DISINFECTANTS AND DISINFECTION

Disinfectants

The information presented in this section will provide a general guideline for selecting a particular disinfectant for use with a given agent.

The best way of ascertaining the suitability of a disinfectant against a particular agent is to challenge that agent with the disinfectant at the manufacturer's recommended concentration. A brief description of the mode of action of each class of chemical disinfectant is given below.

Although physical methods are often superior to chemical disinfection / sterilization, it is not practical to autoclave or subject many items to high heat, especially if the items can be damaged through repeated exposure to heat. Treatment of inert surfaces and heat labile materials can be accomplished through the use of disinfectants, provided that the following factors are considered:

- type and level of microbial contamination
- concentration of active ingredient
- duration of contact between disinfectant and item to be disinfected
- pH
- temperature
- humidity
- presence of organic matter or soil load

The interplay of these factors will determine the degree of success in accomplishing either disinfection or sterilization. In all situations, review the manufacturer's recommendations for correct formulation and use. Do not attempt to use a chemical disinfectant for a purpose it was not designed for.

Most Environmental Protection Agency (EPA)-registered disinfectants have a 10-minute label claim. However, multiple investigators have demonstrated the effectiveness of these disinfectants against vegetative bacteria (e.g., Listeria, Escherichia coli, Salmonella, vancomycin-resistant Enterococci, methicillin-resistant Staphylococcus aureus), yeasts (e.g., Candida), mycobacteria (e.g., Mycobacterium tuberculosis), and viruses (e.g. poliovirus) at exposure times of 30–60 seconds. Federal law requires all applicable label instructions on EPA-registered products to be followed (e.g., use-dilution, shelf life, storage, material compatibility, safe use, and disposal).

Chemical Disinfectant Groups

a. Aldehydes: (Formaldehyde, Paraformaldehyde, Glutaraldehyde)

Formaldehyde – and its polymerized solid paraformaldehyde have broad-spectrum biocidal activity and are both effective for surface and space decontamination. As a liquid (5% concentration), formaldehyde is an effective liquid decontaminant. Its biocidal action is through alkylation of carboxyl, hydroxyl and sulfhydryl groups on proteins and the ring nitrogen atoms of purine bases. Formaldehyde's drawbacks are reduction in efficacy at refrigeration temperature, its pungent, irritating odor, and several safety concerns. Formaldehyde is presently considered to be a carcinogen or a cancer-suspect agent according to several regulatory agencies. The OSHA 8-hour time-weighted exposure limit is 0.75 ppm.
Paraformaldehyde – is a solid polymer of formaldehyde. Paraformaldehyde generates formaldehyde gas when it is depolymerized by heating to 232 to 246°C (450 to 475°F); the depolymerized material reacts with the moisture in the air to form formaldehyde gas. This process is used for the decontamination of large spaced and laminar-flow biological safety cabinets when maintenance work or filter changes require access to the sealed portion of the cabinet. A neutralization step, heating ammonium carbonate, is required prior to ventilation of the space. Formaldehyde gas can react violently or explosively (7.0 – 73% v/v in air), when exposed to incompatibles, therefore, only individuals that have specific training and have been approved by the Dept. of Environmental Health & Safety are permitted to use this gas.
Glutaraldehyde – is a colorless liquid and has the sharp, pungent odor typical of all aldehydes, with an odor threshold of 0.04 parts per million (ppm). It is capable of sterilizing equipment, though to effect sterilization often requires many hours of exposure. Two percent solutions of glutaraldehyde exhibit very good activity against vegetative bacteria, spores and viruses. It is ten times more effective than formaldehyde and less toxic. However, it must be

limited and controlled because of its toxic properties and hazards. It is important to avoid skin contact with glutaraldehyde as it has been documented to cause skin sensitization. Glutaraldehyde is also an inhalation hazard. The NIOSH ceiling threshold limit value is 0.2 ppm.

Cidex, a commercially prepared glutaraldehyde disinfectant is used routinely for cold surface sterilization of clinical instruments. Glutaraldehyde disinfectants should always be used in accordance with the manufacturer's directions.

b. Halogen-Based Biocides: (Chlorine Compounds and Iodophores)

1. Chlorine Compounds

Chlorine compounds are good disinfectants on clean surfaces, but are quickly inactivated by organic matter and thus reducing the biocidal activity. They have a broad spectrum of antimicrobial activity and are inexpensive and fast acting. Hypochlorites, the most widely used of the chlorine disinfectants, are available in liquid (e.g., Sodium hypochlorite), household bleach and solid (e.g., calcium hypochlorite, sodium dichloroisocyanurate) forms. Household bleach has an available chlorine content of 5.25%, or 52,500 ppm. Because of its oxidizing power, it loses potency quickly and **should be made fresh** and used within the same day it is prepared. The free available chlorine levels of hypochlorite solutions in both opened and closed polyethylene containers are reduced to 40% to 50% of the original concentration over a period of one month at room temperature.

