The Antiseptic Properties of Surface Active Agents[1]

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WHEN people clean, they seek to accomplish two things: to remove visible dirt and to eliminate organic matter with its living organisms which breed filth, foul odors, and disease. It is no wonder then, that people look for antiseptic properties in washing agents.

Soap, synthetic detergents, and other surface active agents are antiseptics. Each surface active agent has different antiseptic properties, just as it has different wetting properties and different washing properties. Chemists would like to be able to classify the antiseptic properties and other properties of surface active agents according to their structure. Such a classification has not proven very helpful. While there is some similarity in antiseptic action between surface active agents of similar chemical constitution, surface active agents come from a very wide variety of chemical classes. Among the important commercial surface active agents we have phenols, esters, amides, amines, alcohols, hydrocarbon sulphonates, ethers, and carboxylates. There are aliphatic, aromatic, alicyclic, and heterocyclic compounds.

A comparison might be made between dyes and surface active agents. Dyes, like the surface active agents, are classified by a physical property, but colored compounds can be found in every broad chemical class of the organic compounds. Dyes have a certain similarity of structure which makes the compounds colored, but every change in that structure changes the color and changes the fastness properties. Similarly surface active agents all have a similarity of structure. They have a carbon chain and a group which makes them dispersible in water, but any change in their structure affects their surface properties and their antiseptic properties. While there is some resemblance between products of a very similar chemical structure, just as there is between dyes of similar structure, this does not help to classify them because there are so many different types of surface active agents.

In recent literature an attempt has been made to arrive at a classification by distinguishing between the anionic, cationic, and nonionic surface active agents. Certain surface active agents have been shown to form true solutions and to ionize when tested at extremely low concentrations. When the ionized solutions are converted to colloidal solutions, colloidal ions are generally formed which usually carry the charge of the ion which is responsible for the surface activity. True solutions of surface active agents must be converted to colloidal solutions before they exhibit interesting surface properties.

The classification of surface active agents as anionic, cationic, and nonionic does not group together products of like activity. The variation, for example, between the antiseptic properties of two different anionic detergents may be greater in magnitude than the difference in antiseptic activity between an anionic and a cationic detergent.

A comprehensive understanding of antiseptic properties of surface active agents will require a study as complex as the study of the fastness properties of dyes. It will involve a study of each class of chemical compound which is involved and each member of the class.

The surface active agents are not to be regarded as universal antibiotics that destroy all life which we would like to destroy immediately upon application. Such agents do not exist, and such agents are not a desirable thing. However, certain of the surface active agents do exert a very valuable antiseptic action. If advantage is to be taken of this antiseptic action, it must be understood so that the agent can be properly used. Antiseptic agents are generally useful over limited ranges of concentrations. If insufficient amounts of the antiseptic are used, there is generally no antiseptic action at all.

Soap is the commonest surface active agent, and it is now used for washing where an antiseptic action is required. A surgeon brushes his hands with a strong soap solution over a long period of time before starting an operation. Dirty clothes can be washed with soap so that the development of odor by bacteria can be avoided. There is a general understanding of the antiseptic action of soap and of its limitations. What then can be expected from the new synthetic detergents and the new surface active agents? The activity of certain cationic detergents has been surveyed in a general way in the recent literature, and data describing their unusually strong antiseptic action as well as their limitations in the presence of organic matter are available. In this discussion, consideration will be given to the surface active properties of the anionic detergents. A comparison will be made of the bactericidal activity of soap and certain other anionic detergents.

The surface active agents whose antiseptic properties will be considered here in detail are those manufactured and sold by the National Aniline Division, Allied Chemical and Dye Corporation under the trademark Nacconol. There are a number of these Nacconols which differ from each other in strength, chemical composition, or degree of purity. They are all anionic detergents. The common grade of Nacconol is the Nacconol NR which is a commercial detergent containing about 40% active organic sulphonate and about 60% of sodium sulphate. It has a powerful washing action so it is often used in place of soap.

Bactericidal Action

NACCONOL NR does not show a phenol coefficient by the test described in the U. S. Department of Agriculture Bulletin 198, which requires apparent killing of the bacteria in 10 to 15 minutes. The rate of killing by the Nacconol is too slow.

