

Colloidal Silver: A Closer Look

By Peter A. Lindemann

[Introduction](#) / [Making Your Own](#) / [It's in the Water](#) / [Please Pass the Salt](#) / [The Best is yet to Come](#) / [The Yellow Color](#) / [The Brown Glass Bottle](#) / [The Same Difference](#) / [Colloidal or Ionic](#) / [Purity of Silver](#) / [Concentration](#) / [Dosage](#) / [Safety & Toxicity](#) / [Effectiveness](#) / [The Regulators](#) / [Digestive Interactions](#) / [Septic Tanks](#) / [Conclusions](#) / [References](#) /

Introduction

During the last two years, a number of books and articles have appeared in public on the subject of colloidal silver. Some of these include: the Bio-Tech News Special Report, "Hi-Yo Silver"; Colloidal Silver, The Natural Antibiotic Alternative, by Zane Baranowski; Colloidal Silver, by Tonita d'Raye; and "Banishing Disease with Three Nine Volt Batteries", parts I & II, by Mark Metcalf. Literally hundreds of other newsletters and small publications have repeated the information in these articles without checking the content for accuracy.

The appearance of these materials two years ago was the first wave of public education concerning colloidal silver. Today, most Health Food Stores carry and sell several brands of colloidal silver, scores of MLM companies have colloidal silver products in their lines, and prices are starting to drop. While it is still possible to spend as much as \$10/oz. for colloidal silver in Health Food Stores, prices can be as low as \$5/oz. Some mail order catalogs sell it for as little as \$2.50/oz., and I have seen small classified ads selling it for under \$1/oz. The trend is definitely toward a lower price.

One of the phenomena driving the price down is the appearance of the devices that allow people to make their own colloidal silver. At this time, (Spring 1997) the cottage industry of colloidal silver generators is starting to penetrate the larger market. This is starting to cause alarm in high places. One major commercial manufacturer of colloidal silver has recently issued a warning statement to its customers, alerting them to the dangers of the "inferior quality" of colloidal silver made by these devices. CNN and other major media have also tried to scare the public away from colloidal silver by showing a blue-skinned person who "suffers" from Argyria, a cosmetic condition caused by the build-up of silver compounds under the skin. Even JAMA (The Journal of the American Medical Association) has run articles warning of Argyria and the toxicities associated with "colloidal silver proteins." On January 16, 1997, new labeling guidelines concerning colloidal silver went into effect, issued by the FDA. Other FDA rulings on "safety and effectiveness" are still pending. With all of these developments, it doesn't take a rocket scientist to see that the whole situation around colloidal silver is heating up!

The purpose of this article is to raise the level of public knowledge to a higher degree of accuracy. Knowledge is power, and the public needs to know the truth about colloidal silver.

The first thing people need to know is that there are at least FOUR different products on the market being called COLLOIDAL SILVER.

The first type of product is the classic, original kind, usually called "electro-colloidal silver." This product is made either by the "electro-arc" method in deionized water, or by the "low voltage electrolysis" method in distilled water. This product is usually found in concentrations between 3-5 ppm (parts per million), but sometimes as high as 100 ppm. Properly made, this product consists of microscopic particles of pure, elemental silver suspended in water, with no other elements present. Each particle of silver carries a POSITIVE electrical charge. Colloidal silver made this way appears either transparent-clear or transparent-light yellow.

The second is called "mild silver protein." This product chemically binds microscopic particles of silver to a protein molecule. It is usually found in concentrations between 20-40 ppm. Its appearance may be transparent-clear or amber.

The third are "silver salts." These products can be made either chemically or electro-chemically and usually create a form of silver that DISSOLVES in the water. Concentrations range between 50-500 ppm. Its appearance is transparent-clear. The silver particles do carry a POSITIVE electrical charge, but almost invariably, these products contain other elements or compounds other than silver.

The fourth is sometimes referred to as "powdered silver." This product was developed by the Russians and is made when a pure silver wire is rapidly disintegrated by an high voltage electrical discharge, similar to an old photographic flash bulb. The microscopic silver dust is collected and either dissolved in water or added to salves and creams for topical use. Concentrations range from 100-500 ppm.

