

Repeated Adsorption of Cationic Surfactant on Cotton Cloth

Yuko KOBAYASHI, Tsuneo SUZUKI

*Nagano-ken Junior College, 49-7 Miwa 8-chome,
Nagano, 380, Japan*

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ABSTRACT

The adsorption of cationic surfactant is influenced by many factors, such as temperature, concentration, pH and the mechanical action in stirring. The influences of these factors on the repeated adsorption of cationic surfactant to cotton cloth were investigated. The adsorption quantity increased with the increase of ζ -potential and the concentration of cationic surfactant.

Up to 40°C the adsorption quantity increased and decreased above this temperature. Desorption quantity of cationic surfactant increases with the increase of temperature. In the repeated adsorptions using only cationic surfactant the adsorption amount decreased with the increase of treatment times. It also decreased in the run which washing treatment by water was inserted between the adsorption and the next adsorption of cationic surfactant. But it increased in the run which the treatment by anionic surfactant and the washing treatment by water were inserted between the adsorption and the next adsorption. The contribution of anionic surfactant to the increase of adsorption quantity of cationic surfactant may be conceivable.

INTRODUCTION

Cationic surfactant was generally used as softening finisher, electrostatic prevention, germicidal agent and auxiliary in dyeing. Especially as a softening finisher for home use, cationic surfactants are excellent in terms of adsorption on fibers and exhibit remarkable softening effect by small amounts^{1),2)}.

It appears to be significant to examine the influence of repeated adsorption of cationic surfactant on cloths³⁾.

Dimethyl dioctadecyl ammonium chloride (DSDMAC) is most widely used as a main agent in the softening finisher for domestic use, but its basic properties are merely examined^{4,5,6)}. Safety and biodegradation of cationic surfactants become significant problem with increase of consumption.

In this experiments the adsorption behavior of cationic surfactant on cotton cloth has been studied.

EXPERIMENTALS

Materials

The cotton cloths (NISSHINBO KK NO. 4000) were used after the destarch treatment by a conventional method. The size of cotton cloth used in the following experiments was 15×15cm and its average weight was 2.907g.

Ion-exchanged distilled water was used in the destarch treatment and in the following experiments.

As the cationic surfactant the commercially available softening finisher was used without purifications. Similarly the commercially detergents were used as its composition. All other reagents were analytical grade and used without further purifications.

Method

(1) Treatment of cotton cloth with cationic surfactant

The experimental conditions of adsorption treatment of cationic surfactant on cotton cloth were as follows; the concentration of commercially available softening finisher was 0.005 percent o.w.f., the bath ratio was 1:60, the treatment time was 5 minutes, and the temperature was 25°C. The flask containing these materials described above was rotary mixed on the YAMATO MH-61 MAG MIXER with a constant r.p.m..

Next the cotton cloth was taken out of the flask just after and the concentration of cationic surfactant in the solution was measured by the spectroscopic method which will hereinafter be described. The taken out cotton cloth was squeezed by hand and was air-dried at room temperature.

(2) Repeated adsorption

The cotton cloths air-dried at room temperature after first adsorption were used in the second adsorption treatment. The same adsorption treatments were carried out for six times. The repeated adsorption which washing treatment by ion-exchanged water was done between adsorption and next adsorption were undertaken.

Similarly, the repeated adsorptions interposing the treatment by anionic surfactant between adsorption and next adsorption were carried out. On this occasion, after the anionic surfactant treatment the cotton cloth was rinsed in water on the shaker for three times.

(3) pH change

pH of the aqueous solution containing cationic surfactant was controlled with sodium hydroxide and acetic acid. The region of pH change was from 3.0 to 12.0.

(4) Concentration change

Experiments were made on solutions ranging in concentration of cationic surfactant from 0.0005% o.w.f. to 0.02%. The conditions of this solution other than concentration were the same as described above.

(5) Temperature change

Room temperature, 30°C, 40°C, 50°C and 60°C were chosen for the experiments of the temperature dependence of adsorption behaviour. Measurements of absorbance which will hereinafter be described were maintained after the temperature of this solutions fell to room temperature.