There are two potential occupational exposure hazards when using hypochlorite solutions. The first is the production of the carcinogen bis-chloromethyl ether when hypochlorite solutions come in contact with formaldehyde. The second is the rapid production of chlorine gas when hypochlorite solutions are mixed with an acid. Care must also be exercised in using chlorine – based disinfectants which can corrode or damage metal, rubber, and other susceptible surfaces. Bleached articles should never be autoclaved without reducing the bleach with sodium thiosulfate or sodium bisulfate.

Chloramine T which is prepared from sodium hypochlorite and p-toluenesulfonamide is a more stable, odorless, less corrosive form of chlorine but has decreased biocidal activity in comparison to bleach.

2. Iodophors

Iodophors are used both as antiseptics and disinfectants. An iodophor is a combination of iodine and a solubilizing agent or carrier; the resulting complex provides a sustained-release reservoir of iodine and releases small amounts of free iodine in aqueous solution. Antiseptic iodophors are not suitable for use as hard-surface disinfectants because they contain significantly less free iodine than do those formulated as disinfectants.

Wescodyne, *Betadyne*, Povidone-Iodine and other iodophors are commercially available Iodine-based disinfectants, which give good control when the manufacturer's instructions for formulation and application are followed. **Both bleach and iodophors should be made up in cold water in order to prevent breakdown of the disinfectant.**

c. Quaternary Ammonium Compounds: (Zephirin, CDQ, A-3)

Quaternary ammonium compounds are generally odorless, colorless, nonirritating, and deodorizing. They also have some detergent action, and they are good disinfectants. However, some quaternary ammonium compounds activity is reduced in the presence of some soaps or soap residues, detergents, acids and heavy organic matter loads. They are generally ineffective against viruses, spores and *Mycobacterium tuberculosis*. Basically these compounds are not suitable for any type of terminal disinfection.
The mode of action of these compounds is through inactivation of energy producing enzymes, denaturation of essential cell proteins, and disruption of the cell membrane. Many of these compounds are better used in water baths, incubators, and other applications where halide or phenolic residues are not desired.

d. Phenolics: (O-phenophenoate-base Compounds)

Phenolics are phenol (carbolic acid) derivatives. These biocides act through membrane damage and are effective against enveloped viruses, rickettsiae, fungi and vegetative bacteria. They also retain more activity in the presence of organic material than other disinfectants. Cresols, hexachlorophene, alkyl- and chloro derivatives and diphenyls are more active than phenol itself. Available commercial products are Lysol, Pine-Sol, *Amphyl, O-syl, Tergisyl, Vesphene, L- Phase*and *Expose*.

e. Acids/Alkalis:

Strong mineral acids and alkalis have disinfectant properties proportional to the extent of their dissociation in solution. Some hydroxides are more effective than would be predicted from their values. In general acids are better disinfectants than alkalis. Mode of action is attributed to an increase of H^+ and OH^- species in solutions which interfere with certain microbial functions, however the total effect is not only dependent on pH alone. Weak organic acids are more potent than inorganic acids despite low dissociation rates in solution. Action is attributed to the disruption of 2° and 3° conformation of enzymes and structural proteins.

f. Heavy Metals:

Soluble salts of mercury, silver lactate, mercuric chloride and mercurous chloride are efficient bactericidal agents. Silver nitrate and mercuric chloride are commonly used as 1:1000 aqueous solutions. Action is through attack on protein sulfhydryl groups and disruption of enzyme functions. Organic matter can reverse the disinfectant properties of mercurials.

Caution: Please consult with EH&S's Hazardous Materials group prior to using heavy metals because many of these must be disposed of as a hazardous waste. Specifically, disposal of elemental mercury and salts of mercury are very costly.

g. Alcohols:

Alcohols work through the disruption of cellular membranes, solubilization of lipids, and denaturation of proteins by acting directly on S-H functional groups. Ethyl and isopropyl alcohols are the two most widely used alcohols for their biocidal activity. These alcohols are effective against lipid-containing viruses and a broad spectrum of bacterial species, but ineffective against spore-forming bacteria. They evaporate rapidly, which makes extended contact times difficult to achieve unless the items are immersed.

The optimum bactericidal concentration for ethanol and isopropanol is in the range of 60% to 90% by volume. Their cidal activity drops sharply when diluted below 50% concentration. Absolute alcohol is also not very effective. They are used to clean instruments and wipe down interior of Biological Safety Cabinets and bottles, etc. to be put into Biological Safety Cabinets. Alcohols are generally regarded as being non-corrosive.