All of these products work, to one degree or another, as a broad spectrum germicide because they all contain microscopic particles of SILVER. That said, it is important to understand a number of things: 1) all of these products are not "colloidal suspensions" of silver, 2) these products DO NOT all behave the same in the body or in laboratory tests, 3) effectiveness and dosage varies from product to product, 4) quality varies from product to product and from batch to batch with the same product, and 5) they are NOT all uniformly safe and non-toxic. There are no industry standards that manufacturers voluntarily follow to assure quality control and there is no governmental regulation of the industry.

On the other hand, there are millions and millions of satisfied colloidal silver users who would like to have continued, free access to the product, and a growing number of manufacturers entering the market with a wide variety of new products.

The critical factors that make a "good" colloidal silver product are particle size, purity, concentration, and cost. The only way to authoritatively determine the first three is by laboratory analysis. The best way to determine particle size is by electron microscope photograph. The best way to determine purity is by mass spectroscopy or by x-ray defraction analysis. The best way to determine concentration is by chemical analysis of total dissolved solids. The cost of the product should be calculated in reference to the total quantity of silver present, such as: \$5.00/oz of 100 ppm is equal to 25¢/oz of 5 ppm (the first has 20 times more silver by volume and costs 20 times more by volume.)

Making Your Own

The simplest way to control these factors is to make the colloidal silver for yourself. By doing this, you will not know exactly what is there unless you do laboratory testing, but you will have a pretty good idea. Without laboratory testing of commercial products, you don't know much more, because the quality control batch to batch is loose with most brands. Also, by making it yourself, you will end up with real "colloidal" silver, which is the product referred to in most of the literature.

If you are already making your own colloidal silver, please pay special attention to this section because much of the information you now have may be incorrect.

The simplest way to make real colloidal silver at home is by the "low voltage electrolysis" method. A few batteries may be connected to some silver electrodes and placed in a glass of water. This process will cause small particles of silver to be sintered off the electrodes and enter the water. This deceptively simple method is very easy to do **WRONG**, and most people who are making colloidal silver at home are making an inferior product.

It's In The Water

When you do this yourself, it is very important to control the purity of the water, because the purity of the water is one of the factors that controls how small the particles of silver will be. Only high quality **DISTILLED** water should be used. You cannot use purified or filtered water because it still has too many dissolved minerals in it. You cannot use deionized water because it doesn't conduct electricity well enough to start the reaction. Distilled water is just perfect to start the reaction slowly and let it proceed properly.

Another variable that influences particle size is the water temperature. The warmer the water, the faster the reaction will take place, and the smaller the particles will be.

Please Pass The Salt

Regardless of what anyone has said to the contrary, silver chloride will ALWAYS form if any amount of salt is present. Never add anything to the water that will make the water conduct electricity better. Never add salt, sea salt, or Celtic sea salt to the distilled water because the salt puts chloride ions in the water that react with the silver to form silver chloride. Another serious problem arises when making colloidal silver with salt in the water. The presence of salt increases the electrical conductivity of the water and this dramatically speeds up the reaction. As the reaction speeds up under these circumstances, it produces larger particles. The product produced is invariably cloudy-white in appearance. Actual electron microscope photographs of this material show silver particles in the range of .05 to .15 microns. These particles are TOO LARGE to form a colloidal suspension, and the proof is that the material will settle to the bottom of the container in a very short period of time. Therefore, this home brewed "colloidal silver" product may be dangerous to consume internally for TWO reasons: the presence of silver chloride and the production of large particles.

The Best Is Yet To Come

The very best voltage for the reaction is 30 volts, because the electrodes run the cleanest at this voltage. If you have a small power supply, set it for 30 volts. If you are running on batteries, it is best to start at 36 volts (three 12 volt batteries or four 9 volt batteries) and let the batteries drain down from there. Holding the silver electrodes at a uniform distance away from each other yields a better product.

When 30 volts is applied across silver electrodes held uniformly apart in distilled water, a totally different event happens. First, the reaction proceeds very slowly. Often, for the first 15 minutes nothing seems to be happening. Then finally, a faint yellow mist will begin to form. Within a few minutes, the reaction will speed up, but the particles produced will be a golden-yellow as viewed with a flashlight. Using this method, 8 ounces of distilled water at room temperature can be made into a 3-5 ppm colloidal silver preparation in 20-25 minutes. Made this way, colloidal silver can cost under 10¢/oz to make. Electron microscope photographs of this product show a silver particle size in the range .001 to .004 microns. During manufacturing, the particle cloud is a golden-yellow. These particles will hang in the water at the level they are produced, and for the most part, will not fall to the bottom of the glass. This is what a "colloidal" preparation of silver looks like. After the particles disperse, the water will look clear again, but may turn a light yellow if the concentration is high enough and after the particles have become evenly dispersed.

