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ADSORPTION OF GLYCOLIC AND LACTIC ACIDS FROM AQUEOUS SOLUTIONS ON CHARCOAL

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Adsorption of glycolic and lactic acid from aqueous solutions on surface of activated charcoal at 30° have been accomplished by titrometric method. The rate of adsorption of glycolic acid on activated charcoal is greater than lactic acid. Nature and number of functional groups attached to the side chain influence the constants involved in the langmuir (1/a, 1/ab) and Freundlich (Log a, 1/n) isotherms alongwith the side chain. A possible explaination is also given.

Key words: Polarity, Adsorbate, Adsorbent.

Introduction

Charcoal is extensively used in adsorbing both aliphatic and aromatic compounds although it has no polar group or groups which participate in hydrogen bonding between the surface and organic compounds [1-10]. Only polarity of the compound to be adsorbed is significant. In our earlier paper, the titrometric studies of the adsorption of acrylic acid and crotonic acid from aqueous solution on the surface of the activated charcoal has been reported [11]. It was observed that the rate of adsorption of acrylic acid on the surface of charcoal is higher than crotonic acid. Furthermore the adsorption of these monobasic acids from aqueous solution on the surface of charcoal mostly depends upon the following parameters like solubility of the acids in solvent, polarity of the solvent and nature of adsorbate. This paper describes the adsorption of such aliphatic compounds which have both hydroxyl group and carboxyl group in the chain (glycolic acid and lactic acid) from aqueous solution at the surface of the activated charcoal at 30°.

Experimental

Glycolic acid, lactic acid, sodium hydroxide, phenophthalene, ethyl alcohol, activated charcoal (animal) of E. Merck and double distilled water free from oxidisable impurities were used.

Procedure. All experiments were carried out in nine stoppered reagent bottles. To each bottle, one gram activated charcoal was added. Required volume of acids prepared in distilled water (0.1 mol. dm^{-3}) according to Table 1 was added to each bottle. The volume of each bottle was thus made 100 ml by adding distilled water. All bottles were kept at 30° in thermostatically controlled water bath. The bottles were shaken continuously for one hr. (a test experiment was performed to find the sufficient time for equilibrium) and then the contents were filtered. Filterate from each bottle was titrated against standard sodium hydroxide solution. The amount of acid which could not be adsorbed on the surface of charcoal was determined from these titrations taking the mean of the values obtained.

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Results and Discussion

Table 1 show the results of the adsorption of glycolic acid and lactic acid from aqueous solutions on the surface of activated charcoal at 30°. In Fig. 1, $\frac{x}{m}$ x 10 has been plotted against % acid (0.1 mol. dm^{-3}). It shows that the adsorption of both glycolic acid and lactic acid from aqueous solutions on the surface of activated charcoal gets increased with increase in concentration of acids. The rate ($\frac{c}{x/m}$) of adsorption of glycolic acid is higher than lactic acid. The degree of adsorption of these acids on the solid surface may be controlled by their functional groups (-OH, -COOH) and the side chain to which they are attached. In glycolic acid ($CH_2OHCOOH$), the side chain is small than in lactic acid (CH_3CH (OH) COOH). The polarity of carboxylic and hydroxyl group in glycolic acid is much more effective than in lactic acid [12]. It is because the functional groups in glycolic acid are much more polar than its side chain. The adsorption of molecules of glycolic acid on this surface of activated charcoal occurs through side chain as well as hydroxyl and carboxyl groups. But in lactic acid, it does not happen. The side chain in lactic acid attached to functional groups in bigger than of glycolic acid. Due to lengthening of side chain in lactic acid, the adsorption will take place through only the functional groups (-OH, -COOH).

Therefore, the probability of attachment at the polar or less polar end is significant. During the process of adsorption only those molecules of acids will be adsorbed which strike a part of uncovered surface of activated charcoal. The action of partial forces at the boundry of surface of the activated charcoal results the adsorption. Furthermore the molecules of acid carrying small side chain as a result will tend to erect or lie on the solid surface. Statistically some molecules of acid will orient one way and some in other which becomes the cause

TABLE 1. ADSORPTION OF GLYCOLIC ACID AND LACTIC ACID ON THE SURFACE OF 1GM ACTIVATED CHARCOAL AT 30°.

Expt. No.	Lactic and glycolic acid %	Amount of acid adsorbed X gm		Equilibrium concentration C x 10^2 (mol. dm^{-3})		$\frac{C}{(x/m)}$ x 10 in gm	
		Lactic acid	Glycolic acid	Lactic acid	Glycolic acid	Lactic acid	Glycolic acid
1.	90	0.08136	0.4704	8.193	1.403	1.007	2.983
2.	80	0.0755	0.4658	7.225	1.342	0.956	2.883
3.	70	0.06974	0.3986	6.259	1.173	0.897	2.944
4.	60	0.06393	0.3802	5.225	1.004	0.817	2.641
5.	50	0.06393	0.3258	4.258	0.702	0.666	2.153
6.	40	0.05812	0.2660	3.419	0.593	0.588	2.228
7.	30	0.04649	0.1979	2.452	0.472	0.527	2.384
8.	20	0.04068	0.1307	1613	0.387	0.396	2.962
9.	10	0.02906	0.0616	0.703	0.109	0.244	1.766

