A high-level disinfectant based on accelerated hydrogen peroxide: evaluation of microbicidal activity, human and environmental safety and materials compatibility

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ABSTRACT

Semi-critical medical devices such as flexible endoscopes require high-level disinfection between each use, and glutaraldehyde is often used for this purpose due to its favorable materials compatibility. However, workplace safety and the relatively slow microbicidal activity of such formulations remain a concern. While recently introduced substitutes based on 0.55% Orthophthaladehyde (OPA), 7-14% hydrogen peroxide and 0.1-0.3% peracids are considered less toxic than glutaraldehyde, OPA can be a potential respiratory sensitizer and the materials compatibility profile of peroxide/peracids at effective concentrations remains an issue.

This study describes a high-level disinfectant/sterilant based on 2% accelerated hydrogen peroxide (AHP). It is a blend of stabilized hydrogen peroxide with safe inerts, which act in synergy, and has a 14-day reuse, 5-min high-level disinfection and 6-hour sterilization claim at room temperature. Extensive testing of this formulation using nationally and internationally-accepted protocols has found it to be a fast-acting and broad-spectrum microbicide in addition to being biodegradable, virtually non-toxic and free from volatile organic compounds, and alkyl phenol ethoxylates. Also, comprehensive materials compatibility testing has proven it to be compatible with flexible endoscopes. Therefore, this new chemistry represents a significant advancement in the design of safer and faster-acting, high-level disinfectants.

INTRODUCTION

Semi-critical medical devices, such as flexible endoscopes are heat-sensitive and need to be chemically high-level disinfected either manually or in a machine. There has always been a challenge in creating a balance between materials compatibility, toxicity and microbicidal activity of disinfectants. Generally, broad-spectrum and fast-acting active ingredients are corrosive and/or toxic. For example, chlorine is an effective and rapid microbicide; however, it is not suitable for use on flexible endoscopes due to its high corrosivity. On the other hand, quaternary ammonium compounds have fair material compatibility, but they are ineffective against mycobacteria, spores or non-enveloped viruses and consequently cannot be used for this application.

Glutaraldehyde is the most commonly used high-level disinfectant for reprocessing flexible endoscopes due to its favorable materials compatibility. However, it is a toxic and irritant chemical, a moderate sensitizer of human skin and a protein fixative. Some microorganisms have shown resistance against glutaraldehyde.

Orthophthaladehyde (OPA) is an aromatic aldehyde, which is currently in wide use. It is compatible with flexible endoscopes. It is less toxic than glutaraldehyde. OPA is also faster-acting than glutaraldehyde against mycobacteria, but has much slower sporicidal (1). Although OPA is less toxic than glutaraldehyde, it still has some inhalation and irritation concerns. William (2) described 9 episodes of anaphylaxis following cystoscopy caused by OPA. Rideout (3) showed that OPA has the same predictors of respiratory sensitization as glutaraldehyde as well as an aromatic group. Joshi (4) explained the two cases of OPA-induced allergic reactions in patients undergoing surveillance cystoscopy.

Peracetic acid/peroxides are also used as a high-level disinfectant/sterilant. They have broad-spectrum antimicrobial activity, and are friendly to the environment. However, these solutions have poor stability and are corrosive to many materials.

The objective here is to report on a newly developed high-level disinfectant/chemisterilant, which addresses the concerns of the above-mentioned chemicals. This new product is based on Accelerated Hydrogen Peroxide (AHP) technology. AHP is a synergistic blend of commonly used, safe ingredients that when combined with low levels of hydrogen peroxide dramatically increase its germicidal potency and cleaning performance. AHP contains only those ingredients on the GRAS listing (Generally Regarded as Safe) published by the FDA, which represent unsurpassed health, safety and environmental friendly profiles.

MATERIALS AND METHODS

Formulation tested: The product tested in this study, Accel HLD 5, is a newly developed, AHP-based high-level disinfectant & chemosterilant.
Accel HLD 5 is a blend of 2% hydrogen peroxide, anionic surfactants, non-ionic surfactants and stabilizers. It is a clear, slightly yellowish liquid, odorless and has a pH of 2.5-3.0. It is free from volatile organic compounds (VOCs) and alkyl phenol ethoxylates (APEs). The formulation is registered for sale in Canada, and will soon be registered in the U.S. as well.
Accel HLD 5 was tested for its antimicrobial activity, stability, toxicity, dermal and eye irritancy, biodegradability and materials compatibility using well-recognized protocols.

