



**AIRBORNE SURFACE  
DISINFECTANT**

**HEALTH TECHNOLOGY ASSESSMENT SECTION  
MEDICAL DEVELOPMENT DIVISION  
MINISTRY OF HEALTH MALAYSIA  
003/2010**

**DISCLAIMER**

Technology review is a brief report, prepared on an urgent basis, which draws on restricted reviews from analysis of pertinent literature, on expert opinion and / or regulatory status where appropriate. It has been subjected to an external review process. While effort has been made to do so, this document may not fully reflect all scientific research available. Additionally, other relevant scientific findings may have been reported since completion of this review.

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## **DISCLOSURE**

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## **EXECUTIVE SUMMARY**

## Introduction

Disinfectant is a chemical compound used to inactivate most of vegetative microorganism.<sup>1</sup> Within health care practice disinfectant is an essential part of infection control and very important in the prevention of nosocomial infections. There is various types of disinfectants can be found including alcohols, aldehyde groups like formaldehyde, peroxygens as hydrogen peroxide and heavy metal derivatives especially silver compounds. Those can be used either singly or in combination to have a synergistic effect.<sup>2</sup>

A new generation of airborne surface disinfectant is introduced by [REDACTED] known as [REDACTED]. The biocides used are hydrogen peroxide and silver nitrate as a catalyst, in water based liquid which is administered in aerosol form. This technology review was requested by Director Medical Development Division and Principal Assistant Director (Operation) Engineering Division following the proposal from a company to introduce the technology in health facilities.

## Objective/Aim

The objective of this systematic review was to assess the safety, efficacy or effectiveness of [REDACTED] to disinfect health care facility from airborne pathogenic microbes.

## Results and Conclusions

The search strategies did not specifically yield any article regarding the safety, efficacy or effectiveness of [REDACTED]. The information regarding the effectiveness of [REDACTED] for airborne disinfectant was only available in the document submitted by the company and one study from the company's website.

## Methods

Electronic databases were searched, which included PubMed, Ovid Medline (R) from 1990-2006 (EBM Reviews – Cochrane Databases of Systematic Reviews), National Horizon Scanning, and FDA website, for published reports. There was no limit in the search. Additional articles were identified from reviewing the bibliographies of retrieved articles.

The search strategy used the terms which were either used singly or in various combinations; “[REDACTED]”, “disinfectant”, “hydrogen peroxide”, “silver nitrate”, “hydrogen peroxide as disinfectant”, “silver nitrate as disinfectant” and “cost of [REDACTED]”, cost-effectiveness of [REDACTED] and “hydrogen peroxide in combination with silver nitrate as disinfectant”.







## 1. INTRODUCTION

Disinfectant is a chemical compound used to inactivate most of vegetative microorganisms.<sup>1</sup> Within health care practice disinfectant is an essential part of infection control and very important in the prevention of nosocomial infections. Actually the active chemical agents used in disinfectant are called 'biocide'. It is a general term used for describing a chemical agent in disinfectant, usually broad spectrum disinfectant that inactivates microorganisms. There are various types of disinfectants which include alcohols, aldehyde groups like formaldehyde, peroxygens as hydrogen peroxide and heavy metal derivatives especially silver compounds. They can be used either singly or in combination to have a synergistic effect.<sup>2</sup>

Hydrogen peroxide can be used in combination with silver nitrate as disinfectant. Hydrogen peroxide is a chemical compound of  $H_2O_2$  which is colourless, odourless liquid, strong oxidizing agent, and a weak acid. It is miscible with cold water and soluble in alcohol and ether. Although pure hydrogen peroxide is fairly stable, it decomposes into water and oxygen when heated above  $80^\circ C$ . Because of these properties Hydrogen Peroxide is considered as environmental friendly. It also decomposes with the presence of catalysts, mostly metals like silver, acids and oxidizable organic materials. The main uses of hydrogen peroxide are as a mild bleaching agent and as antiseptic in medical field.<sup>1,2,3</sup> Silver nitrate ( $AgNO_3$ ) is another chemical compound used. Compared to hydrogen peroxide it is a colourless crystalline material and very soluble in water. There are many uses of silver compound in industry especially in photography. However, it is also being used in medicine in the treatment of eye infections and gonorrhoea.<sup>3</sup>

