Adsorption of Fatty Acid Sodium Salts on Ion Exchange Resins

In recent years many adsorbents have been investigated for the purpose of use for treatment of wastewaters.[1] Adsorption on ion exchange resins provides a technique for purification of municipal and industrial wastewaters.[2-4] In the present investigation, the adsorption equilibrium of fatty acid sodium salts with various carbon numbers onto ion exchange resins (IRA94 and IRA68) was studied in aqueous solution to obtain precise information about the treatment of wastewaters containing detergents (see Table I).

EXPERIMENTAL

Materials

The ion exchange resins used in this experiments were a styrene type copolymer and an acrylamide type copolymer known as Amberlite IRA94 and IRA68 (Rohm and Hass Co.). Both are weekly basic resins and the exchange capacities are 4.6 (IRA94) and 5.6 (IRA68) meq/g of dried resins, respectively. The resins were purified by standard methods and used as HBr salts. The absorbate studied were four fatty acid sodium salts from commercial sources (stated minimum assay 98%) and were used without further purification.

ADSORPTION EXPERIMENTS

In a typical adsorption experiment, 0.02–0.1 g of resin was immersed in 10 mL of proper concentration of fatty acid sodium salts in an aqueous solution. Equilibration took place in 20-mL stoppered tubes, which were shaken for 24–48 h in a thermostated bath. After equilibration, the resin was removed, and the amount of bound fatty acid sodium salts was measured by determining the total organic carbon in a Shimadzu Model TOC-10B analyzer.

RESULTS AND DISCUSSION

Figures 1 and 2 show the adsorption isotherms of fatty acid sodium salts (C6–C12) on IRA94 and IRA64 at 25°C. The degree of adsorption is represented as the moles of adsorbed solutes per gram of resin, r vs. the equilibrium concentration of the solute, C(mol/L). As shown in Figures 1 and 2, it is apparent that the amount of the solutes adsorbed on both resins increases as the carbon number of the solutes increases. IRA94 shows greater adsorbability than IRA68 for all the solutes used. The effect of temperature change (15–45°C) on the adsorption of C6–C12 for both resins was also examined in an aqueous solution. However, no temperature dependence is observed within experimental error. Therefore, the equilibrium reaction for these systems is athermal over the temperature range investigated.

The adsorption isotherms could be approximated by the Langmuir type equation. Klotz et al.[5] have derived an equation in which r represents the moles of compounds bound per gram polymer, n is a total number of available binding sites on polymer, K is the intrinsic binding constant, and C is the concentration of free small molecule:

$$\frac{1}{r} = \frac{1}{nK}\frac{1}{C} + \frac{1}{n} \tag{1}$$

The relative values of the successive equilibrium constants can be determined solely by statistical factors. For this situation the equilibrium constants of ith reaction is given by the relation

$$k_i = \frac{n - (i - 1)}{i} K \tag{2}$$

For the first reaction ($i = 1$), the first equilibrium constant, k_1 is equal to nK in eq. (2). If we use nK as the degree of the adsorption, nK is obtained from plots of $1/r$ vs. $1/C$ or nonlinear least

Journal of Applied Polymer Science, Vol. 32, 5665–5667 (1986)

CCC 0021-8995/86/065665-03$04.00

TABLE I
Fatty Acid Sodium Salts

n	$CH_3(CH_2)_nCOONa$	Abbreviation
4	Hexanoic acid	C6
6	Octanoic acid	C8
8	Decanoic acid	C10
10	Dodecanoic acid	C12

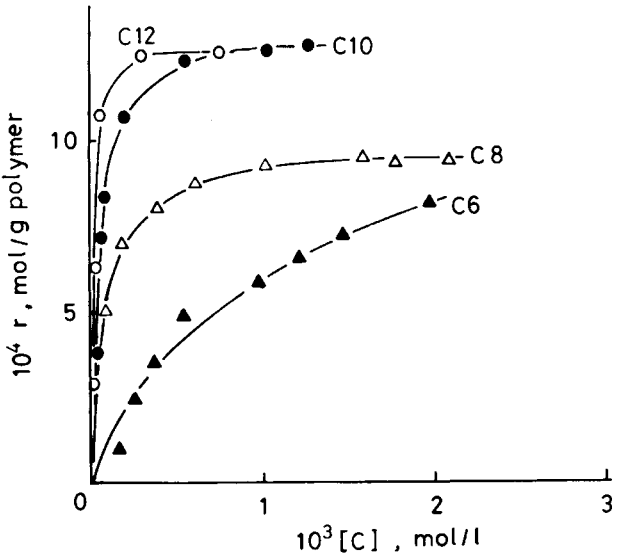

Fig. 1. Adsorption isotherms of fatty acid sodium salts on IRA94 at 25°C.

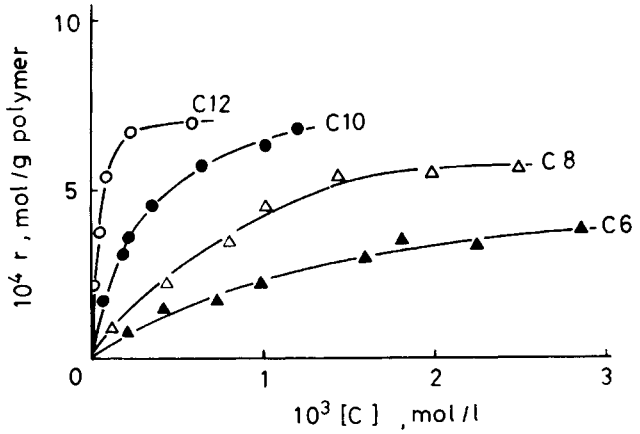

Fig. 2. Adsorption isotherms of fatty acid sodium salts on IRA68 at 25°C.

squares fitting. The nK values of fatty acid sodium salts for both resins are listed in Table II. As shown in Table II, the nK values for each resin increases with increasing carbon number of the solutes. These results suggest that the effect of hydrophobic interaction seems to play an important role on binding. This effect is more favorable for IRA94, which has hydrophobic phenyl groups in the polymer.

TABLE II
Values of nK of the Fatty Acid Sodium Salts for Each Resins in Aqueous Solution at 25°C

Resin	nK (1/g polymer)			
	C6	C8	C10	C12
IRA94	1.37	8.14	36.3	179
IRA68	0.386	0.806	3.08	7.22

Finally the present study shows that the adsorption of fatty acid sodium salts onto the resins involves hydrophobic interaction between apolar side groups of the solutes and polymers, as well as electrostatic attraction of the charged groups between carboxyl and dialkylamino groups.

This work was supported by Grant-in-Aid for Scientific Research from the Ministry of Education, Japan. I thank Makiko Morita, Mutsumi Yatomi, and Yūko Yuasa for technical assistance.

References

1. For example, "Agricultural, Industrial and Municipal Waste Management in Today's Environment," Mechanical Engineering Pub., United Kingdom, 1985.
2. I. M. Abrams and S. M. Lewon, *J. Am. Water Works Assoc.*, **54**, 537 (1962).
3. R. Eliassen, B. M. Wyckoff, and C. D. Tonkin, *J. Am. Water Works Assoc.*, **57**, 1113 (1965).
4. S. Saito, T. Taniguchi, and M. Yukawa, *Tenside-Deterg.*, **12**, 100 (1975).
5. I. M. Klotz, F. Walker, and R. Pivan, *J. Am. Chem. Soc.*, **68**, 1486 (1946).

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Received January 3, 1986
Accepted February 5, 1986