Journal of the Minnesota Academy of Science

Volume 24 | Number 1 Article 12

5-1956

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USE OF RADIOISOTOPES IN THE STUDY OF SURFACE PHENOMENA IN DETERGENCY OPERATIONS. III. STUDY OF SURFACE MEMORY FOR SPOT FORMATION

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INTRODUCTION

Previous work in this series has been reported by A. T. Martin, C. H. Shiflett and J. L. Wilson. At the St. Cloud meeting of the Academy in 1952 they reported the use of radioactive phosphorus, strontium and calcium as tracers in the washing of drinking glasses, sheet glass squares, discs of plastic, and various metals, in a household dishwasher. The various objects used as test materials for washing were not entirely satisfactory for measuring the radioactivity. Also, the large volume of wash solution necessary required relatively large amounts of radioactive materials.

In 1955 at the Mankato meeting a new model dishwasher of plastic was described (Fig. 1). This required only 100 ml. of wash solution. The objects washed were 38 x 75 mm. microscope slides. The radioactive count of objects of such size and shape was relatively easy to measure. Also in this paper was described the preliminary use and testing of a fat tagged with radioactive iodine 131. It was shown that such tagged fat was truly a tracer; that none of the fat was preferentially removed. Comparison of two detergents by the method was reported.

One of the problems in mechanical dishwashing is spotting of glasses (Fig. 2). The spots are formed from droplets of water forming on the glass and drying in place. If the water drained uniformly no drops would be left, and no spots would form. If these drops were removed at each washing, it would not be too serious. However, they increase and become more pronounced.

Two questions arise concerning the spots. Do the spots on a glass remain in the same position in further washes or are the spots removed and an entirely different pattern produced? Secondly, if a spotted glass is thoroughly cleaned by hand and rewashed to produce spots, is the previous spot pattern reproduced perhaps from some condition on the surface of the glass? In other words does a glass surface have (1) a memory of spots from wash to wash, and (2) a memory, after it is thoroughly cleaned, for previous spots on the slide?

EXPERIMENTAL

In washing dishes, two factors enter into the cleaning; first, the removal of the soil on the dish and second the redeposition of the soil in the wash water on the dish. In this paper we have simplified the

picture by placing the soil in the wash water and have studied redeposition only.

The microscope slides are cleaned by soaking in a hot solution of a glassy phosphate, metasilicate and alkyl aryl sulfonate wetting agent. They are then scrubbed with a stiff bristle brush dipped in the above solution, rinsed in running hot tap water, two changes of distilled water and stored under distilled water until used.

The wash solution is 100 ml. of a 0.4% solution of a good commercially available home dishwashing compound in well water to which has been added extra Ca and Mg to reach 360 ppm. hardness. The rinse solutions are of the same hard water. The soil consists of 0.025 gms. of non-fat dried milk solids and 0.1 gm. of fat tagged with radioactive iodine 131. The dried milk is added to the wash solution as 1 ml. of a 2.5% solution. The fat is weighed on the end of a glass rod which is hung in the center of the washer where the wash solution will gradually remove it. The constant temperature bath holds the temperature at 132° ± 1° F.

