The Quaternary Ammonium Compounds in Sanitization*

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THE approval of a new bactericide for the sanitization of food handling equipment, eating utensils, and drinking glasses should be withheld until critical tests, conducted by impartial and competent workers, have established the uses and the limitations of the product. Only after the data have provided positive and favorable answers to the following four questions should approval be considered:

1. Is the product a definite chemical compound or a mixture of known chemical compounds, with the composition definitely stated on the label?
2. Is it toxic to the consumer or to the user? Can it form toxic compounds either with foods or equipment? Can it induce hypersensitivity, so that following previous exposure some people are made ill by using the product or even by eating from utensils sanitized with the product?
3. Is it efficient and reliable both as bactericide and a virucide under the conditions it will be used, against all organisms and viruses of sanitary and public health significance?
4. Is there a reasonably reliable and rapid field test which indicates the germicidal powers of the solution when tested, and not merely the total amount of chemical added; some of which may have been inactivated?

Other pertinent questions are:

5. Is it stable, or will it deteriorate under adverse conditions of storage so that its bactericidal powers are diminished or lost?
6. As offered to the trade, is it constant in composition, or will an occasional lot fail to provide essential protection to the public?
7. Will its presence in the food preparation plant and in the kitchen lead to abuses? Can it be used as a substitute for the sanitary handling of wholesome foods?
8. What are the specificities of the product? Is it highly selective in such bactericidal, bacteriostatic, and virucidal actions as it does exert? What types of organisms might remain viable on partially sanitized equipment and contaminate foods subsequently handled, and what types of organisms could grow in food containing traces of the product?
9. Will the routine use of the compound tend to encourage the development of strains of organisms resistant to it?
10. Does it retain its efficiency in the presence of organic matter and debris? Will the carry-over from the detergent wash inactivate it, or can it be used in a two-compartment sink?
11. Does the bactericide possess a relatively low coefficient of dilution? That is to say, does a reasonable amount of additional dilution prolong the killing time beyond the time of exposure ordinarily given?
12. What is the temperature coefficient of the bactericide? That is, to what extent is the germicidal efficiency influenced by the temperature of the solution?
13. Is it a satisfactory detergent? Can it be combined with present detergents?
14. Does it leave an unsightly deposit on glassware and silver?

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15. Does it possess an objectionable odor or flavor, and does it leave a residue which combines with certain foods or beverages to produce odors or after flavors?

16. Is it corrosive to equipment? Does it tarnish silver?

17. Is it being offered to the trade in an ethical manner or are claims being made, either in advertising or by salesmen, that will encourage practices which jeopardize public health?

18. Does the product have an esthetically acceptable origin?

19. Will its acceptance lead to an improvement of sanitizing practices or will it merely add to the complications facing already overworked sanitarians?

THE QUATERNARY AMMONIUM COMPOUNDS

The many desirable characteristics of the quaternary ammonium compounds make necessary their critical evaluation as bactericides for use in the food industries and in restaurants and taverns. In numerous cities and states they are accepted as the equivalent of the hypochlorites or heat; however, many health officers have withheld approval, awaiting their evaluation and approval by the U. S. Public Health Service or other responsible agencies.

COMPOSITION AND LABELING

The number of quaternary ammonium compounds which can be synthesized is very great and more than a thousand already have been produced. The commercial products usually are definite mixtures of related compounds which differ in the number of carbons in the fatty acid radical.

The health officer should require that the chemical formula be stated on each package, and if the product is formulated from a parent quaternary ammonium compound sold under another name, the name of the parent compound also be stated.

The acceptance, as sanitizing agents, of proprietory products whose compositions may be changed from time to time is both illogical and unsafe. It would be entirely possible for the producer of a proprietory quaternary ammonium bactericide, to use one of the more effective compounds to gain approval of his product and later to substitute a less costly member of the series. The new product might appear identical with the old and give the same reaction with test papers and solutions. The bactericidal efficiency and toxicity, and hence the degree of protection to the public, might be changed greatly. The variance in the germ killing power and specificities of closely related quaternary ammonium compounds is well illustrated by the following data from Valko and DuBois.[1]

Germicidal Activity of Quaternary Benzyl Ammonium Chlorides at 20° C.