(6) Measurement of absorbance

Various methods of detection of cationic surfactant in aqueous solution were reported^{7), 8), 9)}. Spectroscopic analysis using brom phenol blue was chosen in this experiments^{10), 11), 12), 13)}.

The composition of brom phenol blue solution was as follows:

0.2N-sodium acetate	75ml
0.2N-acetic acid	925ml
96% ethanol containing 0.1% brom phenol blue	20ml.

2ml of brom phenol blue solution was added into the solution of cationic surfactant.

As shown in Figure 1, the complex of cationic surfactant and brom phenol blue has a absorption at 608nm. This absorption is not interfered by anionic surfactant and other reagents used in here. So the absorption at 608nm was used to determine the concentration of cationic surfactant. Electronic spectra of these solutions were measured on a HITACHI 228A spectrophotometer. The pH measurements were carried out with a TOA HM-18ET pH meter.

RESULTS AND DISCUSSION

The quantity of active surface of cotton was calculated as $2.7 \times 10^{25} \text{Å}^2/\text{g}$ by H. Stupel¹⁴⁾, A. J. Stamm and H. A. Millet¹⁵⁾ reported it as $3 \times 10^{22} \text{Å}^2/\text{g}$. Using adsorption amount on cotton and the quantity of active surface described above, we can obtain the ratio of coated surface to uncoated it. By this calculation it is become clearly that even nonionic surfactant taking relatively wide cross section size of

molecular can not adsorb above half of active surface of cotton. The adsorption quantity of cationic surfactant on negatively charged cotton is about 1000 times that of anionic surfactant¹³⁾.

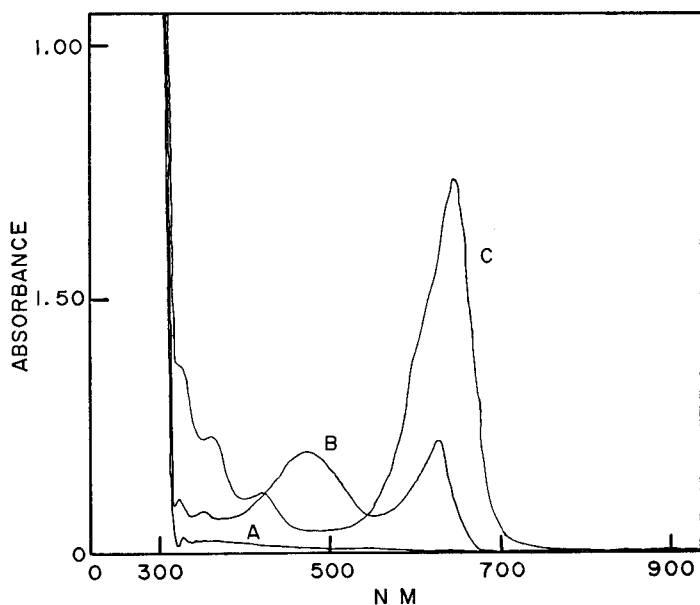


Figure 1 Electronic spectra of the softening finisher solution (A) and bromophenol blue solution (B) and the mixture solution of these (C).

Figure 2 shows the result of repeated adsorption of softening finisher for domestic use. First, the treatments only by cationic surfactant were carried out. During treatment and next treatment the cotton cloth was air-dried at room temperature. In this occasion the adsorption amount increased at second treatment and decreased step by step with treatment times. It is probable that the active surface of cotton decreases with increase of treatment times. And the interaction between negative charge of cotton and positive charge of cation will be decreases.

Second, the treatments by cationic surfactant and washing by water were repeated. Third replicate runs were the treatment which the anionic surfactant adsorption and washing by water were carried out between cationic surfactant adsorption. In all cases, second treatment exhibits higher adsorption than first treatment. The reason of this fact seems to be the relaxation of structure of cloth. The attack of cationic surfactant to internal active points of cotton cloth is more easily than the first time.

In first and second run, because of the decrease of the active surface which cationic surfactants are more easily caught the adsorption quantity decreased with the increase of treatment times. But in third run the adsorption amount increased with the increase of treatment times.

