STUDIES ON THE ^{131}I LABELLING OF CASTOR OIL, AND THE DETERGENCY OF SODIUM DODECYL SULFATE

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I. ABSTRACT

The comparative detergency of sodium dodecyl sulfate (SDS) solution near the first critical micelle concentration (CMC) was measured by means of a ^{131}I-labelled castor oil as a soil.

More than 95% radiochemical purity of ^{131}I-labelled castor oil was obtained using potassium Iidide as a carrier.

Polyester test fabric was soiled with ^{131}I-labelled castor oil, and washed in a conventional washing apparatus mounted on appropriate devices.

Fabric radioactivities were measured before and after washing by a scintilation counter.

Near the first CMC, the detergency of SDS was increased with decreasing of surface tension of SDS.

It was also shown that ^{131}I-labelled castor oil was useful for studying the detergency of SDS.

II. INTRODUCTION

Radioisotopes have been applied extensively in medicine, industry, agriculture, and many other research fields as tracers and as radiation sources.

Gernerally radionuclides are used as simple inorganic compounds, or in the form "labelled molecules." Among many labelled compounds, the largest group consists of compounds of ^{3}H, ^{14}C, ^{35}S, ^{131}I, ^{125}I, and ^{99m}Tc. However, some of them are not suitable for research, because of their long physical half-lives and poor detectability of these radionuclides.

Compounds labelled with radioiodine, or to a lesser extent with radiobromine or radiochlorine are becoming increasingly useful in a variety of research development and routine analytical applications.

Various methods for trace labelling with radioiodine have been reported.[1)-3)]

In this experiment, castor oil was labelled by means of direct iodination.[4)]

The effectiveness of different detegent formulation is usually measured by their ability to remove soil from selected fabric during a washing cycle in an automatic washer or tergotometer.

The choice of an appropriate soil has varied widely indeed over the years ranging from carbon black to naturally soiled articles of clothing.

Carbon black,[5)] clay suspended in lubricating oil,[6)] and other colored soils

have been widely used because of their ready determination on white fabric by reflectance measurements. But, because of the complexity of detergency mechanism, it is relatively difficult to prove the effectiveness of detergency with conventional analytical methods described above, so that there has been a trend toward the use of sophisticated soils together with more accurate analytical method for the soil employed.

Harris et al[7] in 1950 used a carbon-14 tagged amide and hydrocarbon on metal as one of the earliest labelled soils in detergency studies.

Asheraft[8] used carbon-14 labelled tristerarin and carbon black in the study on the relative removal of these two soil compounds from cotton fabric.

Hensely and Inks[6] impregnated clay with calcium-45, which was then suspended in lubricating oil.

Ehren Kranz[9] used tagged tripalmitin in olive oil as a test soil, and Fort et al[10] studied soiling and detergency by using several detergents and four carbon-14 labelled soils.

They used end-window Geiger counter as the method of detection.

Gordon et al[11] used carbon-14 tagged fatty acids and tritium-3 tagged hydrocarbon oil as radiotracers in detergent studies.

It seemed a propriate to make advantage of modern radiochemical technology and to apply modern techniques of radiochemical synthesis and analysis to the study of detergency.

With radiometric measurements, one is able to demonstrate detergency in a simple way and with a low margin of errors.

In this experiment, ^{131}I-labelled castor oil was used, and its radioactivity was 1 mci/ml. It was employed as ^{131}I-labelled castor oil solution in combination with diethyl ether as a soil. And polyester was used in commercial product as a fabric.

The parameter influencing the detergency was fixed i.e. time, temperature of washing water, agitating speed, and degree of water hardness.

There are many methods that measure the surface tension of SDS near the first CMC, i.e., the capillary rise method, the maximum bubble pressure method, the dropweight method, the ring method, Wilhelmy slide method, and so forth.[12] In this work, the ring method was used to measure the surface tension of SDS.

SDS detergent is amphiphilic molecule (i.e., molecule in which a nonpolar or hydrophobic tail is joined to a polar or hydrophilic head group) that dynamically associate in aqueous solution above a certain critical concentration (termed the CMC) to form large molecular aggregates of colloidal dimensions termed micelles.[13)-14)] At concentration below the CMC, surfactants exist mostly as monomers. Above the CMC, there exists a dynamic equilibrium between the monomers and micelles.