	Dilution killing in 10, but not in 5 minutes	
	Staphylococcus aureus	*Eberthella typhosa*
n-Octyl dimethyl	1:170	1:280
n-Dodecyl dimethyl	1:20,000	1:16,000
n-9-Octadecenyl Dimethyl	1:29,000	1:10,000

The n-Octyl dimethyl compound was a relatively poor bactericide, but was more effective against *Eberthella typhosa* than against *Staphylococcus aureus* while the related compounds were much more powerful and were more active against *S. aureus* than against *E. typhosa*.

TOXICITY

Such data as are available indicate the quaternary ammonium compounds to be no more toxic and considerably less irritant than the hypochlorites or chloramines. Since the toxicity of closely related compounds may vary as greatly as their bactericidal efficiency, each compound which is to be approved must be subjected to exhaustive tests. Data from one or two members of a group cannot be interpolated to predict the characteristics of closely related compounds.

EFFICIENCY AND RELIABILITY

Using the F.D.A.[2] technic, and modifications of this technic, the writers have tested Hyamine, Queseptic, $4NH_4$, Strasco Disinfectant, H-G 128, Amicide, Roccal, Teramine, Timsol, Emulsept, Q.A.C., Ster-Bac, M.L. 10 Hospital Germicide, Septo-Sol, Stericide, Thoral, Fuldicide Disinfectant, Phemerol, Quatresin, and a number of experimental modifications of Roccal and Thoral. Almost without exception, the data obtained confirmed the "phenol coefficient," values given on the labels, although erratic end points and "skips" occurred frequently. Unfortunately, the F.D.A. technic fails to parallel conditions of actual use. In fact, the technic is claimed to allow a reasonably accurate evaluation only when comparing disinfectants closely related in mode of action to that of phenol.

The writers believe "phenol coefficient" values of quaternary ammonium compounds are dangerously misleading and should not be included on the label or in advertising.

Certain inconsistencies of the data obtained by the phenol coefficient method indicated the necessity for more exact quantitative studies. In the next experiments, plate counts were made of bacterial populations after varying periods of exposure to quaternary ammonium compounds. It was found that the velocity of decrease was not uniform but that during the first minute the value of

$$K = \frac{1}{\text{time of exposure}} \times \log \frac{\text{initial number of organisms}}{\text{survivors after exposure}}$$

was from 100 to over 1,000 times as great as between the second and twenty-fourth hours [3,4] (Tables 1 and 2).

If the plate counts accurately reflected the number of survivors, then the velocity of disinfection was proceeding in a very unusual manner. Many students of disinfection have confirmed the observation of Rahn [5] that "if the culture for the experiment on the order of death is carefully chosen, not too young and not too old, the bacteria die at a constant rate. This means that the same percentage of all bacteria alive at any given time will die in the next unit of time."

The hypothesis is advanced that exposure to quaternary ammonium compounds, which are extremely powerful

TABLE 1

Death Rate of Pseudomonas aeruginosa in Water Plus 1:40,000 Hyamine and in Milk Plus 1:1,500 Hyamine

Bottle	Dilution of Hyamine [a]	Subcultures after 1 min.	2 min.	5 min.	10 min.	20 min.	30 min.
Milk and Water	1:1,500 [b]	60,000,000	45,200,000	39,000,000	36,000,000	34,000,000	32,400,000
Water	1:40,000	27,000,000	14,000,000	8,200,000	6,380,000	4,460,000	3,280,000
		60 min	120 min.	180 min.	240 min.	24 hrs.	
Milk and Water	1:1,500 [b]	25,000,000	16,100,000	10,200,000	6,600,000	2,100,000	
Water	1:40,000	2,550,000	1,540,000	1,200,000	793,000	26,200	

The proportions of culture to bactericide recommended by the Food and Drug Administration for the testing of disinfectants [2] was followed. 10 ml. of a 24 hour culture of *Pseudomonas aeuroginosa* in F.D.A. broth, which gave a plate count of 1,150,000,000 per ml., was added to 100 ml. of the Hyamine-milk solution. The number of organisms initially exposed to the disinfectant was approximately 104,500,000 per ml.

