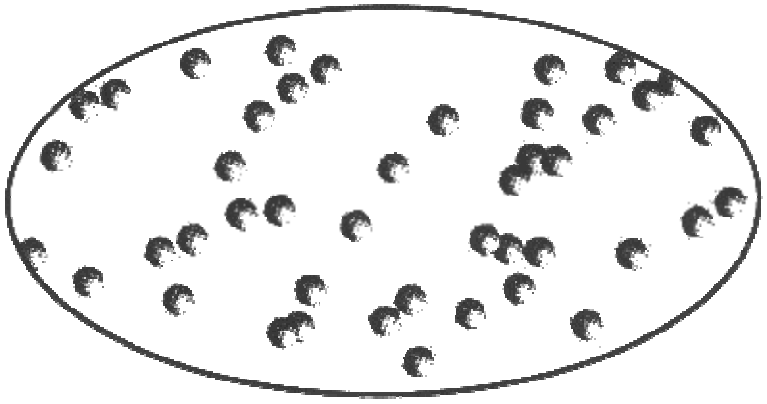
Silver Colloids

Do they work ?



⊢ .001um
Ideal Silver Colloid

By
Ronald J. Gibbs

Silver Colloids

Do they work?

By
Ronald J. Gibbs
Newark, DE 19711

Important Notice:
This book is intended solely for informational and educational purposes. The author does not, directly or indirectly, dispense medical advice, nor prescribe any remedies or assume responsibilities for those who choose to treat themselves. Proper medical attention should not be avoided or delayed when there is reason to seek professional medical help.

About the Author

Professor Ronald J. Gibbs has been the director of the Center for Colloidal Science at the University of Delaware since 1981. He has published over 85 reviewed journal articles and 5 technical reports, edited 14 books, and presented 61 talks at national and international meetings. His research and teaching deal with a wide variety of topics involving colloidal materials covering how to analyze them, what they are composed of, and what happens to them in nature. A related specialty involves studies of metals associated with colloidal particles, their toxicity and benefits to man. Dr.Gibbs' interest in colloidal silver arises from observing an abundance of incorrect and misleading opinions in advertising and related literature, coupled with the lack of availability of correct and useful information.

The Purpose of the Book

The objective of this presentation is to provide a clear, thorough understanding of what to look for and what to avoid in choosing good colloidal silver products. Do they work? & which ones? The growing threat of multi-drug resistant bacteria is good reason to think about colloidal silver. Information presently available about colloidal silver products is sometimes confusing and is often misleading. Much of the advertising and "literature" about colloidal silver is written by non-experts and is slanted toward promoting a particular product or particular devices to make it.

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Introduction

The main purpose of this book is to shed light on how to select a good quality colloidal silver product for nutritional and health purposes. The literature dating back to 1910 on colloidal silver is extensive with most references giving the advantages for the use of colloidal silver for a wide variety of purposes. Therefore this introduction is a limited presentation of the history and uses of these products. The reader will be referred to a number of additional books and articles of interest in the Recommended Reading section.

Many of the articles and books in the Recommended Reading section discuss the uses of silver as far back as several centuries. Documenting of the scientific uses of colloidal silver started in the late 1800s and was quite intense in the 1910 /20 period. Alfred B. Searle, in a book entitled *The use of colloids in health and disease*, published in 1920, reviews dozens of articles on colloidal silver from such respected journals as *Lancet* and the *British Medical Journal* as well as giving a wide range of results of his own work. This book is worth reading, although this old classic is very hard to find. These early researchers studied dozens of metals in colloidal suspension and found that two metals, silver and mercury, were very effective killers of bacteria. Both of these metals were used to treat a wide variety of ailments for many years. The mercury suspension, while effective in killing bacteria, caused harm to patients so its use decreased with time. The work of Henry Crookes [1910] showed silver and mercury suspensions killing *B. coli communis* in two minutes using mercury and in six minutes using a silver

colloid. Impressive results, indeed. However, the concentration of silver that was used at the time is much higher than is considered safe today. Since this was before the advent of the electron microscope, little was known of the true nature of colloidal silver suspensions. From the work of these early researchers came the often-quoted phrase “no microbe is known that is not killed by this colloid in laboratory experiments in six minutes.”

