  $30 \pm 0.2^\circ\text{C}$     [SLES] =  $1.0 \times 10^{-3}$  mol dm<sup>-3</sup>

Mandelic acid	$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	SLES	
			$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
1.0	5.032	5.032	5.436	5.436
2.0	10.151	5.075	10.902	5.451
3.0	15.112	5.037	16.318	5.440
4.0	20.154	5.039	21.864	5.466

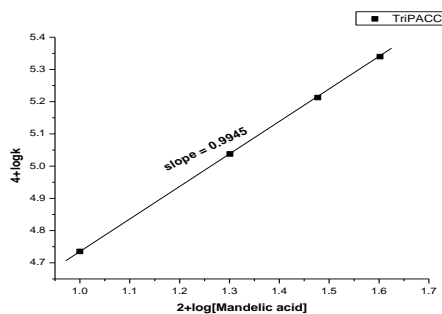


Fig.4: Rate dependence of Mandelic acid in presence of micelle

### 3.3. Rate Dependence on varying Perchloric acid concentration

On varying the concentration of Perchloric acid at  $1.0 \times 10^{-2}$  to  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup> and by keeping other constituents constants, the rate was found to be nearly constant. The plot of  $4 + \log k$  versus  $2 + \log[\text{Perchloric acid}]$  is a linear with slope nearness to Unity shows the Pseudo first order rate dependence of Perchloric acid.

The rate is measured in presence of micelle. It was shown in Table-5 and Fig.5.

$$\text{Rate} = k_{\text{obs}}[\text{Cr (VI)}][\text{HClO}_4] \text{ ----- (12)}$$

TABLE – 5

[TriPAFC and TriPACC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup> [Mandelic acid] =  $4.0 \times 10^{-1}$  mol dm<sup>-3</sup>  
 [Temperature] =  $30 \pm 0.2^\circ\text{C}$  [SLES] =  $1.0 \times 10^{-3}$  mol dm<sup>-3</sup>

Perchloric acid	TriPAFC		TriPACC	
	$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	$10^4 k_1 \text{ s}^{-1}$	$10^2 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
0.1	0.802	0.802	0.975	0.975
0.2	1.611	0.806	1.946	0.973
0.3	2.421	0.807	2.929	0.976
0.4	3.189	0.797	3.889	0.972

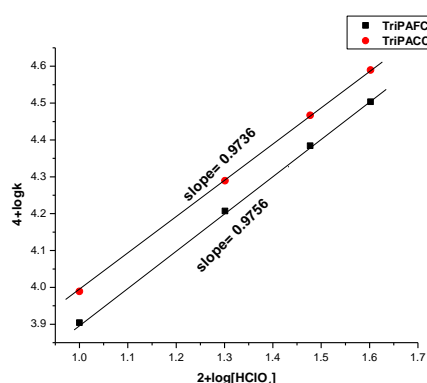


Fig. 5: Pseudo first order plot of rate dependence of HClO<sub>4</sub>

### 3.4. Rate Dependence on varying Micellar concentration

On varying the concentration of micelle Sodium Lauryl Ether Sulphate (SLES) at 0.0001, 0.0052, 0.001 and 0.005 mol dm<sup>-3</sup> shows a progressive increase in the rate. A plot of  $\log k$  versus  $3 + [\text{SLES}]$  gives sigmoidal curve with CMC value  $(1.1 \pm 0.6) \times 10^{-3}$ . Comparison of rate is given in Table-6 and Fig.6 below

TABLE – 6

[TriPAFC and TriPACC] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup> [Mandelic acid] =  $4.0 \times 10^{-1}$  mol dm<sup>-3</sup>  
 [Temperature] =  $30 \pm 0.2^\circ\text{C}$  [HClO<sub>4</sub>] =  $4.0 \times 10^{-2}$  mol dm<sup>-3</sup>

[SLES] mol dm <sup>-3</sup>	TriPAFC		TriPACC	
	$10^4 k_1 \text{ (s}^{-1}\text{)}$	$10^2 k_2 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$	$10^4 k_1 \text{ (s}^{-1}\text{)}$	$10^2 k_2 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$
0.0001	0.124	1.441	1.756	2.102
0.0005	1.222	1.470	1.926	2.110
0.001	1.444	1.444	2.106	2.109
0.005	1.602	1.455	2.216	2.110
0.01	1.621	1.451	2.226	2.111

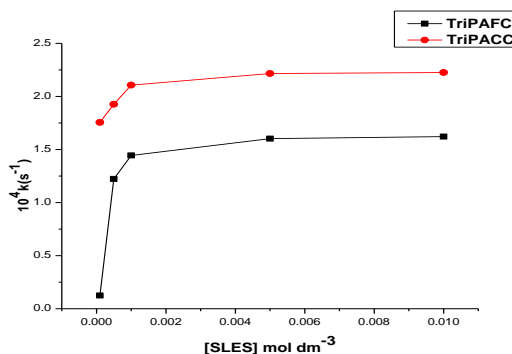


Fig. 6: Rate dependence of SLES variation

### 3.5. Thermodynamic parameters

Oxidation of Mandelic acid by TriPAFC and TriPACC was carried out at four different temperatures keeping all reactant concentrations constant. The rate constant calculated is given in the Table-7 and Table-8. The Arrhenius plot of  $\log k_2$  Vs  $10^3/T$  is given in Fig.7. Arrhenius parameters at 313K for the oxidation of Mandelic acid by TriPAFC and TriPACC is given in Table-9.