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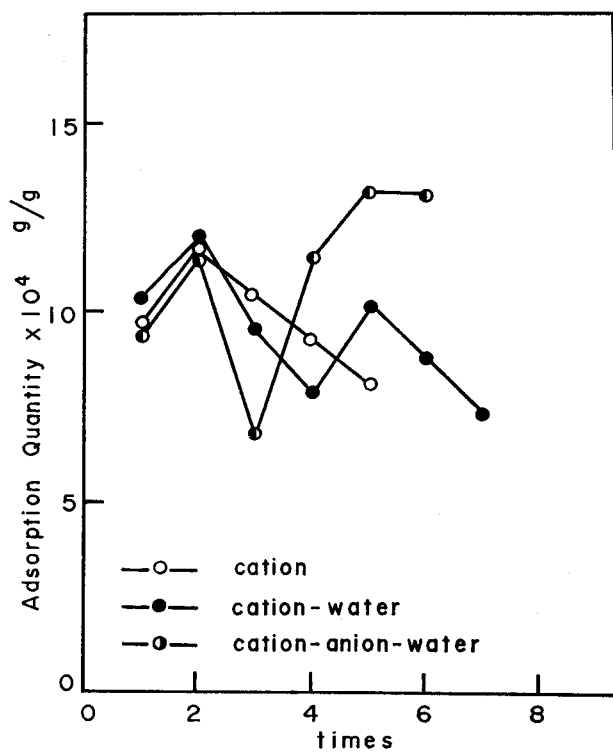


Figure 2 The change of adsorption quantity of cationic surfactant on cotton cloth.

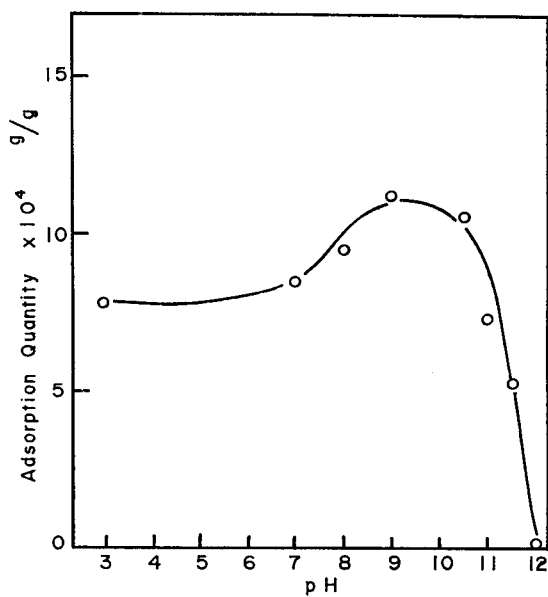


Figure 3 The relationship between adsorption quantity of cationic surfactant and pH.