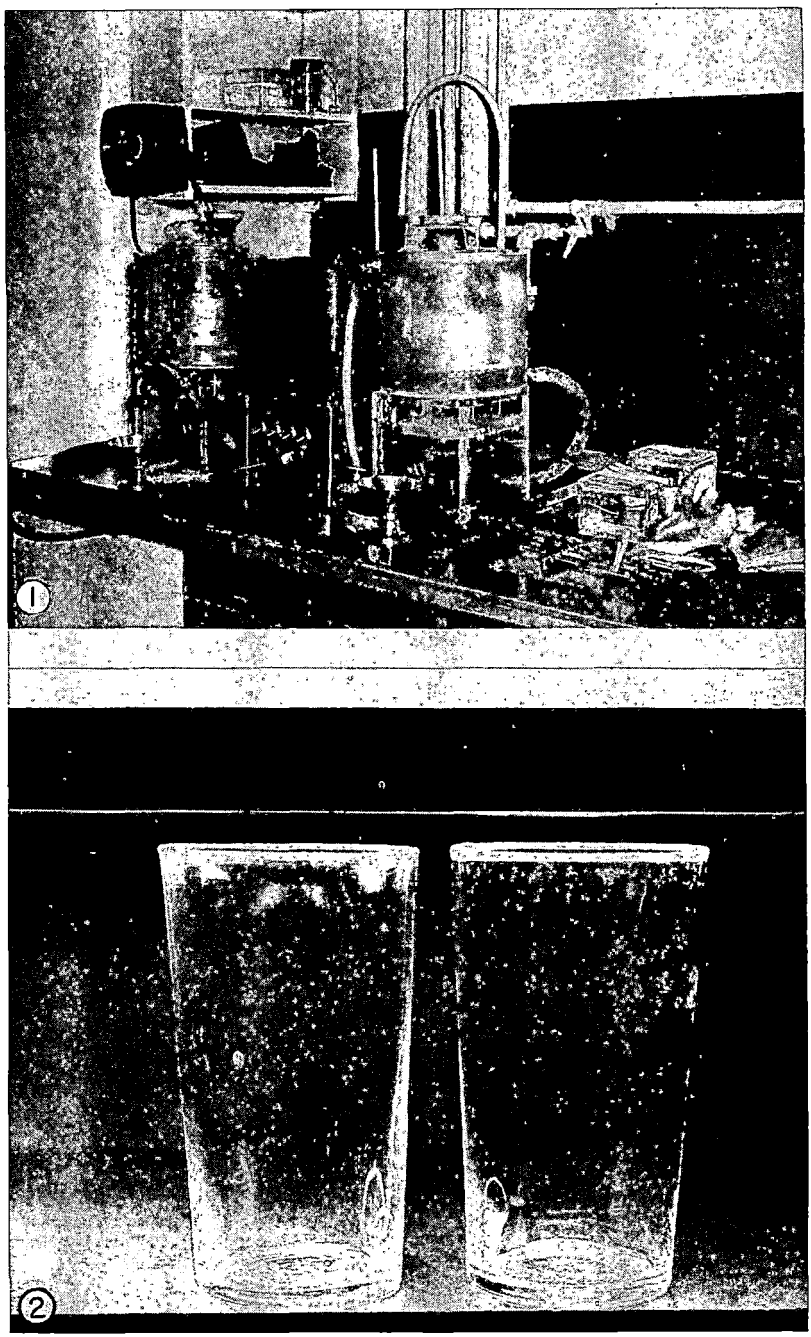
One complete cycle consists of a five minute wash and three one minute rinses with a half minute drain time between each step. The droplets are then allowed to dry. The spots formed are photographed and radioactivity autographed at appropriate points between cycles. The slides are counted with a Nuclear Model 165 Scaling Unit with a G. M. Tube with a 1.8 mgm. per cm^2 mica window. The slide is placed on a shelf approximately 3 mm. from the counter window.

To answer the question as to whether there is a memory for spots through successive cycles, four slides were washed by the above described method through 12 cycles. Uusally, spots start to appear visually after two cycles. Thus, photographing was started after the fourth cycle and continued through the twelfth. Autographing takes over night or longer depending on the activity. Autographs, therefore, were taken only at the end of 4, 8 and 12 cycles.

In the autographs the radioactivity varies and different exposure times were necessary to bring out the picture. The development of negatives and prints here varied still more than in the photographs. The brightness of the spots in the photographs should not be emphasized too much for these reasons. It might be noted here that, even though four slides are used in the washer, a 3 x 5 negative will hold only 3 unless reduced. Since autographs cannot be reduced, as there is no optical system, we have photographed only 3 of the 4 slides so that comparisons can be made.

Fig. 3 shows the photographs of one of these slides from the 3rd to the 12th cycle. Many of the spots on the first picture continue through to the last although other spots appear and disappear.

