ADSORPTION STUDIES OF TARTARIC ACID FROM AQUEOUS SOLUTIONS ON CHARCOAL

A. Rasheed Khan, Fahim Uddin* and Salma Ali*

PCSIR Laboratories Complex, Karachi-75280, Pakistan

The adsorption of tartaric acid from aqueous solutions on the activated charcoal at 30° was studied by titrometric method. The rate of adsorptions of tartaric acid on activated charcoal is higher at higher concentration of acid. Langmuir and Freundlich equations are well obeyed.

Key words: Adsorption, Tartaric acid, Aqueous solutions, Activated charcoal.

Introduction

In our earlier papers, the titrometric studies of the saturated and unsaturated organic acids like crotonic acid, acrylic acid, lactic acid and glycolic acids on the surface of the activated charcoal were reported [1-3]. It was observed that the rate of adsorption of organic acids on the surface of charcoal increases with an increase in the concentration of these acids. Furthermore, nature and number of functional groups attached to the side chain influence the constants involved in the Langmuir and Freundlich isotherms. Solubility of adsorbate in solvent, its nature and concentration and the polarity of the solvent affect on the process of adsorption [4-5].This paper describes the adsorption of tartaric acid from aqueous solutions at the surface of activated charcoal at 30°. Further, the effect of concentrations of adsorbate on Langmuir and Freundlich isotherms are also determined.

Experimental

Activated charcoal (animal), tartaric acid, sodium hydroxide, phenolphthalein, ethyl alcohol, oxalic acid of E. Merck were used without further purification. Double distilled water free from oxidisable impurities was used.

All experiments were performed in nine reagent bottles (numbered as 1-9) according to the procedure given else where [1]. Required volume of tartaric acid according to the Table 1 was added to each bottle already containing 1g activated charcoal. The volume of each bottle was thus made 100 cm³ by adding water. These bottles were kept in a thermostatically controlled bath at 30°. The contents of each bottles were stirred continuously for about an hour with the help of magnetic stirrer and the contents allowed to attain equilibrium. It was thus filtered and filtrate was titrated against sodium hydroxide. It determines the amount of the acid which could not be adsorbed on the surface of activated charcoal.

* Department of Chemistry, University of Karachi, Karachi-75270, Pakistan

Results and Discussion

The data obtained from the adsorption of tartaric acid from aqueous solutions on the surface of activated charcoal at 30° are summarized in Table 1. The results shown in this Table indicate that the adsorption of tartaric acid from aqueous solution on the surface of a ctivated charcoal increased with increase in concentration of tartaric acid. The rate of adsorption of acid from aqueous solution is higher at higher concentration of adsorbate (Fig. 1). The degree of adsorption of tartaric acid on the solid surface may be controlled by the carboxylic and hydroxyl groups attached to both its ends. A similar trend was also obtained in the adsorption of lactic acid and glycolic acid [1]. But these acids are monobasic containing functional groups (-COOH, -OH) in one end as compared with tartaric acid which is dibasic saturated acid. The attachment of functional groups in both ends HOOCCH (OH) CH (OH) COOH make the tartaric acid more polar than glycolic acid ($CH_2OH.COOH$) and lactic acid $CH_3CHOHCOOH$. The polarity of tartaric acid makes the rate of its adsorption on the surface of charcoal higher than for glycolic acid and lactic acid.
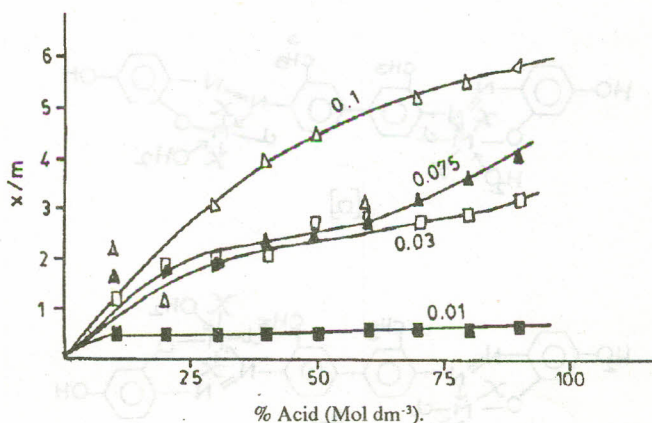

Fig. 1. Effect of concentration on the rate of adsorption of tartaric acid on activated charcoal at 30°C.

