Lonza

A Comparison Study of Disinfectant Cleaners based on Hydrogen Peroxide or Quaternary Ammonium Compounds

Background

Hydrogen peroxide has been used for many years as an antimicrobial. While it has several desirable properties, it has not been used in many hard-surface antimicrobial applications because of an inherent lack of stability and a relatively slow biocidal kill rate. A new technology, based on what is called “Accelerated Hydrogen Peroxide” or “Stabilized Hydrogen Peroxide”, has recently appeared in the Canadian market. It is based on a patented blend of hydrogen peroxide, an acid (typically phosphoric or a phosphonate), and anionic surfactant. The new technology is said to address many of the problems traditionally associated with hydrogen peroxide and now produces stabilized or accelerated peroxide with good antimicrobial properties.

This paper sets forth some comparative testing results between Hydrogen Peroxide (both stabilized and accelerated) and Quaternary Ammonium Compounds (QACs). This paper describes the generally accepted comparative test methodologies employed and clarifies differences between the two antimicrobial systems on the basis of microbiological efficacy (including Time Kill), surface cleaning, metal corrosion, and environmental impact.

Microbiological Efficacy

Methodology

Microbiological efficacy is the most critical attribute of a disinfectant cleaner formulation. Various types of efficacy testing have been employed over the years. The AOAC Use Dilution test is a recognized protocol for evaluating the bacterial activity of hospital disinfectants. In this test, small metal cylinders are exposed to a suspension of the test microorganism. The cylinders are removed from the suspension, dried, and immediately exposed to the use dilution of the disinfectant for a specified time. The cylinders are then transferred to tubes of a growth medium that contains a neutralizing substance capable of stopping any further biocidal activity of the disinfectant. The tubes are incubated for 48 hours and scored for growth/no growth. A use dilution of the disinfectant is considered effective when none of 10 tubes or no more than 1 of 60 tubes shows growth.

Two Hydrogen Peroxide based formulations were compared to a registered disinfectant in an AOAC Use Dilution study. Stabilized Hydrogen Peroxide™ (SHP) is a low level cleaner used for general housekeeping, while Accelerated Hydrogen Peroxide™ (AHP) is a cleaner and disinfectant for higher risk areas in health care facilities. Both products were compared to Lonza Formulation S-21F, a USEPA and Canadian-registered disinfectant cleaner. All products were diluted according to label claims and evaluated via the AOAC Use Dilution test against two organisms: *Pseudomonas aeruginosa* ATCC 15442, and *Staphyococcus aureus* ATCC 6538. Three separate tests were employed to determine the efficacy of the test substance under increasingly more difficult conditions:

DI (deionized) water alone, DI water plus 5% soil, and finally 400 ppm hard water (HH_20). While many products may pass efficacy testing under conditions where DI water is used alone, the presence of soil or hard water makes it more difficult for the disinfectant to work, but is nevertheless more representative of real world conditions.

Because of the stringent requirements for the AOAC Use Dilution test, the SHP sample was not only tested at the level according to the label claim (1:64 dilution), but also at half the dilution rate (1:32). Thus, the SHP product was tested at both 470 ppm concentration at use dilution, as well as *twice that level*, or 940 ppm.

Results

- Lonza Formulation S-21F containing the quaternary ammonium chloride proved more efficacious against *Pseudomonas aeruginosa* at the same 1:64 dilution rate as the SHP in deionized water and in hard water.
- The most significant differences were observed when the Lonza Formulation S-21F was compared to the SHP against *Staphylococcus aureus*. The SHP allowed significant growth of the bacteria, not only at the specified label dilution of the product (the same dilution as the Lonza Formulation S-21F), but even at twice the recommended concentration. This occurred under all test conditions (deionized water, DI water with organic soil added, and hard water).
- The AHP product with 7% hydrogen peroxide equaled the Lonza Formulation S-21F, but this required four times (4X) the amount of active product.

Test results are summarized in Table 1.

Table 1

Product/Lot #	Dilution/Conditions	ppm Active Expected	Results	
			PA 15442	SA 6538
S-21F/100072	1:64/DI	859	0/10	0/10
	1:64/DI + 5% Organic Soil		0/10	0/10
	1:64/400 ppm HH_2O		0/10	0/10
SHP (3% hydrogen peroxide)/5683-13A	1:64/DI	470	2/10	7/10
	1:64/DI + 5% Organic Soil		0/10	10/10
	1:64/400 ppm HH_2O		2/10	10/10
	1:32/DI	940	0/10	10/10
AHP (7% hydrogen peroxide)/5683-13B	1:16/DI	4375	0/10	0/10
	1:16/400 ppm HH_2O		0/10	0/10

Time Kill

Methodology

A Time-Kill assay was run with Lonza formulation S-21F and AHP (7% hydrogen peroxide) in the presence of 5% organic soil against 10^6 cfu *S. aureus*. Samples were neutralized to halt biocidal activity after 0.5, 1, 2, and 5 minutes exposure. Log reduction was calculated based on the number of dilution wells showing no growth, compared to growth of unchallenged test organisms. A 4-log reduction is the detection limit. Results are reproducible, plus or minus one dilution, and are shown in Table 2.

