MARINE ADVISORY PROGRAM
PUBLICATION

SANITIZERS FOR FOOD PROCESSING PLANTS

CUIMR-G-87-002 C3

The most common sanitizers used in food plants belong to four basic groups: chlorine compounds, iodine compounds, quaternary ammonium compounds, and acid-anionic surfactants. The selection of a sanitizer should be based on the type of equipment to be sanitized, the hardness of the water, the sanitizing equipment available, the effectiveness of the sanitizer under site conditions, and cost. Sanitizing compounds which contain phenols impart strong undesirable odors and flavors to foods and should not be used.

Thorough cleaning is essential before sanitizers are applied, since their effectiveness is greatly reduced if food particles or dirt are present on equipment surfaces. Only approved sanitizers may be used in food processing plants. Approved sanitizers are listed in "List of proprietary substances and nonfood compounds authorized for use under USDA inspection and grading programs" (USDA, 1985). If you have questions on the best sanitizer to use, request technical advice from a reputable sanitizing compound manufacturer.

I. SANITIZING COMPOUNDS

Chlorine Compounds

Chlorine-based sanitizers are the most commonly used sanitizers in food plants. Available in solid, liquid, and gas injection forms, they are effective against all bacteria and, in diluted form, are colorless, relatively nontoxic, and nonstaining. They are the easiest sanitizers to prepare and apply, and they are generally the most economical. Generally, no water rinse is required if chlorine solutions do not exceed 200 parts per million (ppm). Chlorine concentrations can be easily measured by a field test. Chlorine solutions prepared from chlorine gas, hypochlorites, and chloramines are not compatable with quaternary ammonium compound sanitizers.

Chlorine Gas Chlorine gas is a highly volatile compressed gas which forms hypochlorous acid ($HOCl$) when injected into water. It may make the pH (acidity/alkalinity) of water slightly lower (more acidic).

Hypochlorites Sodium hypochlorite and calcium hypochlorite are formed by treating alkalis with chlorine gas. In water, they form hypochlorous acid and sodium or calcium salts, which can raise the pH of the water and reduce the killing action of the chlorine. Hypochlorites are unstable; they lose chlorine during storage. Under controlled conditions, the germicidal action of the hypochlorites equals that of chlorine gas.

Chloramines Chloramines are formed by a reaction of chlorine with ammoniacal nitrogen in an aqueous solution. In water, they slowly form hypochlorous acid and organic salts. Chloramines are more stable and less corrosive than hypochlorites, and have a longer lasting germicidal action. They require a long contact time to be effective sanitizing agents.

Chlorine Dioxide Chlorine dioxide (ClO_2) is formed by reacting chlorine gas (Cl_2) or hydrochloric acid (HCl) with sodium chlorite ($NaClO_2$). In water, chlorine dioxide is the active sanitizing compound. It differs from hypochlorous acid in several significant ways.

On the positive side, chlorine dioxide is more effective under alkaline conditions. Hypochlorous acid becomes ineffective above pH 8.5, but chlorine dioxide retains some sanitizing power up to pH 10.0. Chlorine dioxide is uniformly active across a wide pH range, while the germicidal activity of hypochlorous acid varies with the pH of the solution. Chlorine dioxide is a stronger oxidizer than other chlorine sanitizers, and it is less likely to form chlorinated organic compounds; thus it is desirable whenever the organic load of the water is high. In addition, chlorine dioxide removes iron, manganese, odors, flavors, and colors from the water. Concentrations of chlorine dioxide can be easily measured by a field test, and the color of the chlorine dioxide solution as it leaves the on-site generator gives a visual check on chlorine dioxide generation.

On the negative side, chlorine dioxide is more expensive than chlorine gas or hypochlorites. It is highly reactive and cannot be manufactured and shipped in bulk; an on-site generating system is required. Chlorine dioxide decahydrate may be commercially prepared, but must be refrigerated because it decomposes at room temperature and can explode under certain conditions.