Table 1. Adsorption of Tartaric Acid on the Surface of 1 gram Activated Charcoal at 30°C.

Concentration of acid		0.1 mol.dm^{-3}			0.075 mol.dm^{-3}			0.03 mol.dm^{-3}			0.01 mol.dm^{-3}		
Expt. No.	% acid	x gm	C/x 10^2 (mol.dm^{-3})	c/x/m x10^{2}gm	x gm	C/x 10^2 (mol.dm^{-3})	c/x/m x10^{2}gm	x gm	C/x 10^2 (mol.dm^{-3})	c/x/m x10^{2}gm	x gm	C x 10^2 (mol.dm^{-3})	c/x/m x10^{2}gm
1.	90	5.81	35.90	6.18	4.05	24.0	5.92	3.24	8.52	2.63	0.66	4.68	7.09
2.	80	5.51	32.64	5.92	3.60	21.0	5.83	2.88	7.68	2.67	0.63	4.10	6.21
3.	70	5.21	27.95	5.36	3.15	16.5	5.24	2.70	6.90	2.55	0.60	3.56	5.93
4.	60	3.06	21.60	7.06	2.70	15.5	5.74	2.79	6.00	2.15	0.57	3.00	5.26
5.	50	4.59	16.90	3.68	2.47	13.10	5.30	2.61	5.34	2.05	0.54	2.48	4.59
6.	40	4.00	13.70	3.43	2.25	11.60	5.15	2.16	4.02	1.86	0.53	1.90	3.62
7.	30	3.06	9.99	3.26	2.03	7.80	3.84	1.98	3.00	1.52	0.51	1.36	2.66
8.	20	1.23	6.90	5.61	1.80	4.50	2.50	1.89	1.32	0.70	0.48	0.82	1.20
9.	10	2.15	2.60	1.21	1.57	1.95	1.24	1.17	0.60	0.51	0.45	0.28	0.62

During the process of adsorption only those molecules of the acid will be adsorbed which strikes a part of uncovered surface of activated charcoal. The covered surface will remain unaffected. Actually the action of partial forces at the boundry of the activated charcoal results the adsorption. Since the functional groups are attached to both ends of adsorbate, tartaric acid will be adsorbed on the solid surface through functional groups. The polar ends of the molecules will be attached themselves to the active sites of the solid surface [6]. In the adsorption of formic, acetic, propionic and butyric acids [7-8], acrylic acid and crotonic acid [1] and glycolic acid and lactic acid [2] similar results were obtained.

In the adsorption of monobasic and dibasic saturated organic acid from the aqueous solution on the surface of activated charcoal, the intensity of adsorption, amount of adsorbate and surface area of adsorbent may be determined by using Langmuir [9] and Freundlich [10] isotherm equations. In terms of concentration, the Langmuir adsorption equation [9] can be written as,

$$\frac{C}{(x/m)} = \frac{1}{KK_1} + \frac{1 \cdot C}{K} \qquad \text{............................ (1)}$$

where x is the amount of molecules adsorbed on m gram of adsorbent and C is the equilibrium concentration of the solution $1/KK_1$ and $1/K$ are Langmuir constants, where $1/K$ is the measure of surface area of solid and K_1 is the intensity or strength of adsorption. A plot of $C/(x/m)$ vs C gives a straight line of intercept $1/KK_1$ and slope $1/K$. These values obtained for different concentration of tartaric acid (Fig. 2) are summarised in Table 2. The value of $1/K$ x 10 for 0.1, 0.075, 0.03 and 0.01 mol. dm^{-3} are obtained respectively as 1.2, 2.0, 3.1 and 14.0. Similarly the values of $1/KK$ x 10 for 0.1, 0.075, 0.03 and 0.01 mol. dm^{-3} are determined as 23.0, 19.0, 4.0 and 5.0 respectively. These results indicate that at higher concentration of acid, more surface area of adsorbate is utilized. The intensity of adsorption (K_1) of acid molecules on the solid surface increase with its decrease in concentration. The mole-