Stability Tests were done to comply with paragraph C.01.062 in the Food and Drugs Act, wherein the concentration of medicinal active in a drug product cannot lie outside of a band defined by 90% to 110% of the nominal concentration.
Antimicrobial Tests: Three lots of the test solution were stressed for 14 days using procedures, which meet with the requirements of the U.S. FDA and Health Canada. The stressing was carried out according to the procedures described by Sattar *et al.* (5). All tests were done at room temperature.
Toxicity tests: Acute Eye Irritation/Corrosion, Acute Dermal Irritation/Corrosion, Acute Oral Toxicity Study were performed using OECD 405,404 and 425 test methods respectively.
Biodegradability Test: Accel HLD 5 was tested for its inherent biodegradability using OECD 302B test method.
Flexible Endoscope Compatibility Test: Olympus flexible endoscope model GIF-Q160Y2 was tested for its compatibility with the test solution. The test parts were all rinsed with deionized water and dried. Each item was photographed to compare before and after exposure. The items were soaked for 1000 cycles of 5 min high-level disinfection contact time (84 hours). Every 24 hours, test items were visually observed for any damage.

RESULTS

Stability Tests

The solutions had about 5-7% loss for hydrogen peroxide in one year at room temperature. Based on these results and reasoning, the product is stable for a period of 2 years if manufactured at about 110% of its active nominal concentration.

Microbicidal tests (Table 1)

Table 1. Microbicidal activity of the stressed formulation against different microorganisms.

Test Organism	Contact time	CFU per control carrier	CFU per test carrier	Log_{10} reduction
Bacillus subtilis (ATCC 19659)	6 hours	2.79×10^6	0	6.45
Clostridium sporogenes (ATCC 7955)	6 hours	3.02×10^6	0	6.48
S. aureus (ATCC 6538)	5 min	5.48×10^6	0	6.73
P. aeruginosa (ATCC 15442)	5 min	1.49×10^7	0	7.17
S. choleraesuis (ATCC 10708)	5 min	8.28×10^6	0	6.91
Mycobacterium terrae (ATCC 15755)	5 min	3.07×10^6	0	6.49
Trichophyton mentagrophytes, (ATCC 95 33)	5 min	1.32×10^6	0	6.12
Poliovirus type 1, Sabin (ATCC VR-192)	5 min	1.35×10^4	0	4.13
Adenovirus Type 5 (ATCC VR-1516)	5 min	4.23×10^5	0	5.62

The above results show that Accel HLD5 is a high-level disinfectant in 5 min and a chemosterilant in 6 hours.

MATERIALS AND METHODS CONTINUED

Hydrogen Peroxide Levels and pH:

The hydrogen peroxide concentration and the pH were monitored after 7 and 14 days of stress and they did not show any significant change.

Toxicity Tests (Table 2)

Table 2: Toxicity Test Results for Accel HLD 5

Test	Results
Acute Eye Irritation/Corrosion Test	Mildly irritant
Acute Dermal Irritation/Corrosion Test	Slight irritant
Acute Oral Toxicity Study	LD50>2000 mg/kg (Category 5 chemicals)

Flexible Endoscope Compatibility Test:

Non of the tested items including insertion tube, distal end, nameplates, and light guide parts were functionally or visually damaged. The endoscope was also passed the leak test successfully.

DISCUSSIONS AND CONCLUDING REMARKS

High-level disinfectants are required for reprocessing semi-critical medical devices such as flexible endoscopes. However currently used products such as those based on glutaraldehyde and OPA have safety concerns due to their toxic nature. Although OPA has not been in the market for a long time, the inhalation studies suggest that as an aromatic aldehyde, it is toxic.
Others such as peracid have materials compatibility concerns. The balance between user safety, microbicidal activity and materials compatibility has always been a huge challenge for product formulators. Traditional commercial hydrogen peroxide by itself is one of the oldest known disinfectants. It is environmentally friendly since it decomposes to water and oxygen. It is not toxic and is generated in many settings. However, its microbial activity is very slow, and the effective concentrations are corrosive to most items due to its oxidizing nature. It is also difficult to formulate stabilized hydrogen peroxide solutions containing other inert ingredients.
This study shows that AHP technology is now able to address these concerns. All the ingredients used in AHP formulations are on the FDA Gras list or EPA's inerts list. They are free from aquatic toxicants including alkyl phenol ethoxylates (APEs). They are also free from VOC's, and are biodegradable.
In summary, the AHP-based high-level disinfectant tested in this study proved to be a broad-spectrum microbicide, fast-acting, safer to end users, and the environment, and considered to be compatible with flexible endoscopes. Depending on the application, it can be formulated to be used as a cold soak or in a machine in raised temperatures. It, therefore, addresses many of the concerns relating to other types of actives in processing flexible endoscopes and other heat/chemical sensitive medical devices.

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