Iodine Compounds

Iodophors are a combination of iodine and a solubilizing agent that releases free iodine when diluted with water. Iodophors are fast-acting and effective against all bacteria. In diluted form, they are nonstaining, relatively nontoxic, nonirritating to skin, and stable. Iodophors are widely used in hand sanitizing solutions. They are most effective in acidic conditions, and have minimal activity at pH 7. No water rinse is required if iodophor solutions do not exceed 25 ppm. Iodophor concentrations can be easily measured by a field test, and the color of an iodophor solution gives a visual check on concentration. Iodophor solutions may stain porous and some plastic surfaces.

Quaternary Ammonium Compounds

Quaternary ammonium compounds (QAC), in diluted form, are odorless, colorless, and nontoxic. They are stable at high temperatures, over a wide pH range, and in the presence of organic materials. QAC's are effective against some bacteria, but are slow-acting against the most common seafood spoilage bacteria. Although no water rinse is required if QAC solutions do not exceed 200 ppm, QAC solutions may leave objectionable films which should be rinsed off equipment surfaces with fresh cold water. Quaternary ammonium compounds may be combined with nonionic wetting agents in detergent-sanitizer formulations, but are not compatable with other common detergent compounds or chlorine sanitizers.

Acid-Anionic Surfactants

Acid-anionic surfactants are combinations of acid, usually phosphoric acid, with surface-active agents. They are effective only below pH 2.5. These sanitizers are effective against most bacteria, and are odorless, relatively nontoxic, stable, and noncorrosive to stainless steel. They are effective in removing and controlling milkstone and water hardness films.

II. FACTORS AFFECTING THE KILLING RATE OF CHLORINE GAS/HYPOCHLORITES

Concentration of Chlorine The rate at which bacteria are killed is directly related to the amount of free chlorine (hypochlorous acid) in the water. However, high concentrations are corrosive and may adversely effect the flavor of the food product.

pH of the Chlorinated Water In general, killing rates decrease as the pH becomes higher (more alkaline). Very acidic chlorinated water is corrosive to equipment. Very alkaline chlorinated water is also corrosive and has a reduced killing ability. A pH range of 6.0 to 7.5 is recommended for chlorine sanitizing solutions.

Organic Matter in the Water Organic matter in the water will react with hypochlorous acid, leaving less free chlorine. Since it is the free chlorine that kills bacteria, large amounts of organic matter will reduce the germicidal activity of a chlorine solution.

Temperature of Water The killing rate of chlorinated water increases with temperature, but the increased killing rate is counteracted by increased corrosiveness and vaporization (loss of chlorine). Ambient temperatures are recommended.

III. AVAILABLE CHLORINE CONTENT OF COMMERCIAL SANITIZERS

Commercial Name	Chemical Name	Active Ingredient Chemical Formula	% Available Chlorine
---	Chlorine Gas/Liquid	Cl_2	100
---	Pure Hypochlorous Acid	HOCl	134
---	Pure Sodium Hypochlorite	NaOCl	95
---	Pure Calcium Hypochlorite	$Ca(OCl)_2$	99
Clorox, BK Liquid	Sodium Hypochlorite	NaOCl	5.25
Liquid Bleach	Sodium Hypochlorite	NaOCl	12-15
Percloron, HTH, Pittchlor, Lo-Bax, BK Powder	Calcium Hypochlorite	$Ca(OCl)_2$	50-65
Chlorinated TSP	Chlorinated Trisodium Phosphate	$4(Na_3PO_4 \cdot 11H_2O)+NaOCl$	3.5
Chlorine Dioxide	Pure Chlorine Dioxide	ClO_2	263
Chlorine Dioxide	Chlorine Dioxide Decahydrate	$ClO_2 \cdot 10H_2O$	17
Chloramine	Sodium P-Toluene Sulfon Chloramide	---	23-26

IV. CHARACTERISTICS OF SANITIZERS

Sanitizing compounds are available in a variety of forms and in a range of prices. The following list of characteristics for common sanitizers can be helpful in selecting the best type of sanitizer for your specific need.