"The Yellow Color"

There has been a fair amount of controversy in the public literature concerning the appearance of the "yellow" color. A lot of well meaning people have told me that "yellow is bad", "silver isn't yellow", "yellow is sulfur contamination", "yellow is iron contamination", and lots of other things. I finally found what I believe to be

the answer to this question in a book titled Practical Colloid Chemistry, published in London in 1926. In the section on the "Colours of Colloidal Metals", sub-section on the "Polychromism of silver solutions" on page 69, I found the following statements: "The continuous change in colour from yellow to blue corresponds to a change in the absorption maximum of the shorter to longer wave-lengths with a decreasing degree of dispersion. This is a general phenomenon in colloid chemistry illustrating the relation between colour and degree of dispersion." This section goes on to describe the colors that show up in a wide variety of colloidal metal solutions. Interestingly, they ALL have a yellow phase. For true "electro-colloidal" silver, the particle size range that can appear yellow is .01 to .001 microns (10 to 100 angstroms) because that is the size of silver particle that best absorbs the indigo light, leaving only its inverse color, yellow, to be observed. The final transparent-yellow appearance only shows up after the particles have become evenly dispersed.

The Brown Glass Bottle

Once you have gone to the trouble of making colloidal silver particles as small as .001 microns, it is important to protect them. The particles stay away from each other in suspension because they each have a positive electrical charge (+) and these "like charges" repel each other. Anything that can strip this charge off the particles will degrade the quality of the colloidal silver by a process called re-coagulation, where the particles clump together again to form larger aggregates. Ultraviolet light from the sun and many plastics can cause this process to occur. Therefore, colloidal silver is best stored in dark, glass containers. The two kinds of glass container that are suitable for this are the dark amber and the cobalt blue.

The Same Difference

The biggest "secret" about the manufacture of high quality colloidal silver is that it is nearly impossible to standardize the product. Silver is apparently reactive to a number of natural forces that have yet to be identified. Even when the voltage, the water, and the water temperature are identical, different batches will proceed at different rates on different days. The speed of the reaction can vary by over 100% depending on the day. On "normal" days, the reaction is proceeding well by 15 minutes, with a visible cloud of particles. On "slow days" it may take 30 minutes before any visible production of yellow particles begins. Because of this variation, it is always wise to observe the reaction with a strong flashlight so you can see how quickly the reaction is happening. Once the yellow cloud starts forming, time the batch for 5 more minutes. This is the best way to standardize your home brewed colloidal silver.

Colloidal or Ionic?

Another big controversy surrounds the question of whether this method produces "colloidal" silver or "ionic" silver. Most people have been told that colloidal silver is "good" and ionic silver is "bad." Once again, the truth might be unpopular. The word "colloidal" refers to a condition where, in this case, a solid particle is

SUSPENDED in a liquid (silver in water). The solid particles are too large to be considered DISSOLVED, but are too small to be filtered out. This colloidal condition is most easily detected by what is called the "Tyndall effect", where a narrow beam of light is shined through the liquid to produce a cone shaped dispersion of the light. The particles so illuminated also exhibit a random, zig-zag activity called "Brownian motion" when observed under a microscope. When something is completely dissolved, both the Brownian and Tyndall effects disappear.

The word "ionic" refers to a condition where a particle has an electric charge. In the case of "electro-colloidal" silver, this electric charge is ALWAYS positive. Silver will not form a negatively charged ion. So, the truth is that electro-colloidal silver is BOTH colloidal and ionic. It is considered colloidal because of the particle SIZE and it is considered ionic because of the particle CHARGE. In fact, most of the biological studies suggest it is colloidal silver's ionic characteristics that make it such a good germicide. It is also interesting to note that the old chemistry books make no distinction between the colloidal and ionic states of the electro-colloidal metals.