TABLE – 7

$$[\text{TriPAFC}] = 4.0 \times 10^{-2} \text{ mol dm}^{-3} \quad [\text{Mandelic acid}] = 4.0 \times 10^{-1} \text{ mol dm}^{-3}$$

$$[\text{HClO}_4] = 4.0 \times 10^{-2} \text{ mol dm}^{-3}$$

Temperature(K)	$10^4 k_1 \text{ s}^{-1}$	$10^3 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
303	2.413	7.963
308	2.834	9.201
313	3.233	10.33
318	3.657	11.50

TABLE – 8

$$[\text{TriPACC}] = 4.0 \times 10^{-2} \text{ mol dm}^{-3} \quad [\text{Mandelic acid}] = 4.0 \times 10^{-1} \text{ mol dm}^{-3}$$

$$[\text{HClO}_4] = 4.0 \times 10^{-2} \text{ mol dm}^{-3}$$

Temperature(K)	$10^4 k_1 \text{ s}^{-1}$	$10^3 k_2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
303	5.032	16.607
308	5.676	18.428
313	6.252	19.974
318	6.846	21.528

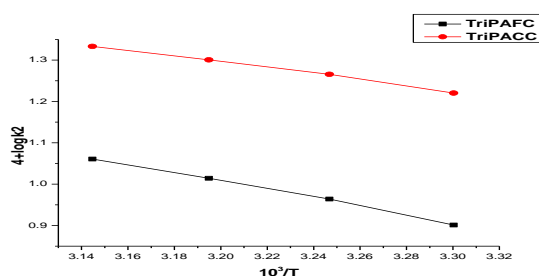


Fig.7: Arrhenius plot of  $\log k$  Vs  $[1/T]$  to calculate thermodynamic parameters

TABLE-9

Arrhenius parameters at 313K for the oxidation of Mandelic acid by TriPAFC and TriPACC

Arrhenius parameters	[TriPAFC]	[TriPACC]
Ea $\text{KJmol}^{-1}$	18.902	19.042
$\Delta H \text{ KJmol}^{-1}$	16.299	16.44
$-\Delta S \text{ JK}^{-1}\text{mol}^{-1}$	186.9	190.04
$\Delta G \text{ KJmol}^{-1}$	74.8	75.91
Log A	3.664	3.973

### 3.6. Polymerisation test and Stoichiometry

To a solution of  $0.1 \text{ mol dm}^{-3}$  of Mandelic acid in perchloric acid medium, a few drops of acrylonitrile was added and shaken well. To this 5 ml of  $0.01 \text{ mol dm}^{-3}$  solution of oxidant in aqueous medium and stirred well and kept under nitrogen atmosphere in a thermostat for one hour. No polymer formation was observed which indicates the absence of radical formation as an intermediate during the course of the reaction. The estimation of unreacted oxidant TriPAFC and TriPACC indicated that one mole of the oxidant was consumed by 0.65 mole of the Mandelic acid (1.00: 0.65) ratio.

## IV. Conclusion

The Mandelic acid oxidation by two new reagents TriPAFC and TriPACC has been investigated in perchloric acid medium at room temperature. The oxidation of Mandelic acid is first order with respect to each TriPAFC and TriPACC, perchloric acid. This oxidation is catalysed by anionic micelle Sodium Lauryl Ether sulphate (SLES). On varying the concentration of substrate, perchloric acid shows a progressive increase in the reaction rate with slope is near to unity. Effect of variation of TriPAFC and TriPACC on Mandelic acid has no progress of increase on rate. Variation of Micellar concentration shows a progress of increase in the rate and a plot gives sigmoidal curve. Rate of oxidation of Mandelic acid and perchloric acid for TriPACC is faster than TriPAFC. Polymerization test shows no intermediate is formed during the course of the reaction. Stoichiometry data shows that one mole of the oxidant was consumed by 0.65 mole of the Mandelic acid. Thermodynamic parameters are calculated at four different temperatures, Arrhenius plots were given.

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### References

- [1]. Murugesan. v., Pandugangan. A. Indian J Chem.1992, 31B, 377
- [2]. K. Choudhari, P.K., Sharma. K. K. Banerji. Int. J Chem. Kinetics.1992, 31, 469
- [3]. Murugesan. v., Pandugangan. A. React Kinetic Catal Lett.1995 54, 173
- [4]. Banerji.K.K j Chem. Society, Prkin Trans, 1998, 2, 547.
- [5]. S.Kavita, A. Pandurangan, I. Alphonse. Indian J Chem., 2005, 44A, 715.
- [6]. Banerji.K.K Bull Chem. Society, Jpn. 1978, 51, 2732.
- [7]. Rathore. S, Sharma. P.K, Banerji.K.K. Indian J Chem., 1995, 34B, 702.
- [8]. V. kumbhat, Sharma. P.K, Banerji.K.K. Indian J Chem., 2000, 39A, 1169.
- [9]. V.Dhariwal. D. Yuajurvedi, p.K. Sharma, J. Chem. Res.,1997,194.
- [10]. R.Gurumurthy, M.Gopalkrishnan, B. Kathikeyan. Asian J Chem., 1998, 10, 476.
- [11]. I. Dave, V. Sharma, K.K. Banerji, J. Indian Chem. Society, 2002, 79, 347.
- [12]. S.A. Chimatadar, M.S.Salunke, S.T.Nandibewoor, Indian J. Chem., 2006, 45A, 388.
- [13]. Mansoor. S.S, Asian J.Chem. 2010, 22(10), 7591.
- [14]. Shanthi S and Mansoor S S, *Chem. Sci Trans.*, 2015, 4(1), 213- 221.
- [15]. Hiran B L, Khuntwal J, Malkani R K and Singh D, *Arab J Chem.*, 2011.
- [16]. Dharmaraja J, Krishnasamy K and Shanmugam M, *E-J Chem.*, 2008, 5, 754-760.
- [17]. Swami P, Yajurvedi D, Mishra P and Sharma P K, *Int J Chem. Kinetic.*, 2010, 42(1), 50 –55.