



## Ag<sup>+</sup>, the silver ion ... a new look at an old friend

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### 1) Introduction

Imagine a solution which:

- Is completely safe to handle, yet destroys pathogenic bacteria, fungi and viruses.
- Can be widely used over extended periods, yet will not engender resistant strains.
- Is tasteless, odorless and colorless and does not stain.
- Has a limitless shelf life.
- A life-time supply can be generated as needed for an initial cost of a dollar.

The solution is a 3 ppm solution of Ag<sup>+</sup> (silver ions) in water, generated in minutes by soaking a swatch of silver-plated cloth in water.

*That a major effort has not been made to expand the role of silver ions in everyday life is extraordinary, considering their long history of safety in human contact, their low cost, simplicity and ease-of-use, the lack of side effects and the now enormous range of modern research data. Herein lies an opportunity, indeed a duty, for me and like-minded persons to improve the health and well-being of millions of people. We should teach the benefits of silver ion solutions and make available low-cost, easy-to-use silver ion generators. Enabling the generation of sanitizing solution as needed, at little cost, will reduce disease, human suffering and death.*

## 2) Ag<sup>+</sup>, History in Drinking Water

Alexander the Great used silver urns to store drinking water for his troops. The Romans stored water and wine in silver vessels. Silverware and silver jewelry was placed in ship's drinking water containers. Settlers in the Australian outback suspended silverware in drinking water tanks. American pioneers placed silver coins in drinking water casks.

Today, campers use tablets containing silver salts to make drinking water safe. Activated carbon faucet and refrigerator water filters contain silver salts. Silver ion water purification filters are used by international airlines. NASA uses silver ion generators to sterilize recycled water in the space lab.

## 3) Ag<sup>+</sup>, History in Medicine



From the early 1800s through the First World War, surgeons used silver sutures to close wounds. It was common practice to place silver-foil dressings over wounds.

Doctors used silver nitrate to treat skin ulcers, compound fractures and suppurating wounds. Dilute silver nitrate solution was applied to the eyes of newborns to prevent eye infections. A silver salve is used for the same purpose today.

During the 1920s, over 3 million prescriptions were written annually for medicinal silver. Silver dressings were used extensively until after World War II. Silver dressings were listed Physician's Desk Reference until 1955. In the 1970s, silver-coated fabrics were introduced as dressings for burns and skin grafts.

Today, the advent of antibiotic-resistant pathogens has caused renewed interest in silver ion therapy. There are no known silver resistant bacteria among medically relevant strains. It is this property that has inspired infection control doctors, surgeons, and wound care specialists to reexamine silver and begin applying silver technology to medical devices such as surgical instruments, catheters, prosthetics, dressings and topical antiseptics.

## 4) Mode of Action

Ag<sup>+</sup> denatures thio (S-H) groups within proteins essential to the structural and functional integrity of micro-organisms. Sites of critical activity:

**membranes** - Proteins are weakened; the membrane bursts and the cell dies.

**mitochondria** - Enzymes essential for respiration are blocked and the cell starves.

**nucleic acids** - DNA and RNA information is scrambled and the cell neither grows nor divides.

Because thio groups are common to non-pathogens, pathogens, antibiotic-resistant pathogens, fungi, algae and viruses, all are affected. For these reasons, Ag<sup>+</sup> is a general "antimicrobial", rather than specifically an "antibacterial".

Today, Ag<sup>+</sup> has been confirmed an excellent antimicrobial. Silver applications currently represent one of the fastest growing sectors in micro-organism control because it is a

remarkably effective defense against an enormous range of infectious diseases - including the increasing number of dangerous “superbugs” like MRSA (methicillin-resistant *Staphylococcus aureus* with its growing number of strains) and newly emerging pandemic threats, such as Influenza A (H1N1), bird flu (H5N1 virus) and SARS (Severe Acute Respiratory Syndrome). Research at Washington University School of Medicine in St. Louis confirms studies that antibiotic resistant strains of pathogenic microbes do not develop with Ag<sup>+</sup> as they have with antibiotics.

### 5) Bacteria & Ag<sup>+</sup>

Independent laboratories in Frankfurt, Germany demonstrated that silver, “fulfilled European Standard EN1040 requiring 99.999% reduction of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*, *Corynebacterium minutissimum* and *Escherichia coli*.”

Independent Nelson Laboratories in Salt Lake City, Utah confirmed the kill of **Methicillin resistant *Staphylococcus aureus* (MRSA) and Vancomycin Resistant *Enterococcus faecium* (VRE) bacteria** by an Ag<sup>+</sup> complex within two minutes of contact.



