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May 2006

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Learning objectives

1. *Explain the types of low temperature sterilization choices*
2. *Explain what oxidative chemistries are*
3. *Explain how oxidative chemistries are used to process instruments*
4. *Identify the three types of oxidative chemistries commonly used in healthcare*
5. *Describe the differences among oxidative chemistries and dialdehyde and ethylene oxide processes*

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SELF-STUDY Series

Understanding oxidative chemistries

by Ronald R. Rahl, R.N., BSN, MPA

Healthcare professionals are constantly looking for better and easier ways to deliver safe and effective care to their patients. This is especially important for the reliable delivery of sterile surgical instruments that are used for invasive and endoscopic diagnostic and surgical procedures.

Compounds called oxidative chemistries have been gaining popularity for the reprocessing of heat-sensitive surgical instruments because they provide safe and efficacious low-temperature sterilization. Before oxidative chemicals came into wider use, healthcare professionals could only choose between high level disinfection with dialdahydes and the longer ethylene oxide sterilization cycles for reprocessing of critical items that could not undergo steam sterilization.

This self-study session includes a discussion of dialdehydes, ethylene oxide, and oxidative low-temperature processing methods and their various risks and benefits.

Dialdehydes

Dialdehyde is the chemical class used to describe glutaraldehyde and ortho-pthalaldehyde. Both chemicals are used for manual soaking or in conjunction with automated washer/disinfectors and provide high level disinfection of temperature-sensitive items. Though each chemical is an effective high-level disinfectant, the nature of the chemicals has caused concern in many healthcare facilities. The toxicity of the fumes has caused headaches and asthma when not properly vented. Dermatitis and skin problems have been reported by individuals who did not use proper gloves. Some patients have developed dialdehyde-induced colitis, and patient deaths have been reported due to improper rinsing of the processed items before use. Dialdehydes have also been linked to the development and support of biofilm.

The term "biofilm" is used to describe a layer of microorganisms in an aquatic environment, held together in a matrix attached to pipes, sediment deposits or any surface. Attachment is a first step in the process of microbial colonization of any surface. Under suitable conditions a biofilm develops, initially through the accumulation of organic matter on a surface, which is then colonized by bacteria. Bacteria subsequently develop into a conglomerate within the polysaccharide matrix that creates the slimy nature of the biofilm. The matrix consists of organic polymers that are produced and excreted by the microorganisms and are referred to as extracellular polymetric substances.

Figure 1 helps to illustrate how biofilm is formed. Bacteria grow naturally on surfaces. To form a biofilm, bacteria bind to a surface, multiply, and form a matrix that protects the bacteria from the environment, including disinfectants. This matrix allows the bacteria to mature by binding other microorganisms or releasing parts of the biofilm to form new biofilm elsewhere. Biofilm has been implicated

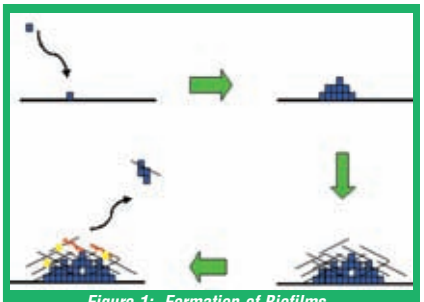

Figure 1: Formation of Biofilms within a liquid environment

in healthcare-associated infections that may have resulted from contaminated washer-disinfectors and medical devices.

Not all disinfectants are appropriate for biofilm control and the wrong ones can actually contribute to the growth of biofilm. Recent reports have suggested that disinfecting systems using 2% glutaraldehyde on a regular basis may have selected and therefore encouraged the growth of strains of *Mycobacterium chelonae*, possibly in biofilm, that have a decreasing susceptibility to glutaraldehyde.

Ethylene Oxide

Ethylene oxide (EO) has been used for decades in agriculture and industry. Healthcare applications account for only a small percentage of its uses. Prior to 1988, when the SYSTEM 1® Sterile Processing System (STERIS Corporation, Mentor, Ohio) was introduced to healthcare professionals, EO was the only viable sterilization option for low-temperature sterilization.

EO is very effective. It can easily penetrate and sterilize various materials. However, residual EO gas can also be difficult to remove from materials, which results in the need for long aeration periods. A typical cycle will last 14 hours or more.

