NOTE

Removal of Tripalmitin-¹⁴C from Cotton Cloth

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1. Introduction

The detergent effect has usually been measured by determining the reflectance on powder-soiled cloth before and after it is washed with detergent to be tested^{1,2)}. The method may be applied to the practical use if one considers that the purpose of using detergent is to make cloth more reflective. However, if it is to remove the soils, the effect should be evaluated in terms not of the reflectance, but of the soil removal which is estimated best by determining the radioactivity of labeled soils, as has been pointed out by one of the authors³⁾. Ashcraft⁴⁾ reported a linear increase in the reflectance with the decrease of radioactivity of ¹⁴C-labeled carbon black, which was used as a soiling substance, caused by being removed with sodium dodecyl sulfate. Various kinds of detergents were comparatively investigated for similar purposes⁵⁾. In all of these experiments, cloth was soiled by inorganic powders such as carbon black^{4,5)}, ferric oxide²⁾, and artificial clay⁶⁾.

In practice, however, clothes are soiled not only with inorganic contaminants but with oils, fats, and other organic substances, to which the reflectance method can hardly be applied. Experiments have thus been carried out on cotton cloth soiled with ^{14}C -labeled oils and fats^{7,8)}, and on stainless steel contaminated with ^{14}C -labeled tristearin⁹⁾. The present paper deals with the comparative studies on detergent effect of various surfactants on removing tripalmitin- ^{14}C from cotton cloth.

2. Experimental

Materials—Tripalmitin- ^{14}C obtained from Radiochemical Centre, England, was pure enough to give the only spot in the proper position on the reversed phase chromatograms⁽¹⁰⁾ varying the compositions of the moving and stationary phases. The radioactive tripalmitin was diluted isotopically with highly pure non-radioactive tripalmitin, so as to give a desired specific activity.

Detergents used were sodium dodecyl sulfate (SDS), sodium dodecylbenzene sulfonate (SDBS), dodecylbenzyl dimethyl ammonium chloride (DBDAC), decaoxyethylene nonyl phenyl ether (DOENPE), and dodecyl diaminoethyl glycine (DDAEG). All of these samples were supplied kindly by Mitsuwa Soap Co., Ltd., Tokyo.

Procedures—A circular swatch (2.4 cm in diameter and ca. 0.03 g in weight) of standard cotton cloth was soiled with 1.4 mg of tripalmitin- ^{14}C by spreading uniformly in benzene solution (1.0%) and dried at approximately 80°C for 10 min by an infrared lamp. It was washed at $30 \pm 1^\circ\text{C}$ with 200 ml of detergent solution in the washing bottle (capacity, 500 ml) containing steel balls and installed in the Lavad-O-Meter (Showa Machine Co., Ltd., Tokyo). It was then blotted with filter paper and dried by infrared irradiation. Radioactivities before and after the washing were determined with a GM counter of 1.4 mg/cm^2 -thick mica window.

3. Results and Discussions

Preliminary experiments showed that the higher detergent effect is obtainable with the more steel balls in the washing bottle and with the longer time for washing. However, too extreme conditions caused mechanical damage of the cotton swatches. Thus, we adopted such conditions as 10 steel balls in each bottle and 10 min for each washing.

Fig. 1 gives the % removal of radioactive tripalmitin as a function of concentrations of anionic (SDS and SDBS) and cationic (DBD AC) detergents. It can be seen that the detergent effect of both anionic and cationic detergents becomes remarkable when the concentrations are higher than the individual cmc values, which were determined separately by solubilization method using Rhodamine 6G.

Fig. 1 Effect of anionic and cationic detergents on the removal of tripalmitin from cotton.

It suggests that the soil removal is made mainly by the formation of detergent micelles. It is quite possible that the soils are removed as a result of solubilization and/or emulsification, for which the micelle formation plays an important role⁷⁾. Similar results were obtained with nonionic (DOENPE) and amphoteric (DDAEG) detergents, as shown in Fig. 2. The high detergent effect of the nonionic detergent agrees with the results obtained with removal of oily carbon black from cotton⁷⁾.

In Fig. 3 is shown the soil removal against

Fig. 2 Effect of nonionic and amphoteric detergents on the removal of tripalmitin from cotton.

Fig. 3 Soil removal against concentration of sodium sulfate added to SDS (circles) and SDBS (triangles) of the concentration above (closed) and below (dotted) cmc.

the concentration of sodium sulfate added to SDS and SDBS of the concentration above (solid curves) and below (dotted) their cmc values. It is seen that the detergency is markedly affected when salt is added to the solutions in the proportion which is greater than cmc by 10^{-2} – 10^{-3} mol/l. This could pos-

sibly be attributable to the enhanced formation of micelles, which, as mentioned above, take an important part in cleansing. Similar explanation can be made with SDS of below cmc. It is well known that the cmc is lowered by addition of salt to detergent solution. In fact, the salt-added solution of SDS produced fluorescence upon the Rhodamine 6G test, in spite of the low concentration of the detergent. On the other hand, SDBS of 2.87×10^{-4} mol/l gave no evidence of micelle formation upon the test, because probably of too low concentration to form micelles even in presence of the salt.

It has been shown previously^{3,11)} that the soils on solid substrates consist of (a) loosely adhered or physically adsorbed contaminants, (b) chemically sorbed, and (c) the penetrated ones which can hardly be removed. The first one is easily removed by washing with water or a detergent solution, while the second is rather difficult to be decontaminated, unless special decontaminant(s) appropriate to the nature of soiling components is used. It has been shown⁹⁾ that the removal of tristearin- ^{14}C from the surface of stainless steel is made in two ways; one is fast and the other slow. In the present experiments, the soils seem to have existed mainly in the form of (b) and/or (c), because of low values, generally, of soil removal in comparison with those obtained by other investigators¹⁻⁸⁾. It is likely that the cloth is soiled first by contaminants of types (b) and (c), and, when more contaminants exist the type (b) contaminant is covered with

the excess soils forming the type (a) contaminant which is rather easily removed by detergent solution.

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