Key Characteristics Of The Principal Hard Surface Disinfectants

Since Lister showed in 1867 that phenol (carbolic acid) would kill microorganisms, many chemicals have been tested for this purpose, and a few have proved to be effective.

These chemicals can be classified relative to our principal area of interest, that is, hard surface disinfection. The following are undoubtedly the most important.

1. Quaternary ammonium compounds
2. Phenolic compounds
3. Iodophors
4. Pine oil

The following discussion will examine the relative advantages of each of these chemicals within the context of their use when formulated with a detergent material to form a hard surface detergent/disinfectant. To do this, however, it is necessary first to consider what we mean by a good disinfectant.

The first criterion obviously is that it kills microorganisms of all kinds, particularly the pathogens, although destruction of others which are considered harmless to humans and animals is sometimes also important.

Many non-pathogens attack organic matter, producing chemicals which may be highly odorous, corrosive or staining. Elimination of such organisms is certainly a plus factor to be desired from any product. Germicidal products which kill a wide range of microorganisms are said to be broad spectrum.

It must be emphasized that hard surface disinfection can best be achieved when it is accomplished as part of a one step operation involving a detergent. If a germicidal agent is applied to a dirty surface, it will kill those organisms which it contracts, but most of them will probably be surrounded by soil and be unaffected by the chemical. Thus it is important that the disinfectant chemical be compatible with the detergent system with which it is to be combined. of course, one could always do the job in two steps - first clean the area, then treat it with a disinfectant. This procedure will be highly effective in terms of reducing or eliminating the bacterial load on the surface but it has two major drawbacks. Labor cost is approximately 95% of the cost of maintenance, and by requiring that an area be treated twice - first for detergency, then for disinfection - labor cost is doubled. This is an extremely important consideration, and it explains the almost complete disappearance of single service disinfectant products. Most products today

combine detergency with
disinfectants so that the job can be done in one operation.

Actually, the matter of labor cost is rather minor when compared to the other drawback. A two step operation of cleaning followed by disinfection greatly increases the possibility and dangers of cross contamination. Consider what happens during the cleaning operation. The custodian applies a detergent solution on the area to be cleaned, then picks it up with a mop or wet vacuum, and finally disposes of the solution containing the picked up soil. The overall effect of this activity has been to concentrate into the dirty water all the microorganisms that have been picked up in the cleaning process. Unless handled with great care, this contaminated solution can contribute to the spread of contamination. Not only is the combination product more cost effective but it will provide far better overall result.

Most detergent/disinfectant products are produced as liquid concentrates which must be diluted with water before use. In handling these products, either as the concentrates or the use dilutions, it is difficult to avoid having them come into contact with the skin. In an extreme case, an accident may occur in which some of the product may be splashed into the face, perhaps into the eyes. An important requirement, therefore, for this type of product is safety -freedom from irritation if product gets on the skin or in the eyes and freedom from toxicity if it is ingested.

In the evolution of environmental sanitation, (hard surface cleaning) the removal of unwanted physical soil was followed by sanitizing or disinfection for the destruction and removal of microorganisms. Eventually, these two functions were combined so that only one product was needed. However, it was later recognized that there is a third important dimension to environmental sanitation - odor control. Unpleasant odors are an unfortunate fact in most hospitals, nursing homes, mental institutions, schools and many other facilities. counteracting these odors required incorporating an odor control system into the detergent/disinfectant product.

To this end, it is advantageous to begin with a detergent/disinfectant that has little or no odor. Chemicals like phenol are highly odorous and they are almost impossible to effectively mask or neutralize. Consequently, detergent/disinfectant products which incorporate phenol derivatives have that tell tale "Hospital odor". Quaternaries, on the other hand, have a very low almost nondescript odor and can thus be readily combined with odor control ingredients.

An important factor in detergency is pH which is a measure of acidity or alkalinity. A product with a pH of 7 is neither acid nor alkaline. It is neutral. Below 7, the product is acid; above 7, it is alkaline. As the pH of a detergent solution rises, i.e., becomes more alkaline, the cleaning efficiency of the product increases. There are limits to this, of course, since too high a pH will frequently result in deleterious effects on the surface being cleaned.

In general, a pH no higher than 10.5 is acceptable. This does not mean that a product is safe at 10.5 and harmful at 10.6. There is a range in which harmful activity will begin, and the breadth of this range is dependent on the other ingredients in the formulation. As a general rule, the use of a pH of 10 gives us a cut-off point with a built-in measure of safety. Another highly important factor is the use of inorganic builders and chelating agents to improve detergency. These agents operate best in an acid medium. Thus, it is apparent that disinfectant chemicals intended for use in a combination product should have good activity at an alkaline pH up to 10.

One final factor requires consideration. The activity of all disinfectant chemicals is affected adversely by organic matter. The degree to which this occurs varies with the particular chemical and probably with the type of organic soil present. Thus. it is advantageous to choose. as the germicidal component of the product. one which is least affected by organic matter.

Having examined the major characteristics to be evaluated in electing the proper germicidal chemical for a
detergent/disinfectant product, we can now evaluate the most important available biocidal chemicals. A recap of these characteristics gives us the following:

1. Broad spectrum activity
2. Compatibility with effective detergents
3. Low oral toxicity and skin irritation
4. Freedom from odor
5. High activity at same pH as the detergent component
6. Retention of activity in presence of organic matter

QUATERNARY AMMONIUM COMPOUNDS

1. Spectrum of Activity

Hundreds of different quaternaries have been prepared and tested. Some are good clothes softeners. Others are effective antistatic agents for certain application. A relatively small number have been found to be highly effective germicidal agents. Of this last group, an even smaller number are bactericidal and fungicidal against an extremely wide range of microorganisms. This activity covers both the gram positive and gram negative bacteria, fungi and viruses. We can say, then, that selection of the proper quaternary will give a product with a wide spectrum of activity.