[a] Hyamine 1622, paradiisobutyl phenoxyethoxy ethyl dimethyl benzyl ammonium chloride monohydrate, is fairly representative of the more actively bactericidal quaternary ammonium compounds.

[b] The Hyamine-milk solution was prepared by adding 50 ml. of "Carnation" Evaporated milk to 50 ml. of a 1:750 dilution of Hyamine.

One ml. portions were withdrawn after the various time intervals and the first dilution was made into a 0.05 per cent solution of the anionic detergent "Vel." Further dilutions were made in water and plating was done in tryptone glucose extract agar. Incubation was at 37° C. for 24 hours.

TABLE 2

Velocity of Disinfection by Hyamine 1:40,000 in Water and 1:1,500 in Milk

Dilution of Pure Hyamine 1622	Value of K *										
	0–1 min.	1–2 min.	2–5 min.	5–10 min.	10–20 min.	20–30 min.	30–60 min.	60–120 min.	120–180 min.	180–240 min.	240–1440 min.
1:1,500 in Milk and Water	0.2409	0.1231	0.0213	0.0070	0.0025	0.0021	0.0037	0.0032	0.0033	0.0031	0.0004
1:40,000 in Water	0.5877	0.2853	0.0774	0.0218	0.0155	0.0133	0.0036	0.0036	0.0018	0.0030	0.0012

Proportions given in Table 1.

$$\text{* Disinfection rate, } K = \frac{1}{\text{time}} \cdot \text{Log}\frac{\text{Initial Number of Bacteria}}{\text{Number of Survivors}}$$

surface active agents, is followed by almost immediate coating of the bacterial cells. These coated cells are not necessarily killed but they do have their surface characteristics altered so that they tend to clump together and to adhere to surfaces. The very rapid decrease in plate counts, which occurs during the first minutes after the exposure of a bacterial population to a quaternary ammonium compound, therefore reflects the sum of killing and agglomeration of organisms into clumps, from each of which many viable organisms produce only one colony. The very slow decrease in plate counts, which occurs after prolonged exposure, is due to the ability of a clump to give rise to a colony as long as a single cell remains viable. The true rate of kill by quaternary ammonium compounds therefore may be reasonably uniform. However, it cannot be ascertained from the value of " K " for any given period, the value being fallaciously high for the first few minutes and low after an hour or more of exposure.

Because a reasonable degree of uniformity in the rate of bactericidal action has been generally accepted, many bacteriologists have based their studies on end points of 99.9 or 99.99 per cent reductions in plate counts and have assumed that their data could be extrapolated to predict the extinction of the bacterial population. When the quaternary ammonium compounds are being evaluated, this practice may lead to conclusions which are dangerously misleading.

Almost parallel difficulties are encountered in using the standard technic[6] for determining the sanitary condition of utensils sanitized with a quaternary ammonium compound. Since the treated organisms tend to adhere to any surface,[7] they resist removal by swabbing. Furthermore, those organisms which are removed may adhere to the cotton or to the side of the container and thus escape plating. The following experiment illustrates these points.