In addition, pure EO can be explosive and combustible when stored in large quantities. In the past, chlorofluorocarbons (CFC) and hydrochloroflourocarbons (HCFC) were added to ethylene oxide in order to increase stability and reduce combustibility. However, CFC and HCFC were depleting the ozone layer, so their use has been curtailed. Fortunately, with today's technologies, 100% EO can be safely used in disposable canisters in its pure form. These canisters are much more stable and safer to use, and 100% EO will not damage the ozone layer.

Oxidative Chemistries

The term "oxidation" was originally used to describe reactions in which an element combines with oxygen molecules and all the different substances they may encounter. Oxidation is the loss of an electron by a molecule, atom, or ion. So, oxidizing agents will contribute oxygen, extract hydrogen, or extract electrons in a reaction.

This term is often associated with "rust." While rust can be a result of oxidation with some materials, not all materials that interact with oxygen create rust. It depends on the material themselves and the particular oxidative chemistry. For example, carbon steel, like the type used to build cars, can rust over time when exposed to salt and water. However, stainless steel surgical instruments are manufactured in a manner that inhibits rust under the same conditions.

Oxidative chemistries are in the class of compounds referred to as peroxygen compounds. These compounds contain an additional atom of oxygen bound to oxygen. Peroxygen chemicals react with proteins, carbohydrates, lipids, and nucleic acids found in the microorganism – also called macromolecules. This interrupts cellular functions and kills the microorganism. Oxidative chemistries exhibit excellent cleaning, disinfecting, and sterilizing properties and are generally non-toxic. They provide increased safety for staff and patients, and are environmentally friendly.

Three types of oxidative chemistries are used in healthcare today: hydrogen peroxide, ozone and peracetic acid. When used properly, oxidative chemistries provide superior sterilization activity over dialdehydes and have significantly shorter cycle times than EO.

Hydrogen peroxide is very environmentally friendly and can be easily disposed of. It is a very good oxidative agent and can achieve high-level disinfection as a liquid, or sterilization as a gas. Hydrogen peroxide typically is used for instrument sterilization, but the physics of the gas plasma prevent it from successfully sterilizing long, complex lumens.

In addition to being a high-level disinfectant and sterilant, hydrogen peroxide is excellent as an antiseptic agent and can also be used for cleaning and surface disinfection. Vaporized Hydrogen Peroxide (VHP®) has been used by STERIS in coordination with the United States government, to disinfect buildings and materials, including papers and sensitive computer equipment that was contaminated with anthrax spores. This dry vapor is highly effective at reaching challenging surfaces in corners, crevices and seams, and is compatible with many surface materials. Since oxygen and water are the by-products of the process, it is safe for the environment.

Ozone shows promise as a sterilizing chemistry. It is a broad-spectrum antimicrobial that uses oxygen, water, and electricity to generate ozone. Ozone is an oxidative gas, which quickly and effectively deactivates microorganisms by denaturing cell membranes. It is also environmentally friendly, since oxygen and water vapor are the by products of this sterilization process as well.

Ozone sterilization has relatively fast cycle times when compared to EO (about 4.5 hours as opposed to 14 hours). It has FDA clearance for stainless steel instruments, hinged instruments and instruments with rigid stainless steel lumens, but has particular restrictions depending on lumen diameter and length. Currently, it is not cleared to process flexible endoscopes, glass or plastic ampoules, liquids or implants.

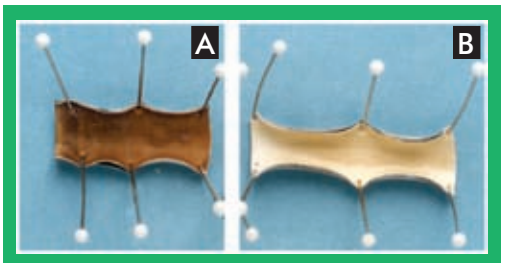

Figure 3: Cross section of endoscope lumen processed in glutaraldehyde (A) followed by processing in a SYSTEM 1® Sterile Processing System (B) employing STERIS 20 Sterilant Concentrate (a peracetic acid formulation).

Peracetic acid (PA) is an effective oxidizing biocide at low temperatures. Its chemical formula is acetic acid (vinegar) plus an extra oxygen atom. This extra oxygen atom is highly reactive and reacts with most cellular components to cause cell death. PA at relatively low concentrations (less than 1%) is an effective germicidal agent and is more potent than hydrogen peroxide. Combined with proper buffers and anticorrosives, it can safely disinfect or sterilize surgical instruments and flexible endoscopes.