Results

The AHP at a 1:16 dilution was equal to the Lonza Formulation S-21 but was clearly inferior at a dilution rate of 1:64, allowing the organism to grow at all time periods tested. Quaternaries are very fast acting antimicrobials, and although some improvement in kill time has occurred with Hydrogen Peroxide technology, *quats still maintain a significant advantage in time kill tests when compared to hydrogen peroxide at similar use dilution concentrations*.

Table 2

S.aureus Initial # Count	Product, Lot #	Dilution in DI + 5% OS	pH	ppm Active Expected	Log Reduction/Log Survivors 0.5 min	1 min	2 min	5 min
$2.1x10^6$	S-21F, 100072	1:64	11.0	859	4/4	4/4	4/4	4/4
	AHP 5683-13B	1:16	2.5	4375	4/4	4/4	4/4	4/4
		1:64	2.5	1100	0/4	0/4	0/4	1/4

Cleaning Performance

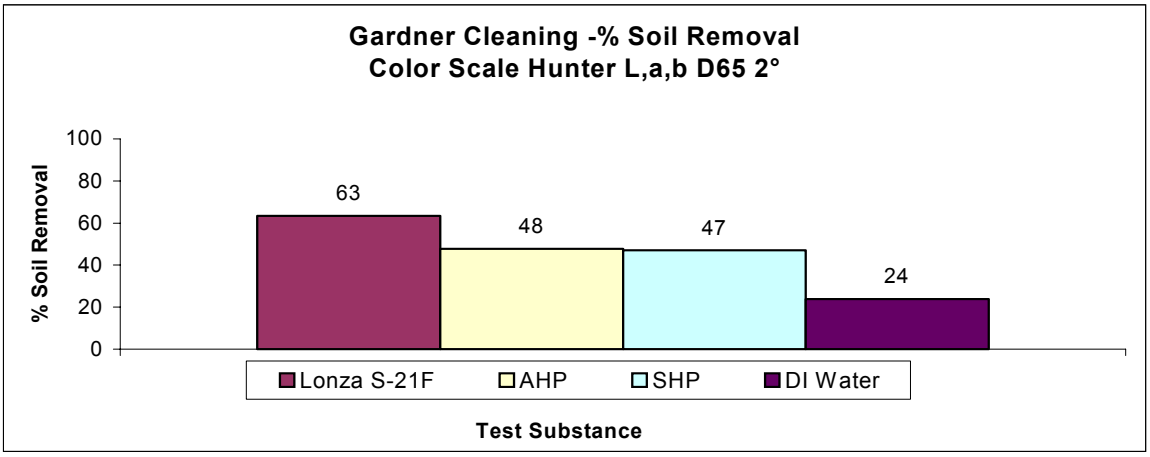
Methodology

To fully assess the cleaning capabilities of the Hydrogen Peroxide formulations vs. a formulated quat, samples were tested for cleaning based on a standard protocol for soiled tile cleaning. Two-by-four-inch squares of white vinyl tiles were coated with a synthetic soil, which was then baked at 100°C for twenty minutes. The cured, soiled tile was then placed in a Gardner Washability and Wear Tester Model # D10 apparatus, a dual sponge was then saturated with the test substance (Hydrogen Peroxide formulations or quaternary formulation), and the apparatus run for 20 cycles.

Results

The three formulations were compared to each other and to DI water as shown in Figure 1. The quat formulation provided over 20% better cleaning at use dilution than either Hydrogen Peroxide formulations at use dilution. The Hydrogen Peroxide formulations were twice as effective as DI water alone while the quaternary formulation was shown to be over 2.5 times more effective than DI water alone.

Figure 1



Corrosion

Hydrogen Peroxide formulations are advertised as being “non-toxic” and “non-corrosive” at use-dilution. “Corrosive” as a term can relate either to the effect on the human eye or skin tissue, or on metal surfaces. In order to compare the corrosivity of AHP and SHP solutions to quats, a series of metal coupon corrosion tests were run. SHP, AHP, and an S-21 quat solution were tested at full strength concentrations (directly from the container) and also at 1:64 use dilution. The former concentrations were utilized to determine any adverse effects if the concentrates were accidentally spilled on a metal surface, while the use-dilution concentrations were utilized to determine the effect, if any, from repeated contact on a daily basis under typical end-use conditions.