*Bacdyn*  
3.2% silver nitrate



*Microdyn*  
3.2% silver nitrate,  
0.6% copper nitrate

### Ag<sup>+</sup> Produce Sanitizers

*Microdyn* and *Bacdyn*, silver sanitizing concentrates for produce, costing about \$1/ounce, have been available in grocery stores throughout Mexico for decades.

Before use, concentrates are diluted 6 drops / quart of tap water (yielding 10 ppm). A 3-oz. (90 ml) bottle makes about 300 quarts of silver sanitizer.

### 6) Fungi & Ag<sup>+</sup>

A College of Medicine, Yeungnam University, Daegu, Korea study shows Ag<sup>+</sup> “has a potent activity against strains of **Trichophyton mentagrophytes and *Candida* species.**” (skin fungi)

A Texas A&M University study concludes, “antifungal activity of ionic or nanoparticle silver has a great potential for use in controlling spore-producing **fungal plant pathogens.**”

### 7) Algae & Ag<sup>+</sup>



Silver electrode electrolysis units are used to generate Ag<sup>+</sup> for algae control in swimming pool and cooling tower waters. Silver wire or silver chloride salt is placed in aquaria to inhibit algae growth.

8,000 ppm Ag<sup>+</sup> solution is used for algae control in swimming pools. Ag<sup>+</sup> is algaecidal in concentrations of 10 to 50 ppb.

## 8) Viruses & Ag+

The Environmental Protection Agency quotes on its website: “based on available scientific information, Ag+ products are effective against the **H5N1 virus**.”

A 2009 evaluation by Kasetsart University, Thailand found that Ag+ completely deactivates the **avian influenza A (H5N1) virus** within ten minutes of contact.

Recently in Hong Kong, Ag+ has proven to be very effective against the **Avian Influenza A (ATCC VR-544, Hong Kong Strain) virus**.

In St. Paul, Minnesota, AppTec Laboratory Services verified “complete inactivation” of the **Human Immunodeficiency type 1 Virus** by an Ag+ complex in less than one minute of contact.”

A University of Texas 2005 study demonstrated Ag+ is effective against **HIV-1 virus**.

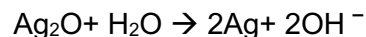
A study at the University of Arizona showed Ag+ to be effective against the **corona virus** that researchers used as the surrogate for SARS.

A 2003 study by the Chinese Center for Disease Control and Prevention found Ag+ to be highly effective against the human **SARS virus**.

## 9) Generating Ag+ from Silver Metal



Silver metal, submerged in pure water which is exposed to air, reacts with dissolved oxygen at the silver / water interface, forming a slightly soluble silver oxide film:



The dissolution rate slows with time and stops at an equilibrium concentration of about 2.8 ppm (2800 ppb). (Ag+ concentrations as low as 10 to 50 ppb have been shown to be lethal to microorganisms.)

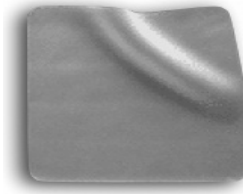
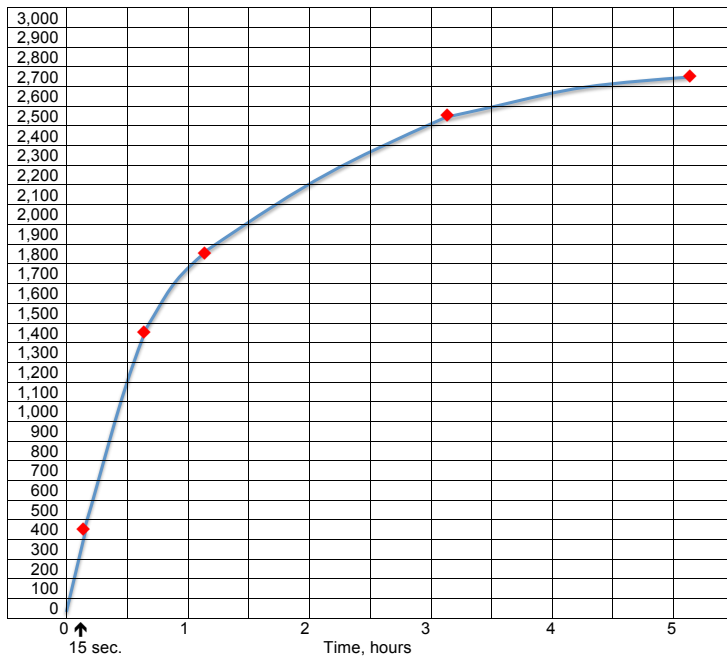
The dissolution rate is impractically slow in a system with low silver surface area to silver mass ratio such as that of a silver coin in a glass of water.