of destruction of packing and leaves gap in between. It would be very difficult to compute accurately the specific surface area of the solid with the help of small side chain acids on carbon. On the other hand the side chain attached to carboxylic group in lactic acid is bigger. With a bigger side chain the polar effect of the carboxylic group will not be transmitted through the side chain [13]. The molecules of lactic acid will be adsorbed on the surface of the activated charcoal through carboxylic group. In the adsorption of formic, acetic, propionic and butyric acids from aqueous solution, on activated charcoal similar results were obtained [4, 12]. Similarly the same things happens in the adsorption of acrylic acid and crotionic acids from aqueous solution on activated charcoal [11]. The order of adsorption depends upon the length of the side chain. The partially polar end of the molecules has a tendency to attach themselves to the active sites of the solid surface.

The Langmuir [14] and Freundlich [15,16] Isotherms help in the determination of intensity of adsorption, amount of adsorbate and surface area of the adsorbent in the adsorption of aliphatic and aromatic compounds from the solution on the surface of the activated charcoal. In terms of concentration, Langmuir equation [14] can be written as:

$$\frac{C}{x/m} = \frac{1}{ab} + \frac{1}{a} C \text{ ....(1)}$$

where x/m indicates the amount of adsorbate per unit amount of adsorbent and C is the equilibrium concentration of the solution. 1/a and 1/ab are Langmuir constants where 1/a is the measure of the surface area of solid and 'b' is the intensity or strength of the adsorption. Thus a plot of $\frac{c}{x/m}$ against C in Fig. 2 and 3 gives a straight line of slope 1/a and intercept 1/ab. The values obtained for these constants from these plots are depicted in Table 2. It is evident from the values of 1/a that surface area of activated charcoal utilized by glycolic acid is nine times larger than that used by lactic acid. But the intensity of adsorption of acid molecules on the solid surface is higher for lactic acid (b = 44.547) than for glycolic acid (b = 0.719). It means that for lactic acid, little surface (due to erection of molecules) for more molecules is enough for its adsorption on the solid surface of activated charcoal.

The linear form of Freundlich Isotherm [15-17] is given below:

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

TABLE 2. FREUNDLICH AND LANGMUIR PARAMETERS IN THE ADSORPTION OF CLYCOLIC ACID AND LACTIC ACID FROM AQUEOUS SOLUTION ON THE SURFACE OF ACTIVATED CHARCOAL.

Acid	Freundlich constants 1/n	Log a	Langmuir constants 1/a	1/ab
Glycolic acid	0.8	0.8	1.15	1.6
Lactic acid	0.44	1.1	10.25	0.23

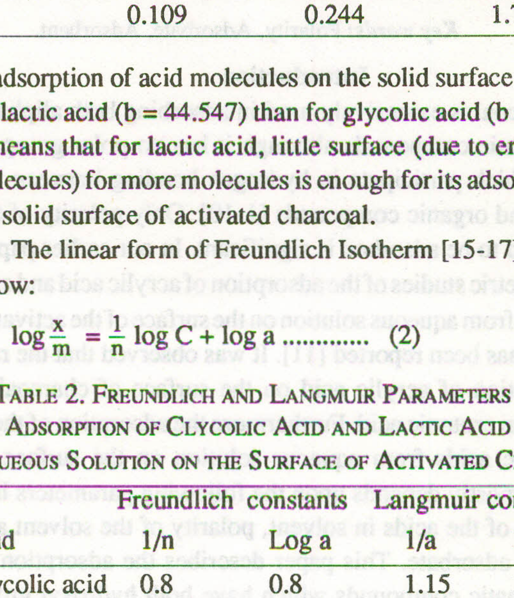

Fig. 1. A plot of (x/m) x 10 against % acid mol. dm^{-3} for the titrometic studies of the adsorption of some aliphatic acids from aqueous solutions on the surface of activated charcoal.

where x is the weight of acid adsorbed on m gm of adsorbent, C is the equilibrium concentration of the solution and log a and 1/n are constant. As a first approximation, "a" is a measure of the intensity of adsorption. Since adsorption isotherms are generally convex to the X-axis, the value of n is correspondingly greater than unity. The plot of log x/m against log C gives a straight line of intercept log a and slope 1/n. The plot shown in Fig. 4 corresponds to glycolic acid and the plot of Fig. 5 relates to lactic acid. The values obtained from these plots for Freundlich constants are shown in Table 2. These results indicate that not only the length of the side chain has significant effect on Freundlich Isotherm (value of 1/n) but the functional groups attached to the side chain also influence the process of adsorption. In the case of acrylic acid and crotonic acid which contain only one functional group (-COOH) in the side chains, the value of log a decreases with increase in length of side chain [5]. But it does not happen amongst glycolic acid and lactic acid which contain two functional groups (-OH, COOH) in the side chain. In this case, the value of log a increases with increase in length of sidechain attached to the functional groups. The same thing also happens in the Langmuir Isotherm, which has also already been discussed in the above lines. The hydroxyl and carboxyl groups of glycolic and lactic acids interfere each other when they strike the surface of activated charcoal. It may be concluded that beside the length of side chain which makes the acid more or less polar, nature of functional group or groups and number of functional group or groups attached to the side chain may change the values of constants (particularly log a, 1/ab) involved in Langmuir and Freundlich Isotherms. Charcoal may be suitably used for the separation of the organic compound carrying more than one functional groups aqueous medium.