2. Detergent Compatibility

The most effective of the products available for use as hard surface detergents are the synthetic nonionics. Properly formulated, the quats are compatible with these materials.

3. Low Oral Toxicity and Skin Irritation

All disinfectant chemicals have some degree of toxicity and irritation in concentrated solution. Many of them carry these properties over into the low concentrations required for effective disinfection. This is not true of the quats. Use concentrations of 400-500 ppm of quaternary are normally used for disinfection. At these concentrations, the product is not irritating and has an extremely low order of oral toxicity.

4. Freedom From Odor
Quaternary ammonium chlorides are odorless.

5. High Activity at Alkaline pH
The germicidal activity of quats increases as the pH increases. This means that optimum germicidal and detergent activity can be obtained from a quaternary/nonionic combination, since both show increasing activity with increasing pH.

6. Retention of Activity of Organic Matter
All disinfectant chemicals are adversely affected to some extent by organic matter. The effect may be large or small. Quats are among the least affected in the presence of organic matter.

PHENOLIC COMPOUNDS

1. Broad Spectrum Activity
Individual phenolics are limited in range with regard to the number of different types of micro-organisms. they will kill. However, the number of available phenolics is large and an effective formulation can be produced by combining several different phenolics.

2. Detergent Compatibility
Phenolics are not compatible with the noionics, the most effective of the hard surface detergents. They are compatible with soaps and/or synthetic anionic detergents. The resulting formulation is, of course, a relatively ineffective detergent product, and as a result, less effective germicide.

3. Oral Toxicity and Skin irritation
Most phenolics have a relatively high toxicity rating and are usually skin irritants, especially so in the concentrations in which they are present in the typical formulation.

4. Freedom From Odor
All of the phenolics have a noticeable odor and most of them a disagreeable one.

5. High Activity at Alkaline DH
Phenolics are most effective against microorganisms at a pH 8 or below. This is usually too low for good detergent action. As the pH increases above 8, germicidal activity decreases.

6. Retention of Activity in Presence of Organic Matter
The activity of some Phenolic compounds decreases quite rapidly in the presence of organic matter. The degree will vary with the type of Phenolic, but as a general rule, the phenolics most effective against microorganisms are moderately affected by organic matter.

IODOPHORS

The type of iodophor always found in the area of detergent/disinfectants is one based on a combination of iodine and nonionic synthetic detergent in an acid medium. The acid is usually phosphoric and the product normally has a pH of 3-4.

1. Broad Spectrum Activity
Iodophors are excellent in this respect.

2. Detergent Compatibility
As a stated before, the type of iodophor normally encountered is a combination of iodine and nonionic. Unfortunately, since germicidal activity of iodine is highest at an acid pH, the detergent activity of the nonionic is very sharply reduced.

3. Oral Toxicity and Skin Irritation
Iodophors exhibit relatively low toxicity and skin irritation.

4. Freedom From Odor
Iodophors have a very low odor level and in this respect are not objectionable. However, they cannot be formulated with odor counteractants or other materials which would normally leave an air freshened effect, since the iodine attacks the odor counteractant chemicals, usually creating an unpleasant odor in the process.

5. High Activity at Alkaline pH
As stated before, these products require an acid pH for germicidal activity. This, of course, drastically reduces the efficacy of the detergent. It also eliminates the possibility of using inorganic builders sequestrants and chelating agents to enhance detergent activity.

6. Retention of Activity in Presence of organic Matter
The presence of organic matter sharply reduces the efficacy of iodophors against microorganisms.

PINE OIL

This product is obtained by several methods from pine wood. It is a mixture of several different chemicals which vary in
their activity against microorganisms. The National Formulary specifies that 95% of the product must distill between 200 and 225 C. This specification tends to fix the types and amounts of chemicals present in the product. A typical pine oil preparation contains 60% pine oil solubilized with soap. Because of certain limitations, to be discussed, these products are frequently fortified by the addition of phenolics. However, it has been found that the phenolics are slowly inactivated over an extended period of time, so that the presence of Phenolic in a pine oil product does not necessarily mean it will be active. The unfortified pine oil formulation must be used in fairly concentrated form, so they are

uneconomical for hard surface cleaning and disinfection where large surfaces are involved.

1. Broad Spectrum Activity
Pine oil is quite active against the gram negative organisms, but totally ineffective against many of the gram positive organisms, such as Staphylococcus Aureus. The addition of a Phenolic is necessary to give activity against the gram positives, but, as pointed out previously, there is a slow inactivation of the Phenolic compound.

2. Detergent Compatibility
Pine oils are compatible with soaps and some anionics. Neither type of detergent is really effective for hard surface cleaning and both, particularly the soaps, will leave a metallic plate if hard water is used.

3. Oral Toxicity and Skin Irritation
Pine oil itself has low order of toxicity and skin irritation. Combined with phenolics, both toxicity and skin irritation are definitely increased.

4. Freedom From Odor
Pine oil itself has a very high odor level which is objectionable to many people. As an odorant, it is frequently used to mask such malodors as those commonly encountered in poorly maintained rest rooms.

5. High Activity at Alkaline pH
Activity of these products is good at fairly high pH. When a Phenolic is present, its activity is, of course, decreased under such conditions.

6. Retention of Activity In Presence of Organic Matter
organic matter causes a moderate reduction in the activity of pine oil. As stated previously, a fortified product (containing Phenolic) is adversely affected since organic matter reduces Phenolic activity.