## 10) Large, Low-Cost Silver Surfaces

Because silver ions are generated and released from the surface of metallic silver, the rate of silver ion release is directly proportional to silver's wetted surface area. Reducing the thickness of a silver mass increases its surface area. More surface area exposes more silver atoms to water and dissolved oxygen and thus increases the rate of silver oxidation and dissolution.

An electroplating process bonds 99.9% pure silver on polyamide (nylon) yarn. A finished SN fabric woven from the yarn is 12% silver by weight. The surface area of silver in the form of a one troy ounce (31.1 gram) silver coin increases from 4.6 sq. in. to 8,000 sq. in. when plated on nylon yarn. The surface area of the silver mass is multiplied 1,750 times.

Silver, ppb



A 9" x 9" square of dry *Balingen* knitted silver-plated nylon cloth was added to one pint of distilled water in a light-tight container.

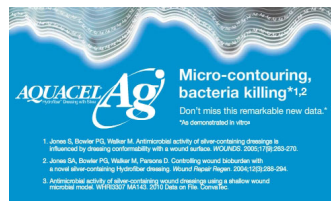
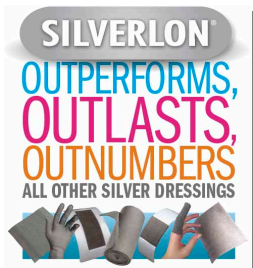
Silver ion concentrations were measured with *Hanna Instruments'* HI96737 Silver Photometer.

| <u>silver, in the form of:</u> | <u>cost of 10 sq. in. of silver surface</u> | <u>relative cost</u> |
|--------------------------------|---|----------------------|
| silver-plated nylon (SN) cloth | = 16¢                                       | 1                    |
| silver foil, 1 mil thick       | = \$30                                      | 187                  |
| silver coin, 1 troy oz.        | = \$43                                      | 268                  |

## 11) Ag+ Generators and Ag+ Solutions in Wound Care



Ag+ generators in over-the-counter bandages



Ag+ generators in professional surgical dressings

## 12) Practical, Portable Ag+ Generator and Applicators

The heart of the silver ion generator is silver-plated nylon (SN) fabric. Silver metal is bound tenaciously to the underlying nylon polymer. SN fabric has been tested for more than 250 machine washings without reduction in antimicrobial effect. In the much milder application in a generator, that of being soaked in water, the silver layer will last for many years.

Placed in water, silver fabric generates 2500 ppb anti-microbiocidal Ag+ solution for years - as long as silver appears on the cloth.



## REFERENCES

### 13) Technical Papers

#### Silver Nylon: a New Antimicrobial Agent

Departments of Surgery & Orthopedic Surgery, Louisiana State University, 1982

#### Silver-Coated Nylon Fiber as an Antibacterial Agent

Department of Molecular & Cell Biology, Pennsylvania State University, 1986

#### Antibacterial Activity & Mechanism of Action of Silver Ion in *S. aureus* & *E. coli*

Department of Microbiology, Seoul National University, 2008

### 14) Current Commercial Applications

Outside the health care sector, silver is incorporated in sponges, food containers, cutting boards, counter tops, tables and refrigerator interiors to protect against food contamination. Toys, sporting goods, athletic equipment, wrestling mats and computer keyboards contain silver. Silver is employed in washing machine wash and rinse waters and in sports and military clothing to reduce infections and odors.

Chemical & Engineering News describes a new method from *Nexxion* for applying a permanent Ag+ coating to **catheters, IV needles, and other medical devices**, the chief technical officer of the company says, "To date, no pathogens have been able to survive contact with silver."

*SilverSanitizer.com* offers self-contained **Ag+ generating applicators** using distilled water and silver cloth.

*AcryMed*, a nanotechnology company, recently announced FDA approval of its product *SilvaGard*, a silver-nanotechnology coating which protects **medical devices** from bacteria. The company states, "Ag+ has been long recognized and used as a highly effective antimicrobial."

**Cooling Tower, humidifier, spa and swimming pool** waters are sanitized with Ag+ ions.

*Covalon*, has introduced an antimicrobial Ag+ releasing, collagen-based sheet **dressing for wound care**. The president of the company says, "In the wound dressings market, silver dressings growth outperforms all others in this category."