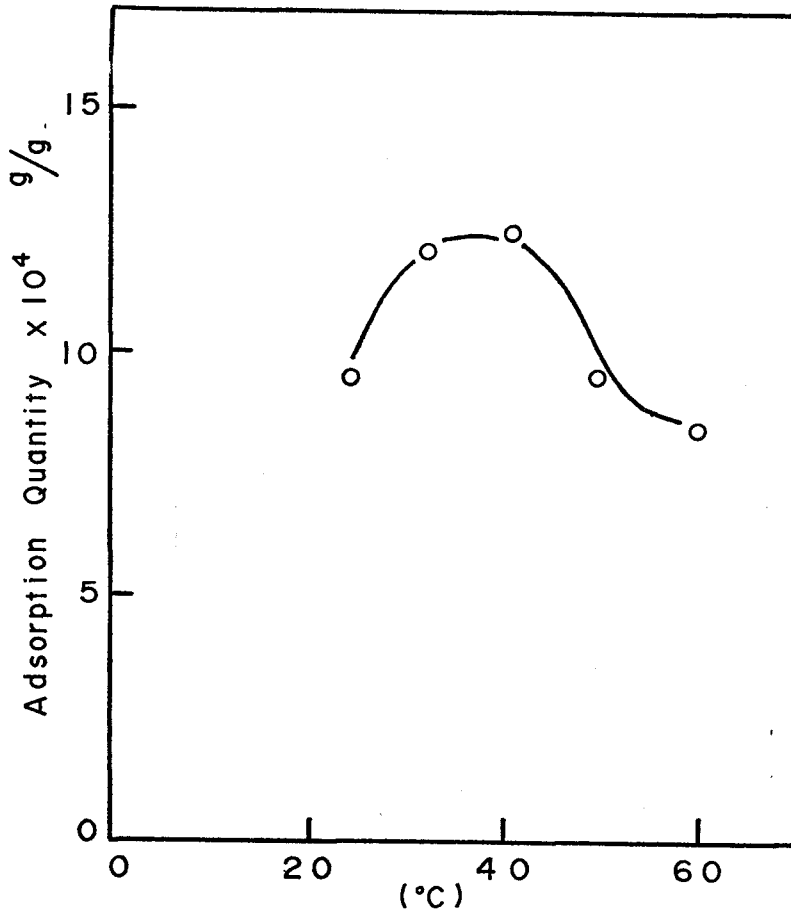


Figure 4 The relationship between adsorption quantity of cationic surfactant and temperature.

On account of the elimination of cationic surfactant from cotton cloth in the treatment with anionic surfactant, it seems likely that the active surface which cationic surfactants are more easily caught is not decrease with the increase of treatment time.

In addition to the reasons mentioned above, the anionic surfactants residued on the cotton cloth contribute to the increase of adsorption of cationic surfactant in next treatment.

Negative charge on cotton fiber can be estimated by ζ -potential of it. Figure 3 shows the change of adsorption quantity of cationic surfactant against hydrogen ion concentration. In the region of pH 3-9 the increase of adsorption amounts is correspond to the increase of ζ -potential of cotton fiber. But above pH 10.5 the decrease of adsorption amounts was observed. It is thought that the adsorption of cation is more affected by the structural factor of cotton cloth than the ζ -potential. More detailed examinations in this regard will be necessary.

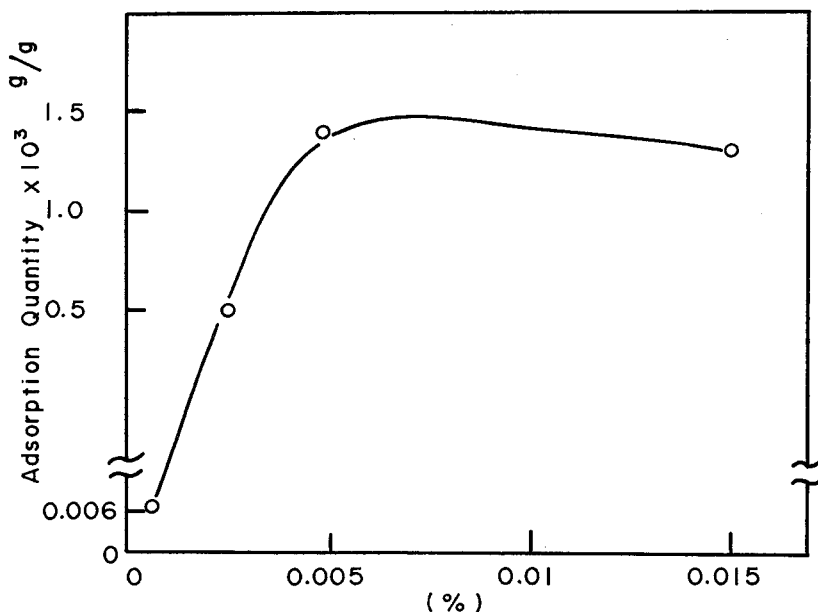


Figure 5 The relationship between adsorption quantity of cationic surfactant and concentration of it.

The influence of temperature to adsorption of cationic surfactant is shown in Figure 4. The adsorption amounts increase with rise in temperature, and decrease above 40°C. Primary adsorption and desorption proceed simultaneously in adsorption of surfactant. Owing to the increase of desorption at higher temperature the whole adsorption quantity decreases above 45°C.

As shown in Figure 5, the adsorption quantity of cation surfactant increases with the increase in concentration. This fact is in accord with the adsorption behavior of other surfactants¹³⁾. The concentration of cationic surfactant examined in this experiments is very dilute compared with that in domestic use of softening finisher.

It will be necessary to examine the influence of repeated adsorption of cationic surfactant at higher concentration region.

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