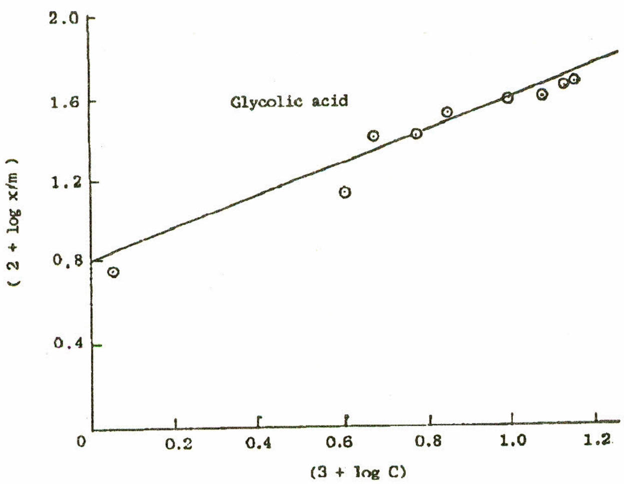

Fig. 2. Langmuir plot for the titrometric studies of the adsorption of glycolic acid from aqueous solutions on the surface of activated charcoal.

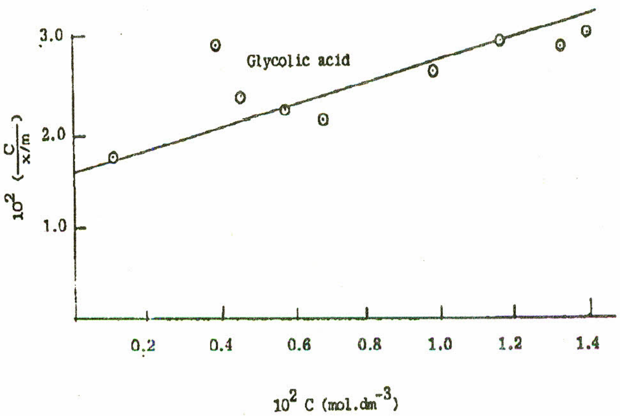

Fig. 4. Freundlich plot for the titrometric studies on the adsorption of glycolic acid on the surface of activated charcoal.

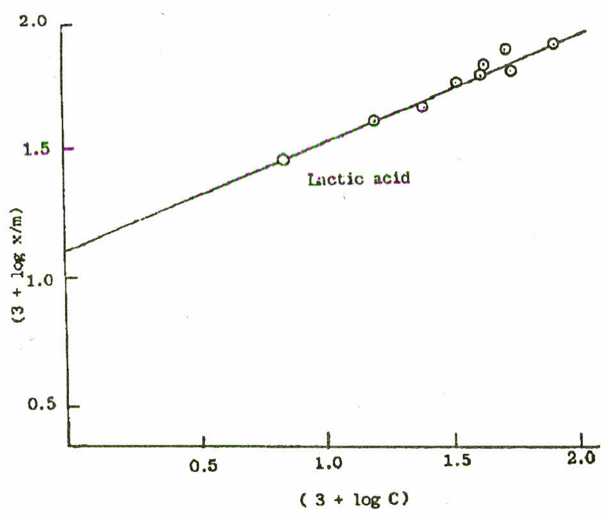

Fig. 3. Langmuir plot for the titrometric studies on the adsorption of lactic acid from aqueous solutions on the surface of activated charcoal.

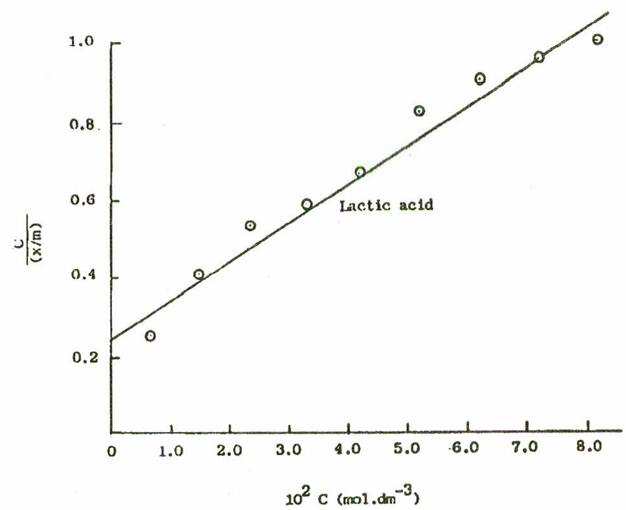

Fig. 5. Freundlich plot for the titrometric studies of the adsorption of lactic acid on the surface of activated charcoal.

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