Methodology

Corrosion tests were run on Q-panel 1010, cold-rolled steel coupons. The coupons were placed in 4 oz. glass jars to which 60 ml. of either AHP or quat solution had been added, and then capped. The jars were then monitored for any signs of corrosion. Initial weights of the coupons were recorded to determine any weight loss or gain. The test substances (in duplicate) were examined at full concentration and at label specified dilution levels in both DI water and 400ppm hard water.

Results

Less than 24 hours later, severe corrosion and weight loss occurred on both the SHP and AHP products in hard water and in DI water at use dilution. This is likely due to the very low pH observed with the SHP and AHP samples (4.2 and 0.9, respectively). The amount of corrosivity can be further observed after seven days, where the loss of coupon weight is quite large even under use dilution.

As shown in the photographs below, the corrosion at use dilution of both the SHP and AHP products was well above that observed for the quaternary formulation. These photographs were taken after 22 hours of coupon exposure.

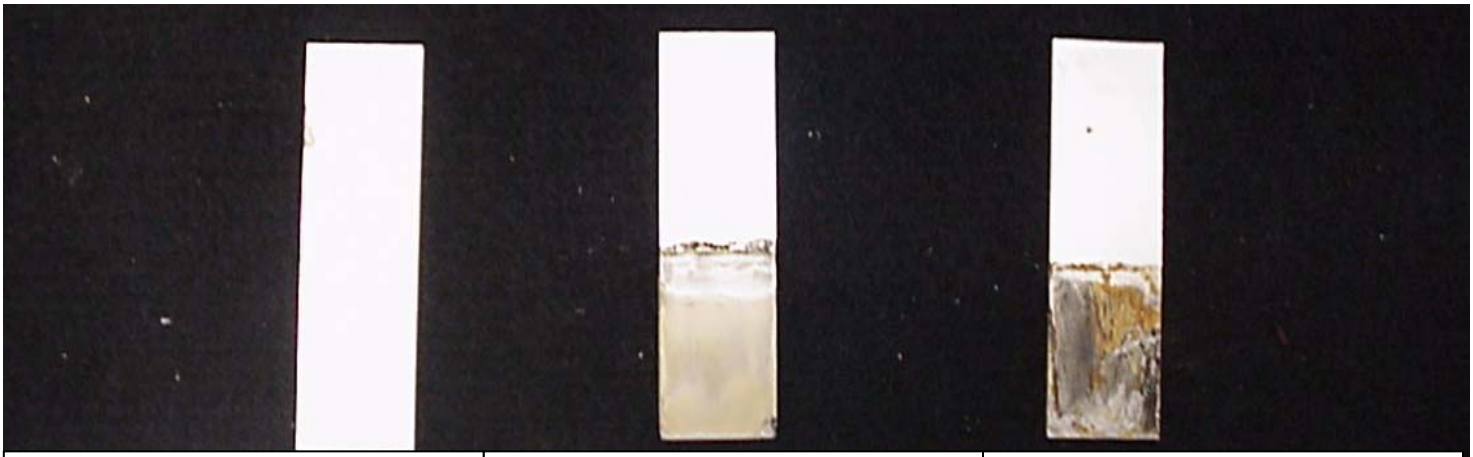
The actual corrosion results are shown in Table 3.