Another interesting study from these early years is the work of Simpson and Hewlett published in *Lancet* in 1914. They used a silver colloidal suspension to kill *typhoid bacillus* in 15 minutes at 500 ppm and in two hours at five ppm. This was the first time that low concentrations of colloidal silver were shown to be effective. Simpson and Hewlett said that one great advantage of colloidal elements in such low concentrations is that they are complete harmless to the patient.

These articles and book are samples of the numerous studies conducted in these early days [too many to present here] that report numerous applications of colloidal silver along with other silver compounds on a wide variety of ailments.

While the research on colloidal silver decreased in the 1940s and 1950s, an article published in 1966 by Brentano, et al. in the *Surgical Forum* reported their testing of ionic and colloidal silver and mixtures of the two in treating burn victims with very favorable results. They tested numerous other materials before determining that silver was the most effective treatment, especially against *Pseudomonas aeruginosa,* the organism that is one of the major factors in burn fatalities.

In a series of papers in the 1970s and 1980s, a research team from the Veterans Administration Hospital in New York produced colloidal silver from silver electrodes placed in and on the body with remarkable results in killing bacteria and providing cures in some very difficult cases. Becker [1985] concluded that what they had done was to rediscover the fact, which had been known for centuries, that silver killed bacteria. Unfortunately, when antibiotics were discovered, clinical uses for silver as an antibiotic were discarded.

In the early part of the century colloidal silver was used extensively. However in the 1940s, with the introduction of antibiotics, the use of and the research on colloidal silver decreased remarkably. The enthusiasm for the new antibiotics ran so high that in 1969 the Surgeon General of United States testified before Congress, “The time has come to close the book on infectious diseases.” The data for the following section on antibiotics were obtained from publications of the U.S. Government Center for Disease Control, the National Institutes of Health, National Institute for AID, and the Food and Drug Administration. An especially frank and factual discussion of the situation of antibiotics in the United States is presented in a British report to the House of Lords by its Science and Technology Committee.

Up until recent years when antibiotics began to lose their effectiveness against bacteria, there was always another “magic” drug on the pharmacist’s shelf. However, now the pharmacist’s shelf is almost empty. The production of new antibiotics has not kept up with the ability of bacteria to become resistant. Over past few decades drug companies have shifted their development efforts to more lucrative drugs for the treatment of heart disease, high blood

pressure, obesity, etc. In effect, in the last decade there have been no new classes of antibiotics approved by the FDA.

In a talk to the American Association for the Advancement of Science in 1994, Dr. Alexander Tomasz stated the concerns of scientists and medical professionals regarding the rapid rise of antibiotic-resisting bacteria. Currently the most threatening multi-drug resistant [MDR] bacteria which are constant problems are:

1. *Staphylococcos aureus [Staph]*
2. *Enterococcus fuecium [EF]*
3. *Tuberculosis* [TB*]*
4. *Streptococcus Pneumoniae,[Strep]*

The resistance of bacteria to antibiotics has increased rapidly in the U.S. in recent decades.
The reason that antibiotics are losing their effectiveness is that they are being overused in multiple ways. The greatest of these is by over-prescription of antibiotics, particularly for upper respiratory tract infections and for children with middle ear infections, but also for conditions such as acute bronchitis or for the common cold where antibiotics are of no use at all. Even more overuse of antibiotics occurs in a preventive fashion, such as the practice of giving children low doses of antibiotics for long periods of time in an attempt to control ear infection-causing bacteria. Even teenagers with acne are given low doses of antibiotics to decrease levels of acne-causing bacteria.

Agricultural uses of antibiotics account for more than 40% of the antibiotics manufactured. These uses include treatment of sick animals, addition to feed, and spraying on fruits and vegetables. These overuses of antibiotics kill off the bacteria susceptible to antibiotics, selectively leaving behind the bacteria that have developed a resistance to the antibiotics. In this way the multi-drug resistant [MDR] bacteria arise.