Purity of Silver

The quality of your finished product depends entirely on the purity of the water you start with and the purity of the silver you start with. Most of the current literature suggests that only 99.9999% pure silver can be used. Most home brew systems use 99.9% pure silver. So, what is the difference? To find out, I contacted Academy Metals, a company in Albuquerque, New Mexico, that produces commercial silver. The total allowable impurities in 99.9% (.999 fine) silver is 1000 ppm or 1 part in 1000. These impurities and their maximums are 1) Copper, 800 ppm, 2) Lead, 250 ppm, 3) Iron, 200 ppm, and 4) Bismuth, 10 ppm. This product is readily available in wire form and costs about \$3.00 above the market (spot) price of silver. When this product is used to make electro-colloidal silver at a concentration of 5 ppm, the total impurities from the silver drop to 4 ppb (parts per billion) copper, 1.25 ppb lead, 1 ppb iron, .05 ppb bismuth. With all allowable impurities at these low levels, there is a reasonable argument for not being concerned. Still, sometimes small things make a big difference. 99.99% silver (.9999 fine) has total allowable impurities of 100 ppm of the same metals in the same ratios, and costs (in wire form) between \$50-\$90 above the spot price of silver. 99.999% silver (.99999 fine) has total allowable impurities of 10 ppm, and in wire form costs about \$250 above the spot price. 99.9999% silver, in wire form, costs more than gold and is very difficult to find commercially.

In one sample of 10 ppm colloidal silver we sent out for total analysis (made with 99.9% silver electrodes), the primary impurities found were: 1) Sodium, 470 ppb, 2) Calcium, 260 ppb, 3) Manganese, 70 ppb, 4) Potassium, 50 ppb, and 5) Magnesium, 24 ppb. Since none of these impurities could have come from the silver, it suggests that the purity of the water should be of greater concern to the

person making their own colloidal silver, than spending extra money on purer silver.

Concentration

The concentration of silver in the water is usually measured in parts per million, or ppm. While this is the standard convention, ppm is a "ratio" and not an indicator of quantity. When a laboratory tests colloidal silver for concentration, they report the findings in milligrams per liter (mg/L). Milligrams per liter is an actual measurement of weight per volume, and therefore is a real quantity measurement. In the metric system, one liter of water weighs 1000 grams, and one milligram is one thousandth (1/1000) of a gram, so 1 mg/L is the same as 1 ppm, as long as we are talking about water. Silver weighs a little more than water, but the equivalence is very close, and the terms are often used interchangeably. With this in mind, we can calculate that one teaspoon of 5 ppm colloidal silver has about 25 mcg (micrograms) of silver in it.

Dosage

In 1940, R. A. Kehoe reported that under normal circumstances, the average daily intake of fruits and vegetables would provide between 50-100 mcg of silver as a trace element. Since that time, the commercial farm soils of this country have become extremely deficient in trace minerals. Although I do not have authoritative figures for silver, according to the Earth Summit Report, issued in 1992, the levels of soil based minerals in North America have dropped over 85% in the last 100 years. Assuming that our ancestor's diet used to contain trace silver, and that our diet probably has greatly reduced levels, there is a reasonable argument for supplementing with colloidal silver. Two teaspoons of 5 ppm colloidal silver provides about 50 mcg of silver and could be considered a "nutritional" amount, if taken on a daily basis. Any amount above four teaspoons a day or 100 mcg should be considered a "therapeutic" amount. That said, it should not be assumed that electro-colloidal silver is equivalent to or has the same metabolic effect as receiving trace silver from dietary plant sources. But since there are very few plant sources of trace silver available today, colloidal silver is probably the best substitute. If you want to experiment with taking colloidal silver for an extended period of time, stay within the amounts considered to be nutritional. If you want to experiment with larger doses, do so with caution, and only for a day or two at a time.

Safety and Toxicity

Silver can act as a heavy metal poison in the body. It can also act as a trace mineral nutrient. The difference is in the particle size, NOT the concentration. Colloidal silver with a particle size of .001 microns has particles 100 times smaller than a preparation of silver with a particle size of .1 microns. The smaller the particle, the less likely it will behave as a toxin. Typically, the worst toxic reaction from metallic silver, cited in the medical literature, is a condition called Argyria. Argyria is primarily a cosmetic condition characterized by a permanent, bluish

discoloration of the skin. Argyria causes no physical discomfort, and does not have any other known side effects. Your skin just looks bluish-gray. In fact, the term "blue bloods," in reference to the royal families of Europe, probably refers to a mild, argyrial condition caused by the constant eating of food from silver place settings. It is interesting to note, however, that there has never been a case of Argyria reported from the use of electro-colloidal silver, free of salts or other impurities.