The rims of 12 sterile glasses were dipped in a broth culture of *Escherichia coli,* removed, and allowed to dry. Three glasses were then immersed for five minutes in a 1:250 dilution of Q.A.C., which is a 10 per cent solution of a quaternary ammonium compound. Three more glasses were immersed in a 1:500 dilution, three in a 1:750 dilution, and three in a 1:1,000 dilution. All glasses were allowed to dry, then two of the glasses dipped in each dilution were swabbed and plate counts made. All plates were sterile, which would indicate a complete kill. Next, all three glasses of each series were placed rim down in sterile evaporated milk to neutralize the remaining bactericide and then placed rim down on very firm (one and one-half strength) Difco phenol red agar base to which 1 per cent of lactose had been added. The glasses were spun over the surface of the agar with sufficient force to cut into the agar. After incubation, the glasses immersed in the 1:250 dilution gave sterile plates; one of the glasses immersed in the 1:500 dilution gave a sterile plate and the other two developed a few colonies; all three glasses immersed in the 1:750 dilution gave a moderate number of colonies while all three glasses immersed in the 1:1,000 dilution gave innumerable colonies on the Petri plates. To give a much more severe test, the rims of glasses were dipped in equal parts of evaporated milk and broth culture of *E. coli* and the experiment repeated. Under these conditions, a 1:25 dilution failed to kill. This last test was severe, perhaps unduly so, but is included so that the absolute necessity of adequate preliminary cleaning can be emphasized.

Tap water may contain impurities which markedly influence the efficiencies of the quaternary ammonium compounds. The data [8] obtained in the U. S. Public Health Service laboratories in Cincinnati might be duplicated in any state or even in a single city which obtains water from several sources.

kill bacteria. Even a microscopic film of grease or oil over a heavily contaminated surface is sufficient to afford protection to microörganisms. Grease films are almost ubiquitous on all restaurant and milk handling equipment. Bactericidal treatment should not be attempted until after the removal of the grease film.

The virucidal efficiency of sanitization is no less important, from the standpoint of public health, than its bactericidal efficiency.

Stock and Francis [9] found that Zephiran inactivated the strain of influenza virus which they tested and Klein, Kalter, and Mudd,[10] using dilutions of Phemerol 1:500, cetyl pyridium chloride 1:1,000 and Zephiran 1:1,000, obtained inactivation of the influenza A virus, vaccina virus and the bacteriophages of *Salmonella paradysenteriae* and *S. aureus* in one minute, but failed to reduce the activity of the Gamma bacteriophage of *E. coli*. These dilutions are based upon the content of pure quaternary ammonium compounds and are more concentrated than the solution actually employed in the sanitization of eating utensils. Kalter, Mordaunt, and Chapman [11] successfully employed Emulsol-607, Zephiran, and cetyl pyridium chloride, in dilutions of 1:5,000 for

Compound Designated	*Parts per million required to produce a 100% kill of Esch. coli in one minute when the compound is dissolved in*			*Parts per million recommended for use by producer*
	Pure water	*Cincinnati tap*	*Norwood tap*	
A	20	100	250	234
B	10	70	250	190
C	5	500	3,200 plus	78

In order for the health officer to be certain that quaternary ammonium compounds could be effectively used, each compound would have to be evaluated in each type of water used, with the tests repeated whenever the source of water was changed.

Another very important point is the inability of quaternary ammonium compounds to penetrate grease films and

the isolation of bacteriophages from sewage.

Because various filtrable viruses may differ as much as bacteria in their susceptibility to quaternary ammonium compounds, it would appear unwise to rely upon their virucidal powers until they have been shown to be actively virucidal against all filtrable viruses of public health significance.

FIELD TESTS

Many companies have developed or are developing field test kits. None that the writers have been able to obtain is capable of differentiating between quaternary ammonium compounds of high and of low bactericidal powers, or between free and active quaternary ammonium compounds in solution and those which have been partially or totally inactivated by combination with certain materials which might be in water or on dishes. Moreover, no test kit has been calibrated to give a simple reading with all types of quaternary ammonium compounds now offered for sanitization.

The Stone-Marshall test papers are very convenient to use, and under most conditions appear to be reasonably accurate. However, certain materials such as milk, which may well contaminate bactericidal solutions, give color changes which may be interpreted as indicating the presence of a quaternary ammonium compound.

STABILITY

The cationic bactericides, stored in glass, remain stable. This is a very great advantage over the active hypochlorite solutions which deteriorate very rapidly when exposed to direct sunlight or high temperatures.