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TABLE I

Germicidal Tests vs. *Staphylococcus aureus*

Medium: B. E. Agar (pH 6.8)

Temp. 37°C. Incubation of Plates—2 days

Product	Dilution	Bacteria per cc. surviving after				
		1 hour	3 hours	5 hours	24 hours	72 hours
Nacconol NR	1:100	45,000	11,000	3,600	300	0
	1:500	79,000	32,000	22,500	3,700	0
Nacconol LAL	1:100	15,000,000	15,000,000	12,000,000	4,500,000	4,500,000
Nacconol FSNO	1:100	5,400	1,400	800	0	.....
Soap USP XI	1:100	7,200,000	3,100,000	1,000,000	21,000	300
Control (Sterile distilled water)	.....	110,000,000	104,000,000	140,000,000	51,000,00	145,000,000

In order to determine just how rapidly the bacteria were destroyed by the Nacconols broth cultures of *Staphylococcus aureus* containing Nacconol NR, soap, or Nacconol LAL were held over a period of three days. At intervals samples were withdrawn, and counts of the bacteria were made. The results are shown on Table I. It will be noted from this table that after the test had run for one hour, the control solution contained 110,000,000 bacteria/ml. After one hour the Nacconol NR at the usual washing strength of 1:500 had reduced the bacteria count to 79,000. Under the same conditions a 1% solution of U.S.P. soap had reduced the bacteria count to 7,200,000 while a 1% solution of Nacconol LAL, another anionic detergent, reduced the bacteria count to 50,000,000. From these figures it will be noted that these anionic surface active agents show a tremendous variation in activity. One of them has permitted the survival of 600 times as many bacteria as the other. These products are not extremes. Another Nacconol has been studied which is four to ten times as strong as Nacconol NR.

It will be noted that as time progresses, the bacteria count of the control continues high, at approximately the original level, while the bacteria count in the case of the Nacconol NR used at ordinary washing concentration decreases to zero. In this period of time the bacteria in the soap solution were reduced to 300/cc. whereas in the case of Nacconol LAL they were reduced to 5,400,000/cc.

In the comparison between soap and the Nacconols it must be remembered that soap solutions are alkaline whereas the solutions of the Nacconols are substantially neutral. The bactericidal action of the anionic detergents appears to be increased in acid solution in contradistinction to the cationic detergents whose activity is increased in alkaline solution. Soap, of course, cannot be made neutral without precipitating the fatty acids. It is not unlikely that the greatly improved antiseptic action shown by Nacconols in comparison with soap results in part from the fact that they can be used in neutral and acid solutions. This point will be investigated.

THIS work with Nacconol NR has subsequently been repeated but has been extended to give a better picture of the effect of concentration. The new data are given in Table II. The data in Table II are not identical with the data in Table I, but they are regarded as a good check for experiments run at different times by different operators and with different materials. The significance of a few hundred bacteria surviving from a culture of 100,000,000

TABLE II

Germicidal Tests vs. *Staphylococcus aureus*

Medium: B. E. Agar (pH 6.8)

Temp. 37°C. Incubation of Plates—2 days

Product	Dilution	Bacteria per cc. surviving after			
		1 hour	3 hours	6 hours	24 hours
Nacconol NR	1:100	750	0	0	0
	1:500	450	120	70	0
	1:1000	1,200	260	160	0
Control—Sterile distilled water	.....	72,000,000	105,000,000	111,000,000	67,000,000

is not altogether clear or subject to exact check. It will be noted that as the concentration of Nacconol NR is increased, the bactericidal action is speeded up. For example, a negative test was obtained with 1% Nacconol solution in three hours whereas the usual washing concentration of 1:500 required 24 hours to give a negative test. It will also be noted that while the results at 1:500 dilution are a little lower than the results from a 1:1000 dilution, both solutions give negative tests after 6 hours. It is very rare that solutions less than 1:1000 of Nacconol NR are used for washing. Taking into account the 40% organic content of the Nacconol NR, the actual strength at 1:1000 dilution is about 0.04% of alkyl aryl sulphonate or pure anionic detergent.

Very good authorities on the testing of bactericides do not favor the use of the phenol coefficient test for the testing of any germicide other than the phenols. Bulletin 198 of the Department of Agriculture also describes the agar cup plate test. In this test Nacconol NR solution is placed in a cup in the center of an agar culture medium containing a freshly inoculated culture of *Staphylococcus aureus*. The solution diffuses through the agar and, when it is effective in controlling the bacteria, there is a clear area around the cup where growth of bacteria has been stopped. Outside of that area where the bacterial growth is normal the agar medium becomes very cloudy. Figure I shows the results of an agar cup plate test made with solutions of Nacconol NR varying in strength from dilutions of 1 to 20 or 5.0% down to dilutions of 1:500 of 0.2% which is the ordinary washing strength. The test is also repeated to show the antiseptic action of Nacconol NR in the presence of organic matter. The upper series of plates shown in Figure I is made with Nacconol and the usual agar. In the lower series of tests 10% of blood serum has been added. It will be noted from the clear areas around the cups that Nacconol exercises a very good antiseptic action. Bearing in mind the fact that the

utility of such an antiseptic take, for instance, the preparation of an antiseptic cotton batting. Cotton batting is often used for the treatment of wounded men, and it provides a very ready source of infection. Cotton batting in packages can be sterilized by heat, but when the package is opened, infection is rapid so that it is no longer sterile. Cotton batting can be sterilized with certain high boiling alkyl phenols, but even though the phenols are high boiling and even though the cotton batting is kept in a closed package, the phenols slowly evaporate and disappear. If larger amounts of phenols are used to compensate for any possible evaporation, then the toxic action of such organic compounds on the skin becomes objectionable. Organic phenols, carboxylic acids, organic amines, and organic ammonium compounds are generally very destructive to human tissues.