Argyria, while not being a deadly condition, certainly is undesirable. It is usually caused by the massive intake of silver salts, such as silver nitrate, silver sulfate, and silver chloride. To determine just how toxic these substances are, I contacted the Agency for Toxic Substances and Disease Registry through their on-line information service at (<http://atsdr1.atsdr.cdc.gov:8080/ToxProfiles>). All of these silver salts are talked about as toxins, but the only consequence of even high exposure in humans that is listed is Argyria. EPA issues a "control code" for each toxic substance it tracks that can cause human illness. Silver nitrate and silver sulfate have control codes, but silver chloride does not. I received essentially the same information when I spoke with Dr. Eidson at the Department of Epidemiology in Santa Fe, New Mexico. Apparently, the government thinks silver and silver compounds are toxins that essentially have no significant toxic effects other than the ability to discolor your skin.

Looking just a little deeper into the situation, I pulled out Lectures on Homeopathic Materia Medica by J.T. Kent. In the section on the use of metallic silver as a homeopathic remedy, there are 7½ pages of indications (symptoms) that include actions on the nerves and cartilage, as well as increased tendency toward emotional outbursts and mental excitability. In fact, the list of symptoms is rather extensive. So, exposure to silver may not kill you or cause organic disease, but that may not mean there is no toxicity. Apparently, silver has the ability to act as a subtle irritant as well as lodge in certain tissues. This suggests that taking colloidal silver every day may not be a good idea for people who already have these symptoms.

Effectiveness

In a study done, in part, by the Institute of Microbiology in Rome, Italy, and published in Applied and Environmental Microbiology, in December, 1992, various forms of silver were tested for their ability to kill micro-organisms. Pure electro-colloidal silver out performed silver nitrate, silver chloride, and silver sulfadiazine as a broad spectrum germicide. For all classes of bacteria, fungus, and mold samples tested, pure electro-colloidal silver worked better, and at much lower concentrations. They concluded that any additives reduced the effectiveness of the pure silver ion; the silver salts being as much as 100 times less effective. Electro-colloidal silver's effectiveness as a broad-spectrum germicide is directly related to the number and size of the particles. The same volume of space taken up by one silver particle .1 microns in size, will hold about 10,000 silver particles .001

microns in size. This reduction in particle size not only allows for a greater distribution of the silver, but it also greatly increases the total surface area of silver available for interacting with the environment. These, plus the stability of the electrical charge, are the most important factors when considering the effectiveness of colloidal silver.

The Regulators

While silver has been shown to be a very effective germicide, killing gram-negative bacteria, gram-positive bacteria, yeasts, molds, and viruses in laboratory experiments, this does not mean that it will invariably cure disease conditions in the body caused by these organisms. Colloidal silver is a fantastic adjunct to the home, but it is by no means a "cure-all". The biggest obstacle to using colloidal silver as a "home remedy" is the lack of information in the public domain on how to use it effectively in any given situation. The FDA has tested colloidal silver extensively and found that different micro-organisms succumb to its action at a wide variety of concentrations and exposure times. If any of this information entered the public domain, the FDA would consider their own research "unsubstantiated medical claims" and reason enough to classify colloidal silver as a "new drug." The "new drug" classification would be "required" because "new use protocols" had been developed that did not exist before 1938.

Here is an example of the problem. It is now estimated that one in four women will develop breast cancer in their lifetime. I have spoken to two women who claim to have cured themselves of breast cancer with colloidal silver. They were both diagnosed by biopsy. After the diagnosis, they took 2 teaspoons of colloidal silver a day until their surgery. One took a home-made product, the other took a silver protein product. In both cases, the biopsy of the removed breast tissue and lymph nodes was cancer free. The question is, will colloidal silver work this well for all cases of breast cancer? Probably not, but in the current legal and political environment, we may never know. No pharmaceutical company can control or monopolize ownership of colloidal silver, so none of them will ever fund the testing, which currently costs over \$10 Million and takes 10 years. FDA says if you claim that colloidal silver cures breast cancer, that would classify it as a new drug, and the public cannot be given access to new drugs without proper testing. Using the FDA model, it could cost the public \$1Billion to "prove" to the FDA what the FDA already knows about colloidal silver. Politics has definitely entered this picture. FDA does not want to be exposed as an enforcer for the drug companies, or be seen as an agency clearly not acting in the public's best interest. While these ideas are not new to some of us, it would be a startling revelation if a large portion of the population began thinking this way. FDA would certainly like to avoid this "public relations" embarrassment. The fact is, FDA has never spent our tax dollars discovering something important, and then published their findings for the benefit of the public at-large; especially when it involved something that was powerful, safe, and inexpensive for the public to make for themselves.