STAPH One of the most common disease-causing organisms, *Staphylococcos aureus [Staph],* now shows a 90% resistance to penicillin. These bacteria which cause skin, heart valve, blood and bone infections can lead to septic shock and death. *Staph* is now showing resistance to the next line of defense, the antibiotic methicillin, at an alarming rate. The incidence of *Staph* resistance to methicillin in hospitals in the United States increased from 2% to 29% between 1975 and 1991. Even the last line of defense against *Staph*, the antibiotic vancomycin, is showing signs that the bacteria are becoming resistant to it. About 5% to 8% of hospital patients acquire bacterial infections and the National Institute for AID believes that about 2,000,000 people acquire infections in hospital in the United States every year. In 1995, in New York City hospitals alone, there were 13,550 *Staph* infections causing 1,400 deaths and requiring treatments costing $435 million. The possibility that *Staphylococcos aureus* infection may become untreatable with antibiotics is **alarming**.

EF Another deadly bacteria, *Enterococcus fuecium,* is showing resistance to the antibiotic vancomycin, an antibiotic that is the last line of defense. For example, the reports of resistance in non-critical care units rose from 5% in 1993 to 9% to 1994 and in intensive care units from 11% to 13% in one year. This bacteria has become one of the dominant hospital-acquired wound and urinary tract infections and one researchers said, frankly, **"If you**

get this infection you are in the Almighty's hands."

TB *Tuberculosis* [TB] is on the increase around the world and the multi-drug resistant [MDR] versions of TB are becoming a global problem. While the MDR versions of TB are still treatable, the cost rises from $200 to $200,000, attributable to expensive drugs and long stays in the hospital. In 1991 MDR-TB was reported in only thirteen states; it is now found in 42 states [latest count, 1999, has it at 45 states] and is probably increasing every year.

STREP A major problem in the United States is the increase in *Streptococcus Pneumoniae [Strep]* resistance to penicillin, cephalosporins and other drugs. *Strep* can affect anyone, including the healthy and wealthy. It may cause only a temporary middle-ear infection or cough, but it may also cause *pneumonia*, *bacteraemia* [blood infection] and *meningitis*. Reports of resistant *Strep* rose from 4% in 1987 to 14% to 1994 and in 1995, 24% of *Strep* was resistant to penicillin.

The four bacteria discussed here are those with the most serious immediate threats to health. However, there are another dozen or so bacteria similarly developing resistance to antibiotics that pose problems for the future.

In mankind's war against bacteria, which started with colloidal silver, then shifted to antibiotics, what is the next weapon? We know that colloidal silver kills a wide range of bacteria and that it does so in ways different from those of antibiotics. There are few studies that indicate that bacteria have a harder time becoming resistant to silver than to antibiotics.

Particle Size in Colloidal Silver

The size of the particles in the colloidal silver suspensions we use for health purposes is very important. Particle size controls the surface area and therefore the effectiveness of the colloidal silver suspension. In Figure 1 the particle sizes typically found in colloidal silver products are shown and with ranges from 1um [micron] down to 0.001 um in diameter; all of the sizes have been found in the products examined. To put this largest size into perspective: one grain of table salt is about 200 um in diameter, so it would take 200 of the 1-um particles side by side to equal it. A 1um particle cannot be seen without the use of some magnification. To illustrate this further, a particle 1-um in diameter is equal to 100,000 particles 0.1um in diameter, 1,000,000 particles 0.01 um in diameter and 10,000,000 particles 0.001 um in diameter.

A suspension of colloid silver having more particles in these smaller sizes is preferred for maximum effectiveness: the higher number of 0.001 um particles provides much greater surface area. A highly undesirable product is one having larger particles present because, although they are part of the reported concentration, it is the greater number of smaller particles having their greater total surface area that provides greater effectiveness. In fact a colloidal silver suspension having its average size in the smaller size range [1/100 um] would be considered ideal for maximum effectiveness.