The linear form of Freundlich adsorption isotherm [11] may be written as,

$$\log(x/m) = \frac{1}{n} \log C + \log K \qquad \text{.................... (2)}$$

where x is the weight of the substance adsorbed by m gram of adsorbent, C is the concentration in moldm^{-3} at equilibrium, log K and 1/n are Freundlich constants. A plot of log (x/m) versus log C gives a straight line of intercept log K

Table 2. Langmuir and Freundlich Parameters in the Adsorption of Tartaric Acid from Aqueous Solution on the Surface of Activated Charcoal at 30°C.

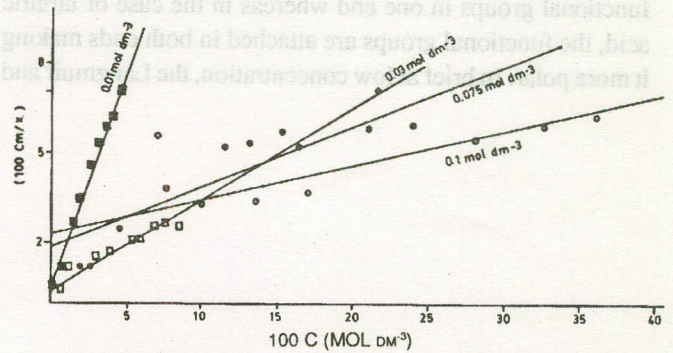| Acid concentration (mol.dm^{-3})	Langmuir parameters		Freundlich parameters	
	10/K	10/KK$_1$	10/n	log K
0.100	1.2	23.0	4.8	0.54
0.075	2.0	19.0	4.0	0.62
0.030	3.1	4.0	3.2	0.86
0.010	14.0	5.0	1.4	0.56

Fig. 2. Langmuir plot for the adsorption studies of tartaric acid for its different concentration from aqueous solution on charcoal.
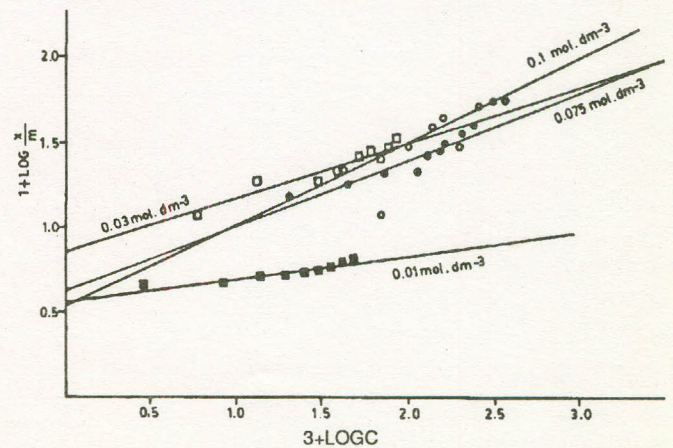

Fig. 3. Freundlich plot for the adsorption studies of tartaric acid for its different concentration from aqueous solution on charcoal.

cules of acid as a result will tend to errect or lie on the solid surface. Statistically some molecules of acid will orient one way and some in the other way which becomes the cause of destruction of packing and leaves gap in between.