UNIFORMITY OF COMPOSITION

Always, the federal and the state food and drug control authorities will have to be alert for the detection of adulterations and substitutions. However, there is no reason why the manufacturers should not be able to maintain the standards of their products.

ABUSES

Under exceptional conditions, the cationic bactericides might serve as food preservatives although they are absorbed on particulate materials, are less effective in the presence of acids, and tend to impart a bitter flavor. Control of abuses should not prove difficult, since significant amounts can be detected by titration with duponal C.P. in the presence of brom phenol blue.

The preservative action of these compounds in milk, either from the small amounts remaining in equipment sanitized by one of these compounds or by material added by unscrupulous dairymen, is of interest. One part of pure Hyamine 1622 was added to 6,000 parts of fresh, raw milk. This is the equivalent of a 1:600 dilution of the 10 per cent solution usually offered. Then, the milk was divided into three portions which were held at 8° C. (46° F.), 30° C. (86° F.) and 37° C. (99° F.) respectively, and plate counts, both in tryptone glucose extract agar and in violet red bile agar were made daily. The results (Table 3) show that this concentration of Hyamine did not prevent the growth of bacteria.

Varying amounts of pure Hyamine 1622, to give final dilutions of from

TABLE 3

Growth of Organisms in Raw Milk After the Addition of 1:6,000 Hyamine 1622

Bottle	Storage Temperature	24 Hours After Hyamine Addition		48 Hours After Hyamine Addition		72 Hours After Hyamine Addition	
		T.G.E. [a]	V.R.B. [b]	T.G.E.	V.R.B.	T.G.E.	V.R.B.
1	Refrigerator 8° C.	3,000	1,000	650,000	700,000	1,230,000	1,900,000
2	Room 30° C.	43,200,000	36,000,000	curdled	curdled	———	———
3	Incubator 37°C.	41,000,000	45,000,000	310,000,000	620,000,000	curdled	———

[a] T.G.E. Tryptone Glucose Extract Agar (Difco)
[b] V.R.B. Violet Red Bile Agar (Difco)

TABLE 4

Plate Counts on the Raw Milk Held at 30° C. After Addition of Hyamine

		Plate Counts		
Bottle	*Dilution of Hyamine*	*24 hrs. after*	*48 hrs. after*	*72 hrs. after*
1	1:1,000	10,000	10,000	132,000,000
2	1:1,500	1,800,000	396,000,000	Milk curdled
3	1:2,250	2,440,000	474,000,000	Milk curdled
4	1:3,400	6,800,000	868,000,000	Milk curdled
5	1:5,050	30,560,000	Milk curdled	———
6	1:7,600	200,000,000	Milk curdled	———
7	1:11,420	219,000,000	Milk curdled	———
8	1:17,000	320,000,000	Milk curdled	———
9	none	256,800,000	Milk curdled	———

Growth of an organism producing a greenish pigment was noted on most of the plates, particularly on plates from bottles 3 and 7. It was later identified as *Pseudomonas aeurginosa.*

Proteolytic decomposition took place rapidly in the first 8 bottles, while bottle No. 9 soured normally.

1:1,000 to 1:17,000 were added to 100 ml. portions of fresh, raw milk and the mixtures incubated at 30° C. Plate counts in tryptose glucose extract agar were made after one, two, and three days. During the first 24 hours of incubation, one part of Hyamine in 5,050 parts of milk significantly retarded the rate of growth of organisms, as compared to the control which contained no Hyamine, while one part of Hyamine to 7,600 parts of milk had no appreciable bacteriostatic effect (Table 4). Even 1:1,000 pure Hyamine only delayed the bacterial decomposition of the milk. Mull and Fouts [12] found Roccal to be somewhat more powerful.

Since the quaternary ammonium bactericides are usually marketed as 10 per cent solutions and usually no more than one ounce of the solution is added to from 2½ to 5 gallons of water, the final dilution of the pure product is 1:3,200 to 1:6,400. Obviously, the amounts of quaternary ammonium compounds left on equipment and in pails, following a rinse with one of these compounds, would exert no preservative action in the milk.