Fig. 4 is of another slide from the same set. On this picture there is a decided spot in the upper left corner of the slide. As the cycles are followed the outline of this spot continues although the center disappears. Fig. 5 is the third slide of this set. Again spots remain as the cycles continue. Another interesting point is well illustrated in this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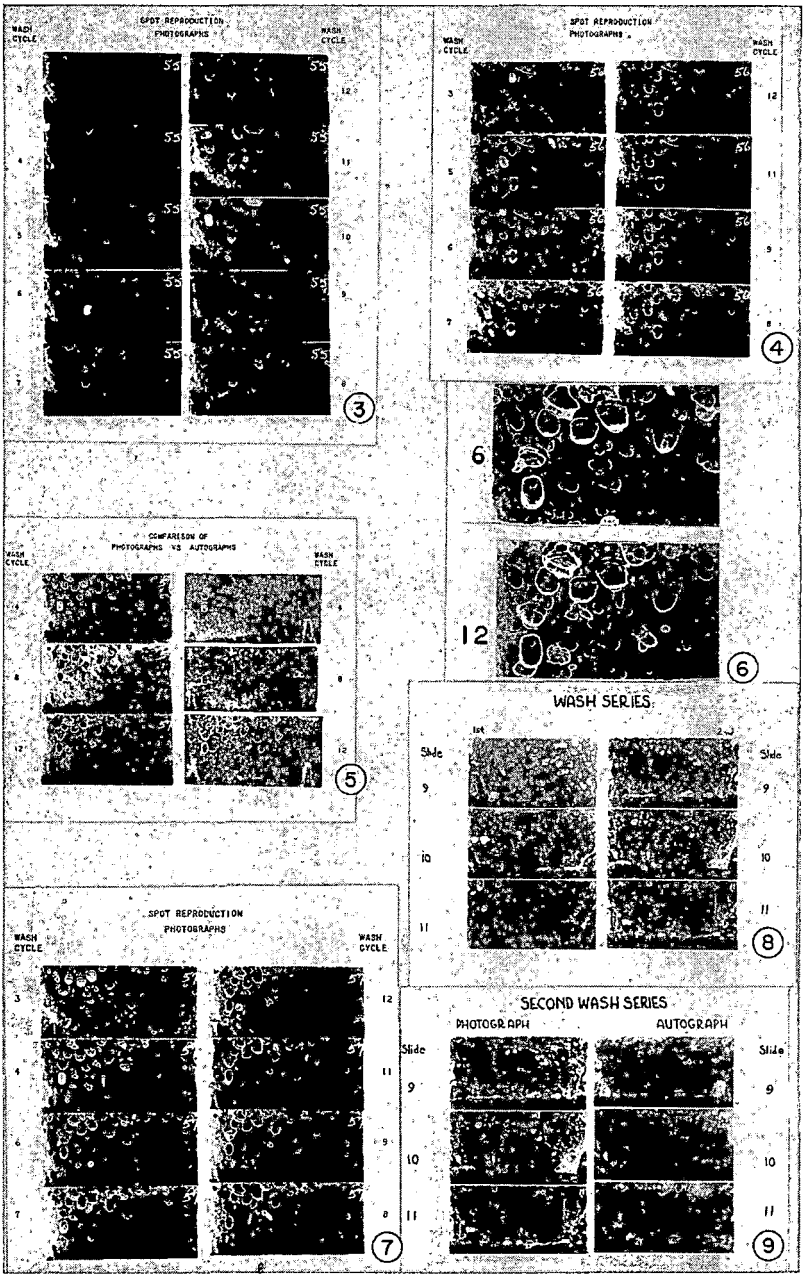
SPOT REPRODUCTION
PHOTOGRAPHS
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SPOT REPRODUCTION
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COMPARISON OF
PHOTOGRAPHS VS AUTOGRAPHS
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SPOT REPRODUCTION
PHOTOGRAPHS
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WASH CYCLE
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SECOND WASH SERIES
PHOTOGRAPH
AUTOGRAPH
Slide
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11
Slide
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9

slide. The spots in the upper left corner of the slide have a topography or inner detail. This topography continues through from the first picture to the last. The next picture (Fig. 6) is an enlargement of the upper left corners of the 6th and 12th cycles. Here the details show up quite clearly.