The linear form of Freundlich adsorption Isotherm [10-11] may be written as:

$$\log (x/m) = 1/n \log C + \log K \quad \text{...........................(2)}$$

where x is the weight of the substance adsorbed by m gram of adsorbent, C is the concentration in mo1 .dm^{-3} in solutions at equilibrium, log K and 1/n are Freundlich constants. Since adsorption isotherms are generally convex to the C - axis the value of n is correspondingly greater than unity. A plot of log (x/m) versus log C gives a straight line of intercept log K and slope 1/n. The plot of (1 + log x/m) against (3 + log C) are shown in Fig. 3 for different concentration of tartaric acid. The values obtained from these plots for 1/n and log K at different concentration are shown in Table 2. It is obvious from these values of 1/n and log K that the values of 1/n are decreasing with decrease in concentration of tartaric acid while in the adsorption of monobasic aromatic acids [3] both the values of 1/n and log K decrease with decrease in concentration of adsorbate. This difference may be due to the attachment of functional groups in one end whereas in the case of tartaric acid, the functional groups are attached in both ends making it more polar. In brief at low concentration, the Langmuir and

Freundlich equations are well obeyed. Charcoal may be useful for the separation of such organic acids which contain functional groups or groups in either or both ends in aqueous medium.

References

1. A. Rasheed Khan, Fahim Uddin and Ghayasuddin Khan, Pak. j. sci. ind. res., **34**, 163 (1991).
2. A. Rasheed Khan, Fahim Uddin and Ghayasuddin Khan, Pak. j. sci. ind. res., **33**, 655 (1989).
3. Fahim Uddin, I. M. Adhami and N. Shahid, J. Sci. Res., **17**, 37 (1988).
4. H. Freundlich, Ann. Chem. Phys., **13**, **76** (1978).
5. H. N. Holmess and J. B. Mckelvey, J. Polymer Sci., **11**, 365 (1983).
6. R. U. Limienx and T. L. Morrison, Can. J. Res., **258**, 440 (1947).
7. M. Afzal and A. Naseer, Pak. j. sci. ind. res., **15**, 137(1972).
8. Salam Ali, M. Sc. Thesis, submitted to Karachi University (1990).
9. Langmuir, J. Am. Chem. Soc., **38**, 2221, 22267 (1916); 40, 1316 (1918).
10 Adamson, *Text Book of Physical Chemistry of Surface* (Inter Science Publication, New York, 1960).
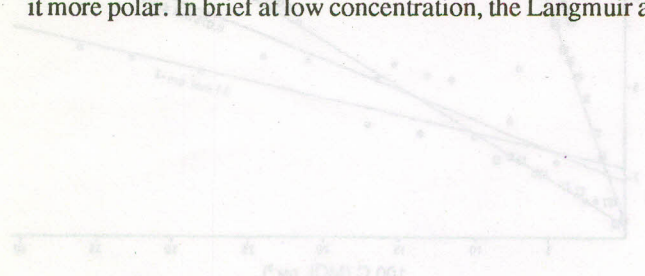11. H. Freundlish, Z. Physik, Chem., **57**, 385 (1907).

Fig. 2 Langmuir plot for the adsorption studies of tartaric acid for its different concentration from aqueous solution on charcoal.
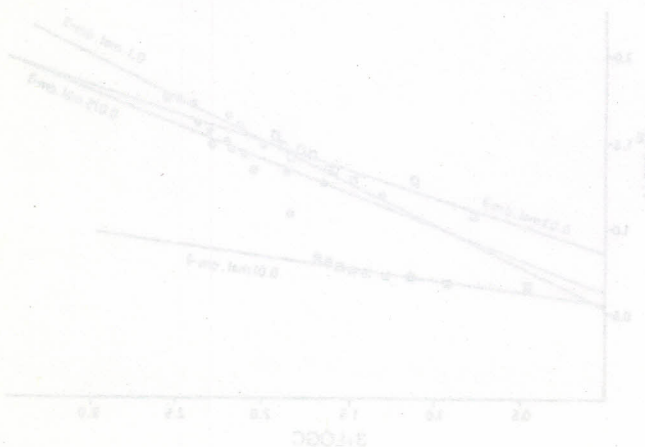

Fig. 3 Freundlich plot for the adsorption studies of tartaric acid for its different concentration from aqueous solution on charcoal.