Obviously, empowering the population to be self-reliant and frugal in relation to their own healthcare is not the FDA's responsibility.

Colloidal silver clearly has some extraordinary capabilities and hundreds of legitimate uses. But without standardization, quality control, and extensive medical testing, the public will never know how best to use colloidal silver in a given situation. FDA may yet try to restrict public access to colloidal silver, claiming it is unsafe, even though they know how "safe and effective" it CAN BE when used properly. In the absence of the release of this authoritative testing data, the public is left just experimenting and groping for the answers. A big fight over the public's access to colloidal silver may be looming because the cost of healthcare in this country is out of control, and the public is looking for inexpensive solutions that work. In that sense, colloidal silver could be "just what the doctor ordered."

Digestive Interactions

Colloidal silver is apparently able to kill nearly all micro-organisms, including the "friendly flora" your digestive system needs for proper function. I have spoken with hundreds of people who have taken colloidal silver on a daily basis and have noticed no digestive upset, even after prolonged use. I have also spoken to two individuals who reported digestive upset after taking colloidal silver one time. So, in my experience, the die-off of friendly flora is possible, but rare.

There are a number of strategies that can reduce the probability of digestive interactions. The simplest one is to swish the colloidal silver around in your mouth for 30 seconds before swallowing. This promotes an absorption of the colloidal silver into the body away from the intestinal tract. Another strategy is to take smaller doses, multiple times per day, or with meals. Either way, if you do experience a die-off of friendly flora, they can be re-populated by taking any of the acidophilus products on the market.

Septic Tanks

Septic tanks are like your home's intestinal tract. They only work when populated with friendly flora. If you live in a rural area with your house on a septic system and you are making your own colloidal silver, make sure you don't throw a lot of it down the sink or your septic system may stop working properly. This problem can be handled by using a product like RID-X periodically, which is a good idea anyway.

Conclusions

Colloidal silver is an extraordinary product. It can enhance your health and the health of your family in hundreds of ways. Everyone should learn how to make high quality colloidal silver, and have that capability in their home, in case the regulators restrict its availability at some point in the future. This could be the best "health insurance" policy you ever implemented!

If you buy one of the colloidal silver makers on the market, make sure it can make the "yellow" particles. When you make it yourself, make sure you are making the "yellow" particles. If you have any doubts about the quality of the product you are making or buying, you can send samples to any of the following laboratories for definitive testing.

For particle size testing with electron microscope, contact: EMS Laboratories, 117 West Bellevue Drive, Pasadena, CA 91105 (818) 568-4065 Price will be under \$200 per sample.

For concentration test (mg/L) of total dissolved solids, contact: Associated Laboratories, 806 North Batavia, Orange, CA 92668 (714) 771-6900 Call for prices.

For elemental analysis, including "Tyndall effect" and "precipitation" test, contact: Kimball Laboratories, 600 East 11800 South, Draper, UT 84020 (801) 571-3695 Call for prices.

These companies are busy professionals who have no idea I am listing them in this article. Please don't waste their time unless you plan to submit samples for testing with payment.

References:

Agency for Toxic Substances and Disease Registry, on-line information service: (<http://atsdr1.atsdr.cdc.gov:8080/ToxProfiles>)

Kehoe, R. A. et al, 1940. J. Nutr. 19:579.

Kent, J.T. Lectures on Homeopathic Materia Medica, Jain Publishing Co. New Delhi, India, reprint 1982.

Michaelis, L. The Effects of Ions in Colloidal Systems, Williams & Williams Co. Baltimore, MD, 1925.

Ostwald, W. Practical Colloid Chemistry, Methuen & Co. Ltd. London, UK, 1926.

Simonetti, N. et al, Electrochemical Ag⁺ for Preservative Use. Applied and Environmental Microbiology. American Society for Microbiology:

Washington, 1992, Vol. 58, No. 12, pp 3834-3836.

The Association for Advanced Colloid Research, 232 NE Lincoln St. Ste."G", Hillsboro, OR 97124, private conversations.

Borderland Sciences Research Foundation, PO Box 220, Bayside, CA 95442

Special thanks to Michael Theroux for valuable research and private consultation.