The Bactericidal Powers of the Newer Detergents

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DURING THE PAST FIVE YEARS, the newer synthetic detergents have replaced the old-fashioned soaps for some domestic and most industrial purposes. Most of these substances were originally developed for use in the textile industry, but, within recent years, they have come to find their place in numerous other industrial fields as well as in the home. The first of these anionic detergents to be widely accepted by the consumer public was probably the "soapless shampoo," *Drene.* This has subsequently been followed by the acceptance of *Dreft, Vel, Trend, Tide, Swerl, Syntex, Oronite D-40, Nacconal,* and a host of others.

The prime attractions of these detergents are: (1) They form relatively neutral solutions, and (2) they do not form insoluble soaps or curds when they come in contact with the calcium and magnesium salts of hard waters. Thus they are able to retain their cleansing action in solutions that are acid, neutral, or alkaline in reaction, and in the hardest waters.

Chemically, these anionic detergents are sulfated or sulfonated oils, esters, amides, hydrocarbons, and similar organic compounds. Among the most promising of these appear to be the alkyl aryl sulfonates, produced by the sulfonation of an alkyl derivative of an aromatic hydrocarbon. Many variations in individual chemical structure are possible with these substances, and several types are available commercially. All detergents, though differing in individual chemical composition, possess within each molecule an hydrophilic and lipophilic group. In these detergents, the hydrophilic group is the sulfate or the sulfonate radical; the lipophilic group is generally the hydrocarbon radical.

In contrast to these detergents, it may be interesting to review briefly the chemistry of the older types of soaps with which we are familiar. These products are usually prepared by allowing caustic soda to combine with the common fatty acids. The glycerine also formed in the process may or may not be removed, and the degree of alkalinity of the soap may be somewhat altered by allowing either an excess of alkali or an excess of fatty acid. Even the superfatted soaps, however, are highly alkaline in reaction when dissolved in water, and lathers of such soaps will almost always pink phenolphthalein, indicating a pH more alkaline than 8.3. Reasonable amounts of free fatty acid will not prevent the condition of alkalinity in a soap solution, because of the ionization and partial hydrolysis of the soap in solution.

There are various types of soaps available commercially. Laundry soaps contain added alkali, sometimes a resin soap, and frequently a filler or builder, such as sodium metasilicate, to aid in the cleaning action. Hand soaps contain less alkali and sometimes some uncombined fatty acid. Toilet soaps can be made by the use of potassium hydroxide instead of sodium hydroxide. These soaps are generally prepared as granules or flakes and then compressed into firm bars. Floating soaps are a group which can be made as pure or impure products, just as long as a sufficient amount of air is dispersed into the semisolid soap to produce the desired property of buoyancy. Liquid soaps will contain from 60 to 70 per cent water, the soap being generally made from the higher fatty acids containing sixteen or more C-atoms in their molecules.

THE PROPERTY OF DETERGENCY

THE MOST IMPORTANT FUNCTION of a detergent is, of course, its cleansing action. There is no significant correlation between the detergent action of these newer products and their sudsing action. Some of the most effective of these detergents will create so little sudsing that many manufacturers are resorting to the addition of sudsing materials, so that their products will obtain the approval of the user. It is helpful to remember that in any cleansing action, water is the primary cleansing agent. A detergent or soap is merely an aid in this action. A good detergent must necessarily be readily soluble in water and must carry within the same molecule a strong lipophilic pole which will combine with oils, fats, and grease and an equally strong hydrophilic pole which will combine with water and allow it to wet and carry away the emulsified material without redepositing it. An oil droplet is held in place by these detergent molecules and is surrounded by an oil-repelling, water-attracting film which prevents coalescence of individual oil droplets. Ability of a detergent to dissolve partially certain types of protein and soil is also a desirable property.

BACTERICIDAL PROPERTIES

SINCE DETERGENTS have gained such wide popularity and are used many times more than all other chemical sanitizing agents combined, we have lately investigated the bactericidal action of these new substances.

The first instinct of a bacteriologist is to follow standard methods. When testing bactericidal activity, this involves comparison with phenol. However, in our investigations, we soon found that direct comparisons of these detergents with phenol were impossible, because of the entirely unrelated mode of action of these substances and the extremely unusual survivor curves obtained of organisms exposed to these detergents.

Classically, when a bacterial population is exposed to an unfavorable environment, the rate of decrease is fairly uniform, so that the velocity of disinfection, or the value of K in the equation of:

$$K = \frac{1}{\text{time } (t)} \cdot \log \frac{\text{Initial number of organisms exposed}}{\text{Number of survivors after time } (t)}$$

will remain fairly constant. Such is the case with phenol and, to a large extent, with the chlorine bactericides. With the surface-active agents, however, an extremely high initial rate of disinfection was revealed, followed by a much less rapid rate of decrease, which was in turn followed by a still less rapid rate of destruction. Logarithms of the survivors of the exposure period, as determined by plate counts, graphed against time of the exposure, showed survivor curves of a type entirely different from that seen using phenol.