SPECIFICITIES

The quaternary ammonium compounds are most effective against streptococci, staphylococci, and other nonsporulating Gram-positive organisms. They are less effective against Gram-negative organisms, such as members of the coliform, paratyphoid, and typhoid groups (Table 5). The writers have found *Pseudomonas aeruginosa* to be extremely resistant, although Johns [13]

TABLE 5

Selective Bactericidal Action of a Quaternary Ammonium Compound
Concentrations of Hyamine, in 50 Per cent Evaporated Milk, Which Reduced Bacterial Plate Counts by 99.97–99.99 Per cent in One Hour

Dilution of Pure Hyamine 1622	*Organism*	*Plate Count* — *Initial number of Organisms exposed*	*Plate Count* — *Survivors After One Hour*	*K **
1:1,000	*Staph. aureus*	65,450.000	14,900	0.0607
1:200	*Esch. coli*	87,000.000	26.000	0.0587
1:100	*Ps. aeruginosa*	90,000,000	11,000	0.0652

Following the Food and Drug Administration technic, the test organisms were incubated 24 hours in F.D.A. broth and one ml. of the culture was added to 10 ml. of the bactericide. The temperature was held at 20° C. throughout the test.

found this organism to be as susceptible as *E. coli*. Raw milk obtained at the College Dairy and also raw milk delivered by commercial dairies in Pullman gave almost pure cultures of *P. aeruginosa* after the addition of 1:2,000 Hyamine and incubation for one week at room temperature. It is possible that imperfect sanitization of equipment with a quaternary ammonium compound might favor the establishment of this organism as a contaminant. *P. aeruginosa* does not ferment lactose, and is proteolytic. The seriousness of this organism was again emphasized in 1945, when milk-borne *P. aeruginosa* was responsible for an epidemic of diarrhea and 9 deaths of new-born infants in Great Bend, Kans.[14]

RESISTANT STRAINS

Acquired increases in resistance, following exposures insufficient to kill all of a bacterial population, is a common phenomenon. The rate of action of the quaternary ammonium compounds (Tables 1 and 2) should favor the development of resistant strains, yet the writers have failed in their attempts to demonstrate the development of such strains.

EFFECT OF ORGANIC MATTER AND DETERGENTS

The cationic bactericides are inactivated by excessive amounts of organic matter, especially when it is acid in reaction or contains cholesterol or other materials which may act as anionic detergents. The amounts of various extraneous materials which neutralized a five fold increase in concentration of Hyamine 1622 are:

Material	*Mg. per ml. or parts per 1,000*
Brain	3
Egg Yolk	12
Evaporated milk	32
Gelatin	50

Soaps and other anionic detergents also neutralize the quaternary ammonium compounds. The available data indicate that under conditions of actual use, a rinse is necessary between the dishwashing operation and the use of a quaternary ammonium compound. These products are no more successful in a two-compartment sink than are the hypochlorites.

COEFFICIENT OF DILUTION

The coefficient of dilution is exponential, and halving the concentration which kills in one minute usually increases the killing time to far longer than two minutes. For a bactericide to be reliable where water may be introduced into the bactericidal solution, a low coefficient of dilution is essential. The quaternary ammonium compounds have low coefficients of dilution, although not as low as chlorine.

EFFECT OF TEMPERATURE

The temperature coefficient of the quaternary ammonium compounds is moderately low, although considerably higher than the temperature coefficient of chlorine. Since the quaternary ammonium compounds are stable in hot water, they may well be used in hot solutions. Very cold solutions of quaternary ammonium compounds are relatively slow and ineffective bactericides.

DETERGENCY

Many of the quaternary ammonium compounds are fairly effective detergents. It has been suggested that these compounds could serve simultaneously as detergents and bactericides. Possibly such a product may be developed and marketed at a price which would encourage its use. The quaternary ammonium compounds which the writers have tested have not been sufficiently active and low in price to justify their consideration as detergents. Also, there appears to be a tendency for the more actively bactericidal of these compounds to be poor detergents and the better detergents to be feeble bactericides.