As a disinfectant, both prove to have the capability of killing microbes. The mechanism of action of silver ion towards certain pathogen varies. First, is the interaction of silver ions with thiol groups (-SH) in bacteria's enzyme which may inactivate the microbes. Secondly, the silver ion will bind to key functional groups of fungal enzymes and cause the release of potassium ions from the fungus. The third mechanism is inhibiting the microbes' growth by being deposited within vacuole and cell wall. Thus, inhibits cell division and damage the cell envelope as well as contents of the bacteria. The fourth mechanism is the silver ion interacts with nucleic acid which is the main chain in DNA formation. For hydrogen peroxide, it acts as an oxidant by producing hydroxyl free radicals

( $OH\cdot$ ) which then attack the essential cell components, including lipids, proteins, and DNA. Due to this property, hydrogen peroxide has broad-spectrum efficacy against viruses, bacteria, yeasts, and bacterial spores. In general, its greater activity is against gram-positive than gram-negative bacteria.<sup>2</sup>

Based on this, a new generation of airborne surface disinfectant is introduced by  as . The biocides used are hydrogen peroxide and silver nitrate as a catalyst, in water based liquid which is administered in aerosol

form. This technology review was requested by Director Medical Development Division and Principal Assistant Director (Operation) Engineering Division following the proposal from a company to introduce the technology in health facilities.

## 2. OBJECTIVE /AIM

The objective of this technology review was to assess the safety, efficacy or effectiveness and cost-effectiveness of [REDACTED] to disinfect health care facility from airborne pathogenic microbes.

## 3. TECHNICAL FEATURES

A new generation of airborne surface disinfectant known as [REDACTED] by [REDACTED] uses the principle of an aerosol. It contains non-toxic hydrogen peroxide ( $H_2O_2$ ) and silver nitrate ( $AgNO_3$ ). Other preservatives are surfactant and pure water. The composition is in liquid form which then will be nebulised to form an aerosol. The aerosol propelled by the turbine at 80m/sec at 37°C. The size of the particle formed is less than  $5\mu m$  in non-wetting fog, to ensure a slow and perfectly uniform sedimentation on each squared centimetre ( $cm^2$ ) of the treated premises without humidity and corrosion. The manufacturer claimed that the advantage of the device is that there is no formation of volatile organic compounds due to the rapid decomposition of more than 99% of the fog which leaves nothing behind once it has acted. Besides, free radicals of hydrogen peroxide has very short life.<sup>4,5,6</sup>

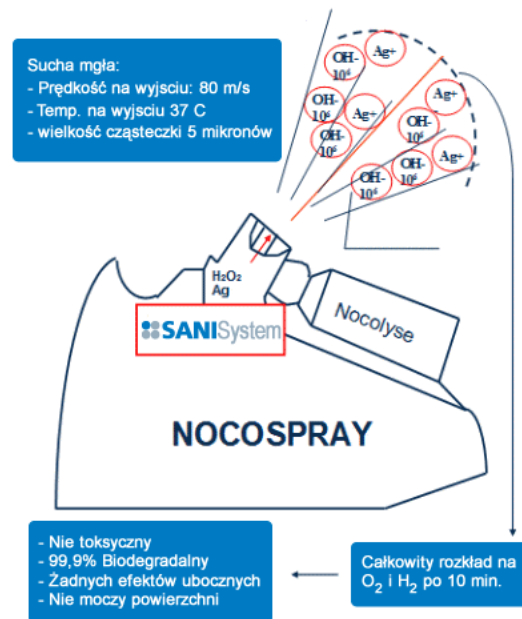
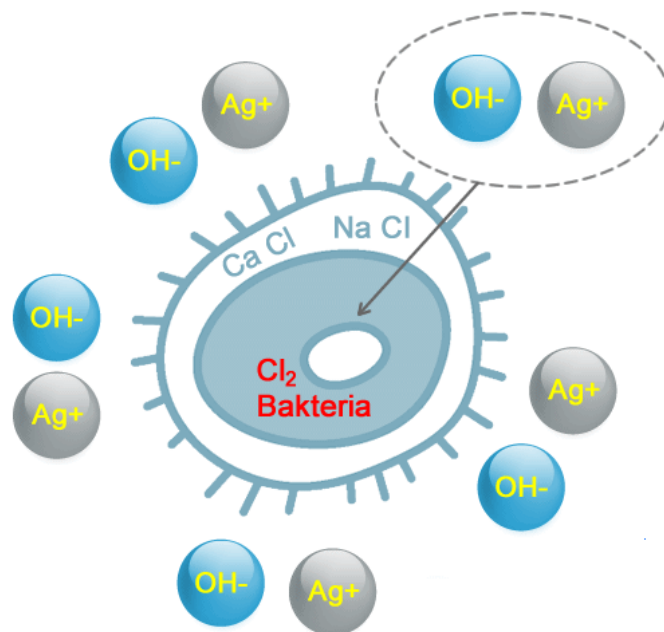