Table 3

Corrosion Testing of S-21 vs. SHP and AHP

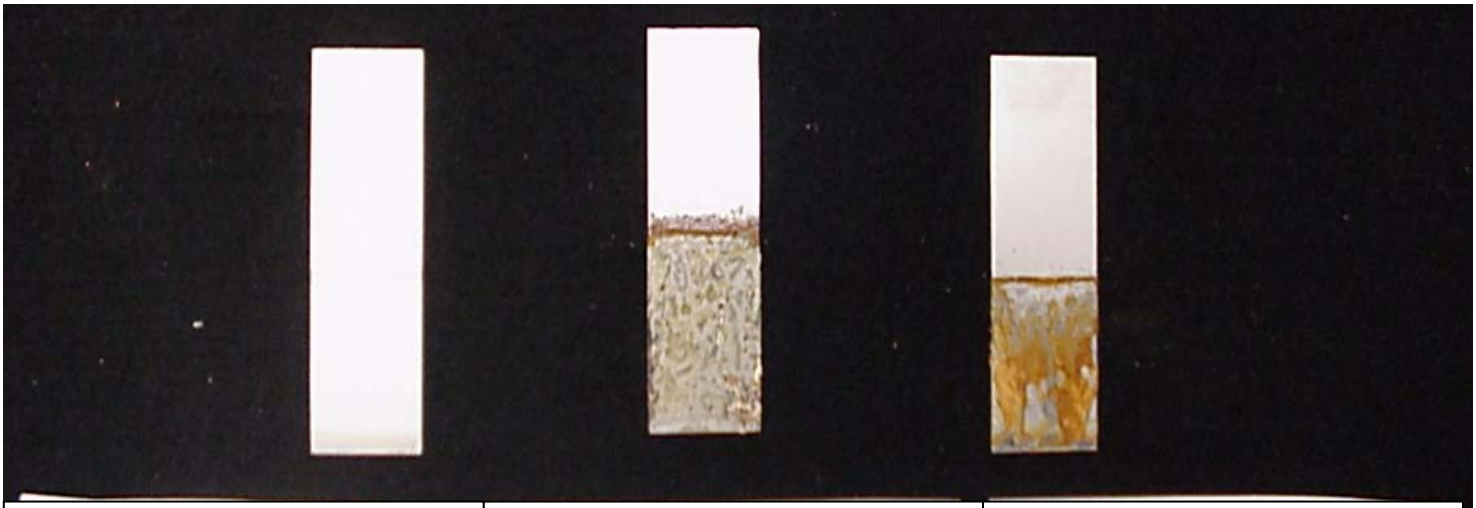
Test		S-21F	SHP.	AHP
pH Concentrate		12.8	4.2	0.9
pH 1:64 Dilution DI H_2O		11.3	4.5	2.3
pH 1:64 Dilution HH_2O		10.2	6.6	2.5
Visual Analysis of Corrosion by 1:64 Dilutions in DI H_2O		None	Severe	Severe
Visual Analysis of Corrosion by 1:64 Dilutions in HH_2O		None	Severe	Severe
Coupon Wt (grams)		1 DAY		
Concentrate	Before	12.24	12.18	12.27
	After	12.24	12.18	12.24
	% Loss	**0**	**0**	**0.24**
1:64 DI	Before	12.30	12.16	12.20
	After	12.29	12.15	12.16
	% Loss	**<0.1**	**<0.1**	**0.33**
1:64 HH_2O	Before	12.32	12.35	12.25
	After	12.31	12.33	12.20
	% Loss	**<0.1**	**0.20**	**0.41**
Coupon Wt (grams)		7 DAYS		
Concentrate	Before	12.29	12.26	12.3
	After	12.29	12.27	12.19
	% Loss	**0**	**0**	**0.90**
1:64 DI	Before	12.26	12.17	12.15
	After	12.24	12.15	12.1
	% Loss	**0**	**<0.1**	**0.40**
1:64 HH_2O	Before	12.35	12.27	12.34
	After	12.35	12.25	12.26
	% Loss	**0**	**0.20**	**0.60**

This level of corrosion for the Hydrogen Peroxide formulation samples is evident not only in Deionized water…



S-21 1:64 dilution with DI Water 1010 cold rolled steel 22 hours @ R.T.	AHP 1:64 dilution with DI Water 1010 cold rolled steel 22 hours @ R.T.	SHP 1:64 dilution with DI Water 1010 cold rolled steel 22 hours @ R.T.

… But in hard water as well.



S-21 1:64 dilution with 400 ppm HH_20 1010 cold rolled steel 22 hours @ R.T.	AHP 1:64 dilution with 400 ppm HH_20 1010 cold rolled steel 22 hours @ R.T.	SHP 1:64 dilution with 400 ppm HH_20 1010 cold rolled steel 22 hours @ R.T.

This shows how detrimental even slight splashing could be to metal surfaces when Hydrogen Peroxide formulations are used, even at use-dilution levels.

Environmental Impact

SHP and AHP claim to be fully biodegradable within one minute in a wastewater facility. The non-active components are also listed as completely biodegradable, based on a semi-continuous activated sludge (SCAS) test published in the Journal of the American Oil Chemists Society, 42, 986 (1965). Likewise, the environmental impact of quaternary ammonium compounds have been reviewed in the scientific literature (by Roy F. Weston, Inc), and by USEPA, 1992.

- The conclusion reached in both reviews is that DDAC (didecyldimethylammonum chloride) and other similar quaternaries fully biodegrade in the environment.

Summary

These series of tests clearly demonstrate the advantages in biocidal efficacy, low corrosion, and effective cleaning, utilized by a fully formulated quaternary ammonium product over Accelerated Hydrogen Peroxide ™ or Stabilized Hydrogen Peroxide™ technology.

2/2002
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