In addition to the broad spectrum of antimicrobial activity, PA is highly water soluble and free-rinsing. As with the other oxidizing agents, it is environmentally friendly and has no harmful by-products (acetic acid (vinegar), water, and oxygen). It's also very effective in the presence of organic matter at low temperatures and has demonstrated improvement and even elimination of biofilms and other organic materials from endoscope lumens.

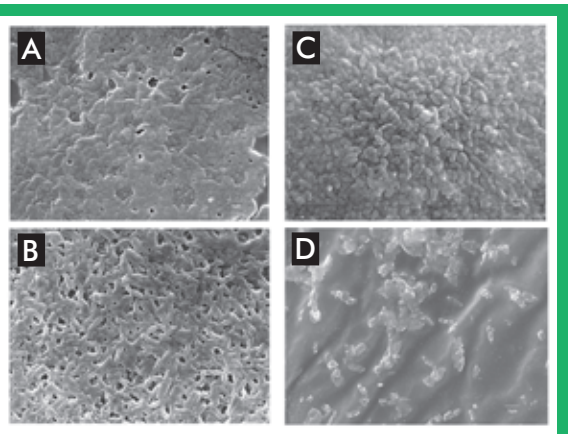

Figure 2: A, B (lower left) and C demonstrate typical biofilms. D demonstrates reduction of biofilm associated with peractic acid sterilization process.

Conclusion

In the current healthcare climate in which hospital-associated infections are being tracked and hospitals are being required to report infection rates, healthcare professionals are seeking decontamination solutions that can provide a high level of patient and staff safety while also assuring deactivation of microorganisms. When comparing the various risks and benefits of high-level disinfection and sterilization methods, there are clear differences.

*See **SELF-STUDY SERIES** on page 34*

Answers
1.A
2.A
3.B
4.D
5.C
6.B
7.B
8.E
9.A
10.G

Oxidative chemistries are versatile, efficacious chemistries that exhibit outstanding antimicrobial activity in a relatively short time and at low temperatures. They provide a high degree of safety for employees, patients, equipment and the environment. In addition, they can be formulated into different physical states, offering a wide variety of options for the sterilization of many different types of instruments and materials. This class of chemistries is clearly a valuable weapon in the infection control arsenal. **HPN**

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Continuing Education Test-May 2006

Understanding oxidative chemistries

CIRCLE THE CORRECT ANSWER

1. **All of the following can achieve low-temperature sterilization except _____.**
   a. Glutaraldehyde
   b. Ethylene oxide
   c. Ozone
   d. Vaporized Hydrogen Peroxide
   e. Peracetic acid
2. **Biofilms form within a liquid system when microorganisms attach to a surface and multiply.**
   a. True
   b. False
3. **Biofilms have never been associated with healthcare acquired infections (HAI).**
   a. True
   b. False
4. **Ethylene Oxide has been used in _____.**
   a. Healthcare
   b. Agriculture
   c. Industry
   d. All of the above
5. **Oxidative Chemistries are also referred to as _____.**
   a. Dialdehyde compounds
   b. Acidic compounds
   c. Peroxygen compounds
   d. Anticorrosive compounds
6. **Oxidative chemistries used for sterilization in healthcare facilities include _____.**
   a. Liquid hydrogen peroxide, ozone, and peracetic acid
   b. Vaporized Hydrogen Peroxide, ozone, and peracetic acid
   c. Ozone, peracetic acid and ethylene oxide
   d. Ozone, peracetic acid and orthopthaldehyde
7. **Hydrogen peroxide is equally effective as a sterilizing agent when used in liquid, gas or plasma states.**
   a. True
   b. False
8. **Healthcare professionals have expressed concerns with dialdahyde for its _____.**
   a. Toxicity
   b. Dialdehyde-induced colitis
   d. A and C only
   e. A and B only
9. **Oxidative chemistries are environmentally friendly.**
   a. True
   b. False
10. **Peracetic acid based sterilants, such as STERIS 20 Sterilant Concentrate, have demonstrated the ability to _____.**
    a. Reduce biofilm formations
    b. Wash endoscopes
    c. Encourage the growth of *Mycobacterium chelonae*
    d. Remove organic materials from lumens
    e. A, B and D only
    f. A and B only
    g. A and D only

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