Figure 1: Principle of an Aerosol of [REDACTED]

### 3.1. Mechanism of Action of Hydrogen Peroxide and Silver Nitrate

The mechanisms of actions of the [REDACTED] are based on the properties of each active ingredient. It is claimed that the device has been created with combination of speed and temperature to enable the ionization of the emitted particles and the degradation of the peroxide to create extremely oxidizing free radicals (superoxide ions) which are extremely active in the destruction of the cytoplasmic membranes of the bacteria.<sup>4,5</sup> Naturally most microorganisms have chlorine substances in their cells. Under the action of free radicals, this chlorine will transform into active chlorine and destroy the bacteria. Another mechanism is that once a nucleation process occurs within the microbes' cell, it will transform into a liquid crystal of peroxide and later contributes to self-destruction. Meanwhile instead of acting as catalyst, the silver ion will inhibit the microorganism growth as it will alter the DNA formation of the microorganism.<sup>4</sup>



**Figure 2: Mechanism of Action of Hydrogen Peroxide and Silver Nitrate**

#### 4. Methodology

##### 4.1. Searching

Electronic databases were searched, which included PubMed, Ovid Medline (R) from 1990-2006 (EBM Reviews – Cochrane Databases of Systematic Reviews), National Horizon Scanning, and FDA website, for published reports. There was no limit in the search. Additional articles were identified from reviewing the bibliographies of retrieved articles.



The search strategy used the terms which were either used singly or in various combinations; “██████████”, “disinfectant”, “hydrogen peroxide”, “silver nitrate”, “hydrogen peroxide as disinfectant”, “silver nitrate as disinfectant” and “cost of ██████████”, cost-effectiveness of ██████████ ██████████ and “hydrogen peroxide in combination with silver nitrate as disinfectant”.

**4.2. Selection**

All published articles related to the efficacy or effectiveness and safety of ██████████ ██████████ in pathogen disinfectant were included. Studies conducted in other field were excluded. Document submitted by a company on ██████████ ██████████ was also included.

**5. RESULTS AND DISCUSSION**

The search strategies did not specifically yield any article regarding the safety, efficacy or effectiveness of ██████████. The information regarding the effectiveness of ██████████ for airborne disinfectant was only available in one document submitted by the company and one laboratory findings from the company’s website. However 5 other studies included in this review were concerned on the efficacy and effectiveness of hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and silver nitrate (AgNO<sub>3</sub>) as disinfectant.

**5.1. EFFICACY OR EFFECTIVENESS**

**5.1.1 NOCOSPRAY NOCOLYSE**

There was no retrievable evidence from scientific databases regarding ██████████. However there was a report on the efficacy of the device which was reported on 20<sup>th</sup> June 2010. The test was conducted from 29<sup>th</sup> May 2007 to 10<sup>th</sup> June 2007 by Biotech-Germade: Hygiene-Training-Evaluation Research and Development. The test was meant for ██████████ as a client to test the ██████████. The objective of the tests was to determine “in situ”, in premises with different levels of infectious risk, the efficacy of an airborne system for surface disinfection based on hydrogen peroxide (██████████ procedure that associates a ██████████ nebulizer with ██████████ disinfectant).<sup>7</sup>

The device involved was ██████████ brand ██████████. The tests were conducted in 3 private clinics (Clinic X, Y and Z) in France. Those clinics are classified according to the following zones:<sup>7</sup>