The admixture of quaternary ammonium compounds with recognized detergents has been tried. The results have been disappointing. If quaternary ammonium compounds are mixed with soaps or the sulfonated oils, esters, or alcohols, these anionic detergents immediately and absolutely neutralize the quaternary ammonium compounds. Also, many of the cationic bactericides are precipitated at the degree and type of alkalinity which would be used. The pH at which a cationic bactericide precipitates depends upon the individual compound, its concentration, and the type of alkali used. Apparently, these compounds remain soluble in the presence of considerable concentrations of the phosphates and are precipitated by small amounts of the metasilicates or orthosilicates. Moreover, the first dishwater is subject to a high degree of contamination with particulate debris, so that the cationic bactericide would soon be removed from the solution.

DEPOSITS ON GLASSWARE

The quaternary ammonium compounds leave a thin film on glassware. Usually, this film is clear, and the glass is clean and sparkling in appearance. From a sanitary standpoint, the glass may have some ability to resist contamination as long as the film remains intact. In beer glasses, this film is said to reduce the "head." When used in too great a concentration, or in exceptional waters, especially if the degree of alkalinity is high, some quaternary ammonium compounds leave an unsightly film on glasses.

ODORS AND FLAVORS

Quaternary ammonium compounds have but slight odor. Although they are intensely bitter, the small amounts which adhere to eating and drinking utensils are not sufficient to impart an objectionable flavor. Neither are they known to combine with foods or beverages to produce objectionable flavors. Here, they possess a distinct advantage over the chlorine compounds which have the unfortunate property of being activated by relatively weak acids. Beer, wines, and soft drinks are acid in reaction. The acid beverage wets the small amount of residual chlorine which remains on the rim of the glass just as the glass is placed to the lips. The released chlorine reaches both the taste buds and the nostrils, assuring maximum effect. In the case of beer, which contains hops and other aromatics, something analogous to the formation of a chlorophenol may be formed by the activated chlorine.

CORROSIVENESS

The quaternary ammonium compounds are not corrosive to equipment and they do not tarnish silver. These are distinct advantages over the use of the chlorine compounds.

CLAIMS MADE BY MANUFACTURERS

Data published by the manufacturers of quaternary ammonium compounds have, for the most part, been found to be accurate when the experiments were repeated by the writers. It appears that the three important methods of evaluating bactericides; the phenol coefficient method, the plate count technics which use 99 per cent to 99.99 per cent reduction to establish the rate of kill and extrapolate to supposed extinction, and the swab technic as applied to eating utensils; all give data which indicate the quaternary ammonium compounds to be much more efficient than they actually are. It is not to be anticipated that manufacturers of a product would be dissatisfied with methods which yield data favorable to their product.

ORIGIN

The cationic bactericides are synthetics, and the fats and oils used have been most thoroughly processed.

WILL THE APPROVAL OF THE QUATERNARY AMMONIUM COMPOUNDS SIMPLIFY OR COMPLICATE SANITARY CONTROL?

The characteristics of the quaternary ammonium compounds appeal to many users. They do not contribute to off-flavors, corrode equipment, tarnish silverware, leave unsightly films upon glassware, or encourage chapping of the hands of the dishwashers. The sale of these products is profitable, and health officers will be under pressure from both potential users and potential vendors to give approval for their use.

Bacteriologically, the quaternary ammonium compounds do not offer as positive protection to the consuming public as do reliable hypochlorites and they certainly are inferior to hot water or steam. These compounds are somewhat more costly than the hypochorites, and there may be a tendency for users to be influenced by the high phenol coefficient numbers against *S. aureus* and to use less than directed.

The efficiency of each quaternary ammonium compound must be ascertained in each type of water which might be used in a given locality. This is, in itself, a major undertaking in regions served by several water supplies.