At surfactant concentrations near the CMC, aggregation starts to form roughly spherical or ellipsoidal shaped micells. Each micelle is composed of a certain number of surfactant molecules (termed aggregation number) that determine the general size and geometry of a particular micelle system (Fig. 1).

III. EXPERIMENTAL

1. Equipment

a. Bechman model G pH meter with microelectrode.
b. Tensiometer; Fisher model 215 autotensiomat surface tension analyzer.
c. Ionization chamber, Transistorised physics range D.C. amplifier NE 503B.
d. Single channel scitillation counter, with well type NaI crystal; ORTEC
e. Switch control machine.

2. Material

a. Purified sodium dodecyl sulfate (Sipon crystals manufactured by American alcohol corporation.)
b. Hydrochloric acid 0.5 N (Analytical reagent grade)
c. Na ^{131}I; KAERI (Korea Advanced Energy Research Institute)
d. Diethyl Ether; Merck for analysis.
e. H_2O_2 ; Merck, 35%.
f. KIO_3, $Na_2S_2O_3$, KI; Analytical regent grade

All experiments were performed in the well-ventillated hood. Lead brick and lead glass were used to shield the emitted radiation from ^{131}I. Radioiodine is especially hazardous and if it does enter the human body it is rapidly concentrated in thyroid gland where it can cause serious and permanent damage.

3. Labelling

One mmole of potassium iodide in 1 ml of distilled water was mixed with radioiodine Na ^{131}I, to which 0.5 ml of potassium iodate in 1 ml of distilled water was added.

Following this, 5 ml of hydrogen peroxide (35%) was added. To this mixture, 0.5 ml of 5 N hydrochloric acid was added with stirring.

It results the yellow ^{131}I monochloride solution.

Two grams of castor oil dissolved in 40 ml of diethyl ether was mixed with ^{131}I monochloride solution at 0-5°C.

After 20 min., the mixture was transferred to a separatory funnel.

The reaction flask was rinsed thoroughly with successive minimum portions of diethyl ether.

The upper layer containing labelled compound was purified repeated washing with 1% of sodium sulfite solution.

The activity of ^{131}I-labelled castor oil solution was measured with a ionizatin chamber.

4. Soiling

Preparation of soiled swatches is of paramount importance in detergency study involving very large numbers of samples.

Section of fabric (10cm x 10cm) were prepared by several procedures.

Continuous padding was tried where in a section of each cloth draped over in a hood to promote air circulation for one day.

Swatches of fabric (1cm x 1cm) were prepared and the activity of soiled fabric swatch (1cm x 1cm) was about 100,000 cpm.

5. **Washing**

The soiled swatch was treated in 600 ml beaker equipped with a thin round plate with many hole, 5cm distance from breaker bottom, fixed with wire to prevent a whirl produced by mixing.

Magnetic stirrer was controlled by switch controller and voltage stabilizer to maintain the constant speed of stirring (Fig. 2).

The washing proceeded according to the following conditions;

Washing water; distilled water
Temperature of washing water; 30 ± 1°C
Water hardness; 0
Agitating time; 10 min.

The procedure of washing is as follows.

a. Prepare a soiled swatch (1cm x 1cm).
b. Check the back ground activity of test tube.
c. Put the soiled swatch in radioactivity checked test tube.
d. Count the activity of the soiled swatch in scintillation counter.
   Operating condition of scintillation counter.
   Window (upper) level ; 1.4 ow
   Lower level ; 1.5
   High voltage ; 750 volt
   Counting time ; 1 min.
e. Pour 400 ml of testing SDS solution into washing beaker.
   1) Control the temperature of testing SDS solution.
   2) Control the speed of magnetic stirrer with switch controller, and voltage stabilizer.
f. Immerse the soiled swatch in testing SDS solution.
g. Wash for 10 min. under constant washing condition.
h. Put the washed swatch in the test tube.
i. Count radioactivity of the washing swatch by scintillation counter.
j. Compare the radioactivity charge of swatch between before and after washing.