In the next picture (Fig. 7) are compared the photographs and autographs after the 4th, 8th, and 12th cycles of the slide on the last photograph. The 12th cycle shows most clearly the fact that each spot contains radioactivity. In fact, the material forming the visible spot is in each case tagged sufficiently to show up as a spot in the autograph. It should be emphasized that it is the mineral matter from the water and not the soil that is causing the spots in the photographs. On the other hand, in the autograph it is the iodine 131 tagged fat of the soil that records.

To summarize the illustrations, the spots once formed remain throughout further cycles. There is a memory in this respect. Much of the internal detail of a spot also remains. The autograph shows that each spot on the photograph appears in the autograph at least as to outline and in many cases the detail as well. In other words the fat and mineral matter are closely associated in the spot. A photographed spot is strongest when it first appears and decreases in succeeding cycles. The autograph intensity increases from cycle to cycle.

Whether the material forming the spot of the photographs and autographs are removed and redeposited at each cycle or simply not removed are not answered by the present data. However, work not yet completed indicate that the fat is partically removed and redeposited. With alternate cycles of active and inactive fat, spot reproduction occurs but the radioactivity decreases. In the case of the mineral matter, which the X-ray has shown to be CACO3, part of the spot is seen to be removed in the photographs as cycles continue. Normal equilibrium conditions would lead one to expect that the mineral matter should be soluble. Experiments with radioactive calcium in the water hardness are planned to clear this picture.

To obtain reproduceable spots both fat and milk solids must be present, for if either is omitted the spots do not remain in further cycles. Purified casein can be used indicating that it is the protein of the milk solids that is responsible for the effect. Further experiments are planned to clear this interdependence of the fat and protein.

As for the memory for spots when the slide has been hand cleaned and recycled, only preliminary work can be reported. The slides obtained to date have not been such as to answer the question in a definite way.

In the next picture (Fig. 8) are the photographs of three slides. On the left are the spots formed after 6 cycles. After photographing the slides were carefully washed by hand by the method previously described. They were then recycled to obtain the photograph to the right.

The next picture (Fig. 9) is of the slide of the second series of

cycles and their autographs. The radioactivity was low on this slide so that the spots are not as clear as in the former autographs. However, the spots are tagged as before. These slides, as well as previous work, have not led to a definite conclusion. Definite clearly defined spots will be necessary to apply any statistical method.

Reproduction of a spot in the two series of cycles would indicate some critical point—nonuniformity of the slide surface to cause a droplet of water to hang at the same place in the two series. If such a critical point exists the conditions of the cycle at the time for formation of the spot may cause the drop of water in one series to extend to one side and to the other in the next series. The shape of the spot in the two series might well be different. In fact it would be surprising if they were the same. Thus, comparison is not merely a matter of superimposing the two negatives on a viewing box and noting which spots match. It will have to be decided if two overlapping spots could come from the same critical point.

There are several ideas as to how to attack this comparison but, until slides have been obtained that are sufficiently clear, we feel the attempt is not worthwhile. Our impression is that we will not find the memory for spots.

Photographs have been presented that, at least for our particular set of conditions, have shown that the mineral spots persist from cycle to cycle both as to position, shape and detail. Autograph spots of the radioactive fat generally are reproductions of the mineral matter. It has been indicated that fat and protein along with the water hardness are necessary for persistence of a spot.

Photographs and autographs of two series of cycles of the same slides have been inconclusive to show a reproduceability of spot position from the first series to the second.

BIOPHYSICAL APPLICATIONS OF THE MASS SPECTROMETER

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ABSTRACT

The mass spectrometer at the Mayo Clinic has been used for analysis of several anesthetic agents in blood (Jones and associates, 1953; Hattox and associates, 1953) and for carbon dioxide and oxygen studies in blood (Patrick and associates, 1954). The latest program for which the mass spectrometer has been used is that of employing heavy water as a tracer for determination of absorption rates in the gastrointestinal tract of human subjects. Blood samples containing small concentrations of D_2O (heavy water) must be converted to the