Field test kits which measure the germicidally active concentrations of all quaternary ammonium compounds have yet to be developed. Bacteriological tests therefore must replace chemical tests. The technics now in common use fail to reveal the presence of many organisms which remain viable on utensils and glassware sanitized by quaternary ammonium compounds so that special laboratory technics are necessary to demonstrate the presence of viable organisms on such glassware. These special methods more closely approach the conditions of actual use than do the accepted methods of evaluation.

The problem of control is further complicated by the policies of several manufacturers to supply concentrates to vendors who will dilute, bottle, and sell under diverse private labels. It will be difficult to prevent a vendor from switching from one concentrate to another or from altering the formula for economic reasons. This problem might be solved by approving, by name, only a few brands which are manufactured by the larger and more dependable companies. However, in a democracy, it would be difficult to give approval to the products of large corporations located outside the boundaries of a municipality or state and at the same time to withhold approval of identical or similar products compounded by vendors who live and vote locally.

The problem confronting the health officer who must accept or reject the quaternary ammonium compounds is real and serious. He cannot jeopardize public health by authorizing the use of compounds whose full spectrum of contraindications, incompatibilities with local water supplies and specificities are not known to him, even though refusal to give such authorization will certainly result in criticism and even abuse from those who would profit from the sale of these compounds. The complexities inherent to the problem of evaluating all of the quaternary ammonium compounds under all conditions and against all types of infectious agents pertinent to the protection of public health are much too great to allow the work to be carried out by any state or city health organization. No compound should be accepted, whose efficiency will constitute the only barrier between infection and the public, upon the sole recommendations of the manufacturer or on the data supplied by laboratories controlled or subsidized by the producers. It is strongly urged that the U. S. Public Health Service continue its studies on these products until sufficient data are obtained to allow definite recommendations. Until such recommendations have been made, health officers can well be guided by the memo of June 6, 1947, of the U. S. Public Health Service[8] which points out some of the difficulties of evaluating these compounds and which states,

"In view of the foregoing, no changes in the provisions concerning chemical bactericides of the milk and restaurant sanitation ordinances recommended by the Public Health Service are contemplated until further information is available for consideration by the PHS Milk and Food Sanitation Advisory Board."

This confirms the attitude previously expressed by Dr. Ringle[15] in the following memorandum issued October 18, 1946, by the Washington State Department of Health.

"To: All Local Health Departments
Attention Sanitarians

FROM: Arthur L. Ringle, M.D., State Director of Health.

SUBJECT: Use of Quaternary Ammonium Compounds for Bactericidal Treatment of Utensils in Public Eating and Drinking Establishments.

"In December, 1945, a committee was appointed by the State Director of Health to investigate the Quaternary Ammonium Compounds and to advise the State Department of Health as to the effectiveness of their use as sanitizing agents in public eating and drinking establishments in the State of Washington.

"This committee, under the direction of Dr. E. C. McCulloch, Professor of Bacteriology at Washington State College, has been studying this problem extensively since that time.

"The results of studies now in progress have led the committee to question the efficiency of these Quaternary Ammonium Compounds. Commonly accepted techniques in evaluating the efficiency of bactericides do not necessarily reflect the true efficiency of this type of compound.

"There is evidence that at least part of the apparent reduction of bacterial counts is due to an agglomeration of viable bacteria without killing. Also, there is no evidence that the Quaternary Ammonium Compounds are effective in destroying some of the filtrable viruses of public health significance.

"Until proof has been presented to show conclusively that the Quaternary Ammonium Compounds, when used as sanitizing agents, provide adequate protection to public health, the committee has recommended that their acceptance as bactericides in restaurants and taverns be delayed.

"In view of the above it is further recommended that experiments in the field using the presently accepted techniques be suspended until such time as a satisfactory technique is devised which will eliminate false interpretations resulting from agglomeration of organisms rather than true killing efficiency.

"Based upon the recommendations of this committee, the use of Quaternary Ammonium Compounds as sanitizing agents in public eating and drinking establishments will not be approved until such time as more positive proof of their efficiency is demonstrated to the satisfaction of the committee."

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