IV. RESULTS AND DISCUSSION

Labelling; The radiochemical purity of the ^{131}I-labelled castor oil was greater than 95%. The radiochemical purity tests were carried out by means of ascending radiopaper chromatography using methanol/distilled water (75/25 v/v), and diethyl ether as the mobile phase.

Fig 3, 4 shows the paper chromatogran scan of ^{131}I-labelled castor oil.

Carrier free form method[16] resulted the radiopurity of the product was only 50%. However, by using KI as a carrier resulted in good labelling yield of more than 95%.

Fig. 5 shows the plot of the surface tension as a function of SDS concentration. A sharp break occurs at the SDS concentration of 0.24%, corresponding to the first CMC of the aqueous SDS solution.[14)-15)]

Fig. 6 displays the plot of relative detergency as a function of SDS concentration near the first CMC. It also revealed a sharp break at 0.24% of SDS concentration, corresponding to the first CMC of the aqueous SDS solution.

Fig. 7 shows the relation between the reciprocal of surface tension, $\frac{1}{\gamma}$ and relative detergency of SDS near the first CMC.

On the basis of results shown in Fig. 7, it may be concluded that the detergency of SDS is directly proportional to the reciprocal of surface tension of SDS near the first CMC.

REFERENCES

1. Hunter, W.M., Radioactive pharmaceuticals (Proc. Symp. Oak Ridge, 1965), USAEC. D.V. Techn. Inform. Extension, Oak Ridge (1966) 245.
2. BOCCI, V, Int. J. appl, Radiat. Isotopes 15(1964) 449.
3. Mani, R.S., Kulkarni, P.V. Ind., J. Chem. 4(1966) 498.
4. Radioisotope production and Quality control Techn. Reports Series No. 128. Int. Atomic Energy Agency, Vienna (1971) 8430876.
5. Hensley, J.W., M.G. Kramer, R.D. Ring and H.R. Suter, J. Am. oil Chem. Society 32, (1955) 138.
6. Hensley, J.W., and C.G. Inks, ASTM Special Techn. Publ. No. 268(1959) 27.
7. Harris, J.C., R.E. Kamp and W.H. Wanko, ASTM Bull No. 170(1950) 82.
8. Asheraft, E.B. ASTM Special Techn. Publ. No. 215, (1956) 30.
9. Ehren Kranz F. Soap Chem. Spec. 32 (1956) 41.
10. Fort, T. Jr., H.R. Billica and T.H. Grindstaff, Textile Res. J. 36 (1966) 99.
11. B.E. Gordon, J. Roddewig. and W.T. Shebs, J. Am. Oil Chem. Society 44 (1967) 289.
12. Arthur, W. Adamson, Physical Chemistry of Surfaces Interscience Publ., New York (1967).
13. J. Moilliet, B. Collie, and W. Black, Surface Activity, Van Nostrand, Princeton, New Jersey (1961).
14. M.J. Shick, Editor, Nonionic Surfactants, Marcel Dekker, New York (1967).
15. K.L. Mittal, Editor, Solution Chem. of Surfactants, Plenum Press, New York (1977).
16. David J. Introduction to Radiochemistry, the Macmillan Press LTD., London (1977) 107-108.

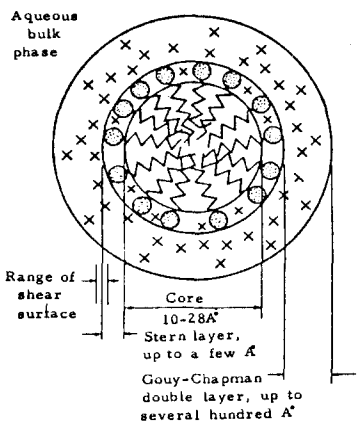

Fig. 1 Two-dimensional schematic representation of the regions of an ionic spherical micelle. The counterions (x), the head group (◎), and the hydrocarbon chains (⋀⋀⋀) are schematically indicated to denote their relative locations but not their number, disbribution, or configuration.