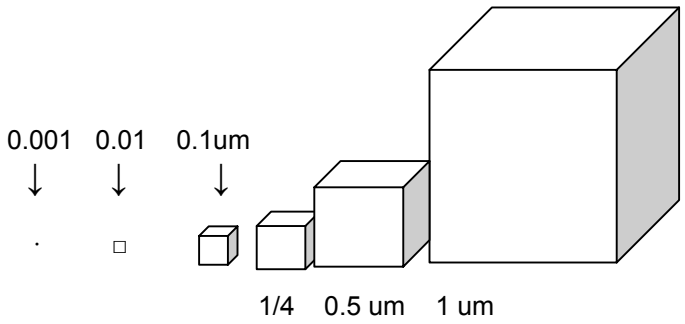


Figure 1. The relationship of particle sizes in a colloidal silver suspension.

Silver Concentration

The total silver concentration reported on the products in this study are determined from chemical analysis and are a function of:

1. the particulate silver
2. the dissolved silver.

While most of the products investigated for this study have concentrations of silver in the 3 to 10 parts per million [ppm] range, the actual proportions between dissolved and particulate material were rarely discussed in a quantitative manner on the labels.

In fact, analyses conducted on these products indicated that a great deal of the material in many of the samples was dissolved in nature. Therefore these samples had far lower concentrations of particulate silver than stated because of the large proportion that was dissolved silver. A combined value [particulate and dissolved material] is often given because the chemical analysis required to obtain silver concentration would dissolve the particles in strong acids, destroying them. As an example, in a ten ppm sample actually composed of half dissolved and half particulate material there would be only five ppm of colloidal particles present.

Particle size ranges encountered in these suspensions pose an even more difficult problem, as shown previously. Only a few of these larger [greater than 1um] particles are required to dominate the concentrations that are reported, possibly without any of the smaller colloidal particles present. In the example discussed above having half of the silver in particulate form [5 ppm] dominated by large particles [>1um] the effective colloidal silver present could be very low, even less than one ppm, hardly an effective suspension of colloidal silver.

While the concentration of silver in colloidal silver samples is important, concentration alone is misleading without knowing the proportion of dissolved material to particulate material and without knowing the size distribution of the particles. We should always try to ascertain the proportion of dissolved material to particulate silver material as well as the size distribution of the particulate silver if we are to know the quality of the colloidal silver product we are using.

The Ideal Colloidal Silver

The Ideal colloidal silver product would be made up of particles less than 0.1 micron [um] and preferably ranging from 0.01 to 0.001um. Since it is desirable to have pure colloidal silver only, the product should be in distilled water with no additional dissolved substances. There should be no solids other than the silver particles, including no gelatin stabilizers nor other extraneous material, present by accident or design. Admittedly, it is difficult to attain the ideal colloidal suspension, but we must strive to create the most ideal colloidal silver product possible. Most of the samples we will discuss fall far short of the ideal quality level we would hope for. Figure 2 below is a drawing showing what an ideal colloidal silver suspension would look like and what we should hope to find in a product purported to be a silver colloidal suspension.

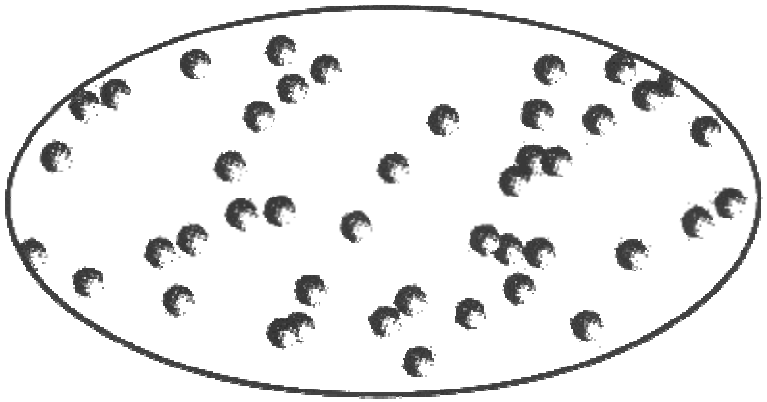


Figure 2.