CLINICS	CRITERIA
Clinic X	<ul style="list-style-type: none"> <li>• Operating room with high risks of infection</li> <li>• Room</li> </ul>
Clinic Y	<ul style="list-style-type: none"> <li>• Operating room with high risks of infection.</li> </ul>

	<ul style="list-style-type: none"> <li>• Delivery Room</li> <li>• Men's locker room.</li> </ul>
Clinic Z	<ul style="list-style-type: none"> <li>• Sterilization conditioning zone.</li> </ul>

**Table 1: Criteria of the Clinics**

The different areas were tested (collection by count-tact and analyses):

After the bio-cleaning procedure but before the use of

- ii) 30 minutes after the use of the aerosol – Delay required for the complete sedimentation of the microparticles on the surfaces and for the site tested.

The samples were analyzed; the total mesophilic flora was researched after 5 days of incubation at 30°C. The microorganism isolated were counted and identified with the usual laboratory techniques including Gram Staining. The result was in Unit Forming Colonies (UFC/25m<sup>3</sup>) grow on the plate agar.

At the end of the study they found that, at those 3 clinics, the growths of microorganisms were significantly reduced after the used of. From the test a reduction of *Staphylococcus* coagulase negative were significant in all 3 clinics; from a total number of more than 1 UFC/25m<sup>3</sup> it was reduced to less than 1 UFC/25m<sup>3</sup>. The results also showed the reduction for all the microorganisms detected before disinfected process; *Bacillus sp*, *Micrococcus sp*, and mold.

### 5.1.2 Other Disinfectants Using Hydrogen Peroxide with Silver Nitrate

Tote K *et al.* conducted a study to evaluate the use of hydrogen peroxide and stabilized hydrogen peroxide combination products. In the same test, they also tested a new novel test system, for evaluation of the antimicrobial activity of antiseptics and disinfectants called Resazurin Microplate Method (RMM). The RMM might be a challenge to the standard test used before that is Plate Count Challenge Test (PCCT). Using the validated RMM, it was shown that hydrogen peroxide in combination with silver possessed a higher bactericidal and fungicidal activity compared to native hydrogen peroxide with or without glycerol. Finally, they concluded that hydrogen peroxide with silver was clearly more potent disinfectant compared to hydrogen peroxide alone in killing bacteria and fungi.<sup>8</sup>

### 5.1.3 Other Disinfectants Using Hydrogen Peroxide Alone

Orlando P *et al.* conducted a study to assess the efficacy of a system of nebulisation of a hydrogen peroxide-based solution for surface disinfection. They used hydrogen peroxide alone as a disinfectant but with different concentrations (1, 2, and 4ml/m<sup>3</sup>). The solutions of hydrogen peroxide were nebulised inside a 50m<sup>3</sup> experimental environment. The

disinfection efficacy of the system was evaluated by comparing the total bacterial load measured on the surfaces before and after the treatment with nebulised hydrogen peroxide. After the analysis they found the higher the concentration of the hydrogen peroxide the more reduction in the mean bacterial load on the surfaces (1ml/m<sup>3</sup> was 54.9%, 2ml/m<sup>3</sup> was 70.9% and 4ml/m<sup>3</sup> was 86.9%). They concluded that in healthcare facilities, disinfection by means of nebulisation systems could help to reduce the risk of spreading nosocomial infections.<sup>9</sup>