Characteristics	Hypochlorites (Liquid)	Iodophors	Quaternary Ammonium Compounds	Acid-Anionic Surfactants	Chlorine Dioxide
Activity against microorganisms	Active against all microorganisms and bacteriophage. Active against spores at high temperatures with long contact time.	Active against all microorganisms except bacterial spores and bacteriophage.	Active against many microorganisms. Slow activity against coliforms and common seafood spoilage bacteria. Not effective against spores and bacteriophage.	Active against many microorganisms and bacteriophage. Not effective against spores.	Active against all microorganisms and bacteriophage. Active against spores at higher concentrations and/ or longer contact times.
Cost	Inexpensive	Expensive	Expensive	Expensive	Expensive
Shelf life	Unstable; short shelf life	Stable; long shelf life	Stable; long shelf life	Stable; long shelf life	On-site generation; precursor stable with long shelf life
Preparing dilutions	Easily dispensed and controlled	Easily dispensed and controlled	Easily dispensed and controlled	Easily dispensed and controlled	Easily dispensed and controlled
Corrosiveness	Corrosive to some metals	Noncorrosive	Noncorrosive	Corrosive to metals, except stainless steel	Corrosive to some metals
Effect on skin	Adverse effect on some people	Nonirritating	Nonirritating	Adverse effect	Adverse effect
Foam formation	Nonfoaming	Nonfoaming	Foam formation with high pressure sprayer	Foam formation with high pressure sprayer	Nonfoaming
Film formation	Does not form film	Does not form film	Leaves residual film	Leaves residual film	Does not form film
Odor	Chlorine odor	Iodine odor	Odorless	Odorless	Chlorine odor
Effectiveness: hard water	Unaffected by hard water salts. Precipitates in iron waters.	Unaffected by hard water salts	Depends on type	Unaffected by hard water salts	Unaffected by hard water salts
Effectiveness: porous surfaces	Poor penetration qualities	Good penetration qualities	Good penetration qualities	Good penetration qualities	Poor penetration qualities
Effectiveness: presence of organic material	Decreased effectiveness	Decreased effectiveness	Effective	Effective	Effective
Effectiveness: acid/alkaline conditions	Ineffective above pH 8.5	Slow acting at or above pH 7.0	Effective over wide pH range	Optimum effect at pH 1.9-2.2. Not effective above pH 3.0	Effective over broad pH range. Realistic maximum pH 10.0. Far more effective than hypochlorites above pH 8.5.
Effectiveness: high temperatures	Dissipates rapidly from solutions above 120°F.	Should not be used above 120°F	Stable at all temperatures	Effectiveness increases with high temperature	Effectiveness increases with high temperature, but dissipates rapidly > 120°F
Normal concentration used	25 to 200 ppm Cl_2	25 ppm I_2	200 ppm	400 ppm	0.25 to 5 ppm

V. REFERENCES

Forwalter, J. 1980. 1980 Selection guide: Cleaning and sanitizing compounds. Food Processing, Putnam Publishing Co., Chicago, IL.

Haverland, H. 1978. Cleaning and sanitizing operations. In "Sanitation notebook for the seafood industry," Ed. Flick, G.J., Kassem, C.L., Huang, F., Ward, D.R., Thompson, M.J. and Fletcher, C., p. II-85. Virginia Polytechnic Institute and State University, Blacksburg, VPI-SG-78-05.

Katsuyama, A.M. (ed.). 1980. Principles of food processing sanitation. The Food Processors Institute, Washington, DC.

Lentsch, S.E. 1978. Sanitizers for an effective cleaning program. In "Sanitation notebook for the seafood industry," Ed. Flick, G.J., Kassem, C.L., Huang, F., Ward, D.R., Thompson, M.J. and Fletcher, C., p. II-77. Virginia Polytechnic Institute and State University, Blacksburg, VPI-SG-78-05.

USDA. 1985. List of proprietary substances and nonfood compounds authorized for use under USDA inspection and grading programs. Miscellaneous Publication No. 1419, U.S. Department of Agriculture, Washington, D.C.

York, G.K. and DeJong P. 1980. Detergents and sanitizers. University of California Cooperative Extension, Davis.

Prepared by: Robert J. Price (A/EA-1)
Seafood Technology Specialist
Food Science & Technology Extension
University of California
Davis, CA 95616
Pub. # UCSGEP86-12

June, 1986