Consider, then, the use of Nacconol NR as the antiseptic agent. It is water-soluble so it can be added to the cotton in the processing operations; it is absolutely non-volatile; the amounts required to render the cotton antiseptic are very small; and the product is non-irritating. By the use of Nacconol NR bacteristatic cotton has been developed commercially which retains its activity indefinitely.

Non-toxic antiseptics such as the Nacconols are valuable for use in the processing of foods. When they are used to wash dairy equipment, particularly milking machines, the bacteria count of the milk is reduced to a fraction of its ordinary value.

It has been found possible to raise the quality of butter by the use of Nacconol for washing dairy equipment. In dairy country where only 30% of the butter was A Grade, it has been found possible to raise the quality so that 70% was A Grade by no change except washing the dairy equipment with Nacconol.

In recent years the utilization of acid cleaners for the dairy industry has attracted the attention of scientists. Such acid washes are ideal for cleaning milk cans and other dairy equipment. These acid cleaners are mixtures of a surface active agent with an acid. The valuable antiseptic action of the surface active agent is greatly increased in acid solution, and a remarkably good, non-toxic cleansing and antiseptic agent is produced.

In the present war one of the important uses of surface active agents is for the mobile laundry work. Mobile laundries are intended for use at the front. They may be forced to use a water supply which is badly infected with bacteria and fungi at the outset. It is important that the bacteria, pathological fungi, and insects present in the dirty clothes be destroyed. An antibiotic action is far more important than the improvement of the appearance of the clothes, all of which are colored. Nacconol NR with its antiseptic and strong deodorant action has been found to be an ideal agent for that purpose.

Nacconol NR in an acid solution is useful in controlling pathological fungi on humans. It may be used, for example, for the control of infectious dandruff and athlete's foot.

The antiseptic properties of Nacconol NR make it valuable for the washing of vegetables which are to be preserved by canning or freezing.

When dishes which have been used for food are washed, the food stuffs remain in the washing solution. This solution is ideal for the breeding of bacteria and other organisms, and the bacteria counts of such dishwaters are very high. It is not uncommon in humid, warm weather for the bacterial activity to be so great that a foul smell is given off by the dish cloths and other absorbent material used for dishwashing. This does not happen when a strong antiseptic like Nacconol is used as the ordinary household cleaning agent.

In the army dishes washed with soap are sterilized by an antiseptic wash containing a bactericide and a surface active agent.

In the commercial laundering of ordinary clothes it is desirable that the bacteria counts be reduced to as low a level as possible. In the laundering of white goods they may be given a final treatment with hypochlorite which destroys practically all bacteria. In the laundering of colored goods such a sterilizing rinse cannot be given, and the number of bacteria in the wash water runs to astronomical figures. These bacteria counts cannot be reduced to zero by the use of a surface active agent like Nacconol, but it has been found possible to reduce bacteria counts to 20% of their original value.

In commercial mixtures of soap and synthetic detergents the synthetic detergents prevent the development of rancid odor in the soap.

The Nacconols have shown promising results as disinfectants for plant roots. They are used for the cleaning of the interior of buildings where it is desired to have an insect repellent action and as much antiseptic action as can possibly be obtained. Nacconol NR has been used to wash streets, and consideration has been given to its use in the "packaging" of foods and other articles.

Antiseptic activity is not always a desirable feature. For example, if spent Nacconol wash waters are segregated from other sewage, the antiseptic action may be so strong that it may sterilize the sewage and so destroy the bacterial action necessary to most sewage disposal systems. If all sewage is mixed together, there is insufficient Nacconol to effect the operation of the sewage disposal systems.

Summary

Soap has always been and still is a valuable antiseptic agent. Among the new synthetic detergents products are available which can be used in neutral or acid solutions to give a much stronger antiseptic action than is possible with soap solutions. These new detergents are valuable because a really worthwhile antiseptic action is obtained from products which are not toxic. The new detergents are non-volatile so that they are stable under storage conditions, and they dissolve rapidly to start their sterilizing action. Further study of these products is worthwhile and necessary because no antiseptic is of any value unless it is properly used.

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