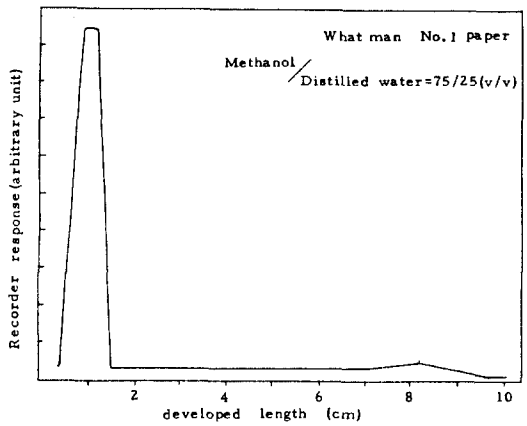

Fig 3 Radio paper chromatogram scan.

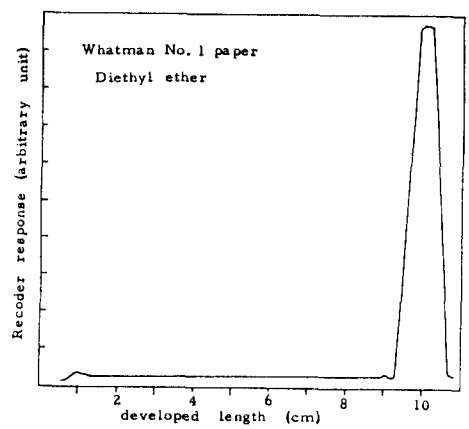

Fig 4 Radio paper chromatogram scan

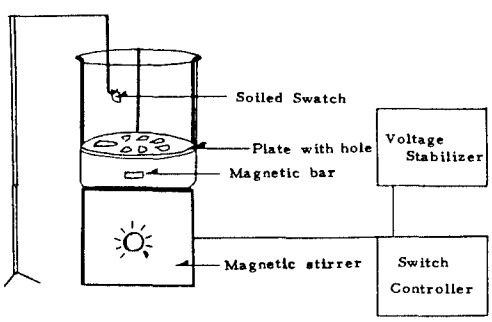

Fig2. Washing Apparatus

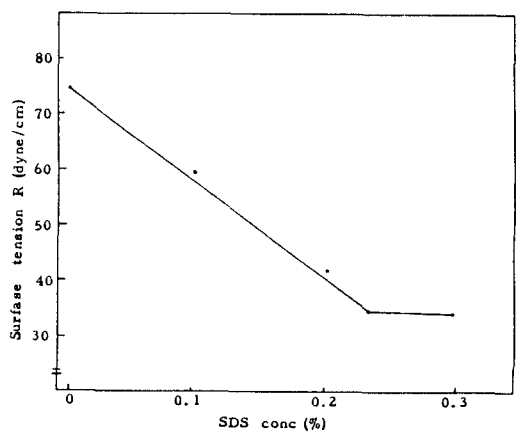

Fig. 5 The surface tension of SDS near the first CMC

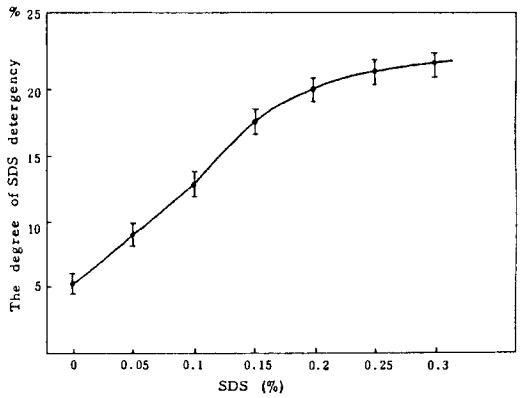

Fig.6 The detergency(%) of SDS near the first CMC

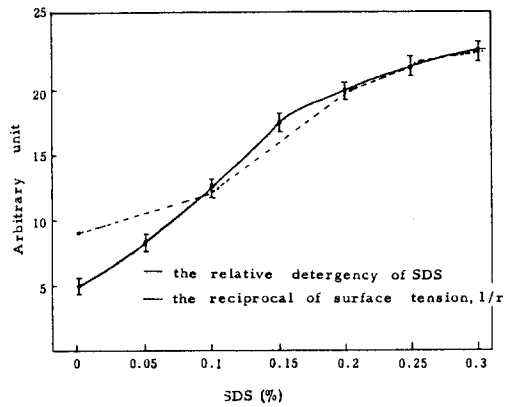

Fig.7 The relation between the reciprocal of surface tension, 1/r, and the relative detergency of SDS.