Barbut F *et al.* conducted a prospective, randomized before-after trial to compare the efficacy of a hydrogen peroxide dry-mist disinfection system with 0.5% sodium hypochlorite solution to eradicate *Clostridium difficile* spores. The trial was done in-situ and in-vitro that involved two French hospitals affected by *Clostridium difficile*. In-situ disinfectant efficacy was assessed in rooms that had housed patients who were infected with the bacteria. When the patients were discharged; environmental contamination in the patient's room was evaluated before and after disinfection with hydrogen peroxide and hypochlorite. From those rooms, 748 surface samples were collected. From 748 surface samples taken; 360 samples were from rooms treated with hydrogen peroxide and 388 samples from rooms treated with hypochlorite. Before disinfection, environmental contamination for both rooms were assessed, they found that 46 (24%) of 194 samples were obtained from the rooms that treated with hypochlorite and 34 (19%) of 180 samples from rooms which treated with hydrogen peroxide were contaminated. After disinfection, 23 (12%) of 194 samples from hypochlorite-treated rooms and only 4 (2%) of 180 samples from hydrogen peroxide treated rooms showed environmental contamination. The percentage showed a decrease in contamination of 50% after hypochlorite decontamination and 91% after hydrogen peroxide decontamination. Barbut *et al.* then concluded, in-situ experiments showed that hydrogen peroxide dry-mist disinfection system was significantly more effective than 0.5% sodium hypochlorite solution to eradicate *Clostridium difficile* spores and might represent a new alternative for disinfecting the rooms of patients with *Clostridium difficile* infection.<sup>10</sup>

#### 5.1.4 Other Disinfectants Using Silver

Jung WK *et al.* conducted a study to investigate antibacterial activity and mechanism of action of the silver ion in *Staphylococcus aureus* and *Escherichia coli*. The silver ion solution was electrically generated and was exposed to the culture of both pathogens for various lengths of time. The antibacterial effect of the solution was tested using the conventional plate count method and flow cytometry (FC) analysis. They found reductions of more than 5 log<sup>10</sup> CFU/ml (Colony Forming Unit per millilitre) in both *Staphylococcus aureus* and *Escherichia coli* after 90 min of treatment with the silver ions. The researcher concluded that silver ion may cause both pathogens reached an active but non-culturable (ABNC) state and eventually die after the exposure.<sup>11</sup>

Feng QL *et al.* conducted a mechanistic study of the antibacterial effect of silver ions on *Escherichia coli* and *Staphylococcus aureus*. This study used silver nitrate (AgNO<sub>3</sub>) as disinfectant which then was examined under electron microscopy and X-ray microanalysis. Final observation, they found that similar morphological changes occurred

in both pathogens. Their cytoplasm membrane detached from the cell wall and under an electron-light region they saw the deoxyribonucleic acid (DNA) molecules in both of them condensed. Many small electron-dense granules also surrounded the cell wall and deposited inside the cells. Under X-ray microanalysis they detected elements of silver and sulphur in the deposition. From the findings they concluded that silver ions may alter DNA replication process and it also inactivated protein which was very crucial in DNA replication of the bacteria.<sup>12</sup>

## **5.2. SAFETY**

### **5.2.1. [REDACTED]**

There was no retrievable evidence on the approval of [REDACTED] by the U.S. Food and Drug Administration (FDA). However, this device is having CE Mark 0499. CE Marking is a mandatory conformity mark to many products placed on the single market in the European Economic Area (EEA). The CE Marking certifies that a product has met EU consumer safety, health or environmental requirements. Besides, the company also certified with ISO 9001:2000/EN ISO 13485:2003.<sup>4,5</sup>

### **5.2.2. Other Safety Issue**

There was no retrievable evidence which demonstrated that [REDACTED] is well tolerated, without serious adverse events.

## **5.3. COST- EFFECTIVENESS**

There was no retrievable evidence on the cost-effectiveness of [REDACTED]. The price of [REDACTED] could not be found.

## **6. CONCLUSION**

### **6.1. EFFICACY OR EFFECTIVENESS**

There was limited evidence on the efficacy or effectiveness of [REDACTED]

### **6.2. SAFETY**

There was limited evidence to suggest the safety of [REDACTED] to be used as disinfectant

### 6.3. COST- EFFECTIVENESS

There was no retrievable evidence on the cost-effectiveness of [REDACTED]

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## **9. APPENDIX**

### **9.1 Appendix 1**

#### **DESIGNATION OF LEVELS OF EVIDENCE**

- I Evidence obtained from at least one properly designed randomized controlled trial.
- II-I Evidence obtained from well-designed controlled trials without randomization.
- II-2 Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one centre or research group.
- II-3 Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence.
- III Opinions or respected authorities, based on clinical experience; descriptive studies and case reports; or reports of expert committees.

**SOURCE:** *US/CANADIAN PREVENTIVE SERVICES TASK FORCE (Harris 2001)*