It is doubtful whether all of this rapid initial rate of decrease represents actual destruction of the exposed organisms. It is more probable that, although bactericidal action is also indicated, a significant portion of the decrease represents the agglomeration of still viable organisms into clumps, surrounded by these surface-active substances. In the case of plate counts in agar, the many viable organisms in these clumps would give rise to but a single colony and hence would be read as only one viable inoculum. Later on in the exposure period, when the rate of decrease is extremely slow, the reverse of the previous statement might hold true. The actual destruction of the cells could be taking place at a more rapid rate than indicated by the plate counts, as a clump of organisms will continue to produce a colony on a plate even though 90 to 99 per cent of the organisms within that clump had been rendered nonviable.

Most bactericides are more effective against certain types of microorganisms and less effective against other types; that is, most bactericides exhibit specificities in their action. With some of the disinfectants, such as iodine, these specificities are not great, and concentrations which are effective against one type of organism will not differ greatly from those concentrations effective against other types. The anionic detergents, however, do show marked specificities in their action. In general, they are very effective against the organisms of the nonsporulating Gram-positive groups. The staphylococci and streptococci are readily destroyed by even very dilute solutions of these detergents and at ordinary temperatures. The comparative efficiencies of some of the more familiar of these compounds in tests against *Staphylococcus aureus* were: *Oronite D-40 H, D-40, Santomerse, D-40 R, Trend, Swerl, Dreft, MP-189, Vel,* and, lastly, *Tide* and *Syntex.* There is every reason to believe that these relationships will not differ too greatly against the pneumococci, micrococci, and even the gonococci. Against *Escherichia coli,* however, considerably higher concentrations of the detergents were required to effect destruction, and the compounds which were most effective against *Staphylococcus aureus* were not the most effective against *Escherichia coli* and, presumably, against those organisms of the Gram-negative typhoid, paratyphoid, and dysentery groups. Fortunately, these latter groups of organisms are the least resistant to the effects of heat, drying, and to chlorine, so that washing with these new detergents, followed by drying, should provide reasonably good protection when the initial degree of contamination is not excessive. When materials known to be contaminated are to be cleaned and sanitized, the washing should, of course, be followed by heat or hypochlorite treatment.

Bactericides are subjected to dilution as they are used, and many of them are rendered inert by even moderate dilution. The resistance of the anionic detergents to the effects of dilution is phenomenal. The differences in the bactericidal action of various dilutions of the detergents are not as pronounced comparatively as they are in many other disinfectant solutions. The phenomenon of "micelle" formation may perhaps be applied as an explanation of this property. These detergents, like soaps, are ionized in aqueous solutions. In a condition of increased concentration of the detergent, aggregations of the ionized molecules together with some of the still-neutral molecules will take place to form large, highly charged colloidal particles known as micelles. As the solution becomes more dilute, these colloidal aggregations break up and are again dispersed in the solution.

This same phenomenon would also account for the marvelous recuperative powers of these compounds when they are subjected to repeated contamination with organic materials. Even after a 1 to 1000 dilution of a sulfonated paraffin had been contaminated four times with successive 5 ml. portions of a heavy-broth culture of organisms in one test series, the solution was still able to reduce the bacterial population significantly. In another series of tests, a similar solution was found to be active after the addition of ten successive 5 ml. portions of broth culture. Probably sufficient micelles became dissociated after each addition of culture to compensate for the detergent molecules which had become tied up with previously added organic materials, so that the effective concentration of the detergent in the solution remained essentially constant. The significance of this phenomenon in dishwashing and even in laundering and general cleaning is obvious.

The bactericidal efficiency of the anionic detergents is markedly influenced by the temperature at which their solutions are held. For example, a 1 to 400 dilution of an alkyl aryl sulfonate at 44° C. is considerably more effective than a 1 to 100 dilution at 10° C. Correspondingly, a 1 to 1000 dilution of the material at 55° C. is more bactericidal than a 1 to 500 dilution at 30° C.

CONCLUSION

THIS NEWLY DEVELOPED GROUP of compounds does certainly increase the ease with which materials can be cleaned and sanitized. Maximum advantage should be taken of their bactericidal powers, which are so superior to those of the ordinary soaps. It is not proposed, nor is it to be assumed, that these compounds could be safely considered as both detergents and bactericides where public health and individual safety demand not only cleaning and detergency but also positive disinfection. Rather, these materials should be recognized as exceedingly efficient detergents which can well be used to precede the standard bactericidal procedures of sanitization.