A press release by *Curad* quoted Philip M. Tierno, Ph.D., Director of Clinical Microbiology and Immunology at New York University Medical Center and author of *The Secret Life of Germs* (Atria Books 2004), "Silver is a natural antibacterial that works by killing bacteria, fungi and yeast by interfering with metabolisms necessary for life."

*Curad* and *Johnson & Johnson* **bandages** are now available impregnated with Ag+.

*AgION* states that, "Today silver is a key ingredient in new high-tech, powder-coated finishes that hospitals and doctors' offices are using to **protect walls, counters** and other **germ-gathering surfaces**."

Hospitals and other medical facilities use Ag+ technology in **climate control system components** and **ductwork** to prevent the transmission of bacteria that cause Legionnaires Disease. **Water service to hospitals** use silver-ion technology.

*ARC Outdoors* uses silver-infused fabric from *NanHorizons Inc.* to produce **antimicrobial socks** for the U.S. military, *Wal-Mart*, *Bass ProShops* and *Cabelas*.

*SmartSilver* is a brand of odor-eliminating **underwear, stocking caps** and **gloves** that employ Ag+ to kill bacteria on contact.

**Slippers and pillows** now have Ag+ compounds incorporated into the fabric to prevent odor-causing bacteria.

*Samsung* recently introduced a clothes **washing machine** that kills 99% of bacteria in cold water using electrolytically-generated silver ions.

**Containers for food storage** are now being impregnated with Ag+ releasing compounds to prevent bacterial growth that contributes to spoilage.

*Adidas* and *Polartec* have licensed silver-coated nylon fabric from *X-Static* to incorporate germ-killing silver in **athletic and outdoor clothing** for their ability to kill odors (caused by organisms).

*Gray Matter* brand air filter media, produced by BEC Technologies of Colorado Springs, CO, contains activated carbon made antimicrobial with Ag+.

*J-Wear* is a new type of anti-bacterial, water-absorbent, odor-eliminating **clothing designed for space missions**. Antistatic and flame retardant, their **socks, T-shirts, trousers** and **leggings** are made of cotton and polyester coated with silver.

Writing **pens, bath mats, cutting boards** and **door knobs** are being coated with silver compounds to prevent bacteria from reproducing and spreading.

*Microbecide*<sup>™</sup> incorporates Ag<sup>+</sup> technology for diverse use in personal, professional, commercial and industrial applications. Other areas of use include **food contact surfaces, clinical work surfaces, medical wipes** and **water treatment applications**.

Prisons, where stubbornly resistant staph infections are problematic, are turning to Ag<sup>+</sup> for a solution. Ag<sup>+</sup> technology is presently being utilized in 15 different **correctional facilities** in Oklahoma, Kansas, Tennessee, Ohio, Minnesota, Louisiana, Pennsylvania, Florida and Texas.

**Cruise lines** are employing Ag<sup>+</sup> technologies as a defense against ship-wide Norovirus (stomach virus) outbreaks.

### 15) Articles

*"Silver Bromide Shines In Bacteria-Fighting Coating," Bethany Halford, Chemical & Engineering News, Latest News – Nanotechnology, July 12, 2006*

*"New Nanotechnology Receives FDA Approval - Setting Stage For New Era In Battle Against Hospital Related Infections," December 12, 2005*

*"SILVERCEL<sup>™</sup> Antimicrobial Alginate Dressing Protects the Healing Environment With Silver, Johnson & Johnson News, April 13, 2004*

*"University Study Shows Ag<sup>+</sup> Effective Against SARS; Supports Previous Research Findings on SARS Virus," BioPortfolio by AgION Technologies, June 13, 2005*

*"Study Shows Silver Nanoparticles Attach to HIV-1 Virus," Syeda Z. Hamdani, October 14, 2005*

*"Silver Fights Germs Naturally," Press Release from Curad, October 19, 2004*

*"Old Curative Gets New Life at Tiny Scale," Barnaby J. Feder, The New York Times, December 20, 2005*

*"Ag<sup>+</sup> Complex Designed for Antimicrobial Use in Humans Receives U.S. Patent," Invision International Health Solutions, Inc. Press Release, June 29, 2005*

*"Tulsa County Jail Eradicates Long-Standing Staph Problem: No New Cases in 5 Months With Use of Staph Attack Disinfectant" Lexdon Business Library, Feb 08, 2007*

### 16) Books

Silver in Healthcare: Its Antimicrobial Efficacy and Safety in Use, by Alan B. G. Langsdow, 2010. Published by the Royal Society of Chemistry, [www.rsc.org](http://www.rsc.org)