Results of microscope study

In-water study on confocal microscope

Of the fifteen colloidal silver product samples investigated using the confocal microscope with the colloidal silver samples in water, four samples contained a variety of impurities ranging from unidentifiable large particles on the bottom, hair, large silver particles, and fibrous organic material [probably paper filter fibers]. Because of these impurities these four samples were eliminated from further consideration. A fifth sample considered showed fuzzy clusters around silver particles when viewed in water [Figure 3A]. Because these clusters resembled bacteria, a special staining technique was utilized to confirm the impurity. The sample was injected with live cell nucleic acid stain [STYO 13] which is taken up by live bacteria and shows as bright green when viewed using a 500 nm-long pass emission filter for fluorescence detection. As suspected, this fuzzy material fluoresced indicating the material was, indeed, live bacteria growing on gelatin that had apparently been used to stabilize the colloidal silver suspension. In Figure 3A the black dots inside the fuzzy mass are the silver particles. This sample exhibits the poor quality control that is totally unacceptable in this type of product. This sample was removed from further consideration and analysis.

The next colloidal silver product sample considered showed a large number of clusters of silver particles when viewed with the confocal microscope [Figure 3B]. These collections of silver particles are called flocs and greatly decrease the effectiveness of a

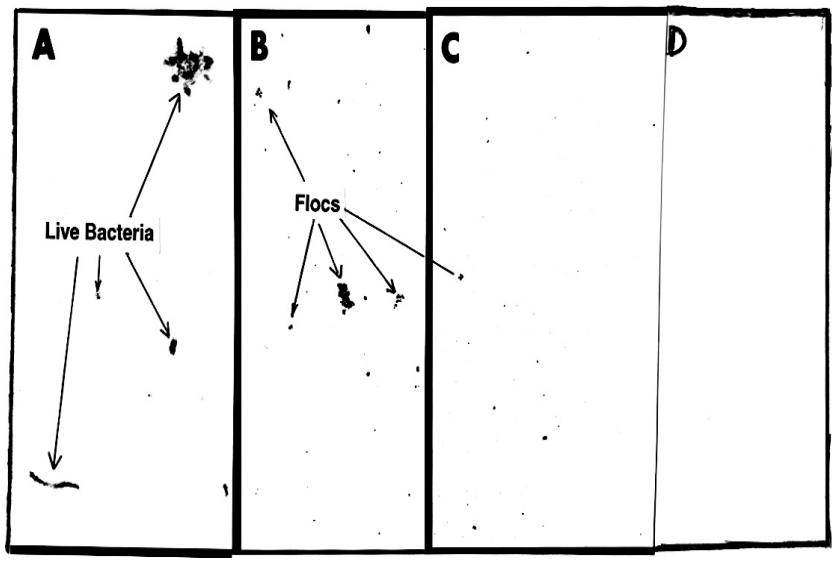


Figure 3. Photomicrographs of colloidal silver particles in water using a confocal microscope.

colloidal silver suspension. A sample having this degree of clustering of silver particles is, therefore, considered undesirable. A total of four product samples were determined to contain silver particle clustering.

In the next category of 3 samples [Figure 3C] a number of very small clusters were identified along with a number of small silver particles when viewing the sample in water with the confocal microscope. These samples would be further analyzed to determine their quality.

Three samples show some very small flocs as well as many individual silver particles [figure 3D]. These samples were of sufficiently good quality for further analysis.

Dried sample on confocal microscope

The next step in this process of elimination of imperfect samples of colloidal silver products is to examine the samples that passed the first stage a second time, this time with a confocal microscope with the samples dried. This analysis shows what was in solution and then precipitated upon drying. If the product sample contains only colloidal silver particles and distilled water very little other material will precipitate.

In fact, after drying, the ideal colloidal silver suspension sample would show only the black dots of colloidal silver particles with nothing between them, because we should be drying distilled water with only colloidal particles in it. The overall results of this test on the six product samples examined after drying showed that the majority of the samples contained a large amount of material that had precipitated from the dissolved material that existed between the silver particles. Some of the samples showed large crystals that had grown while drying, while other samples showed a large variety of small crystals, equally undesirable in the quality we want in our colloidal silver suspensions.

Transmission electron microscope study

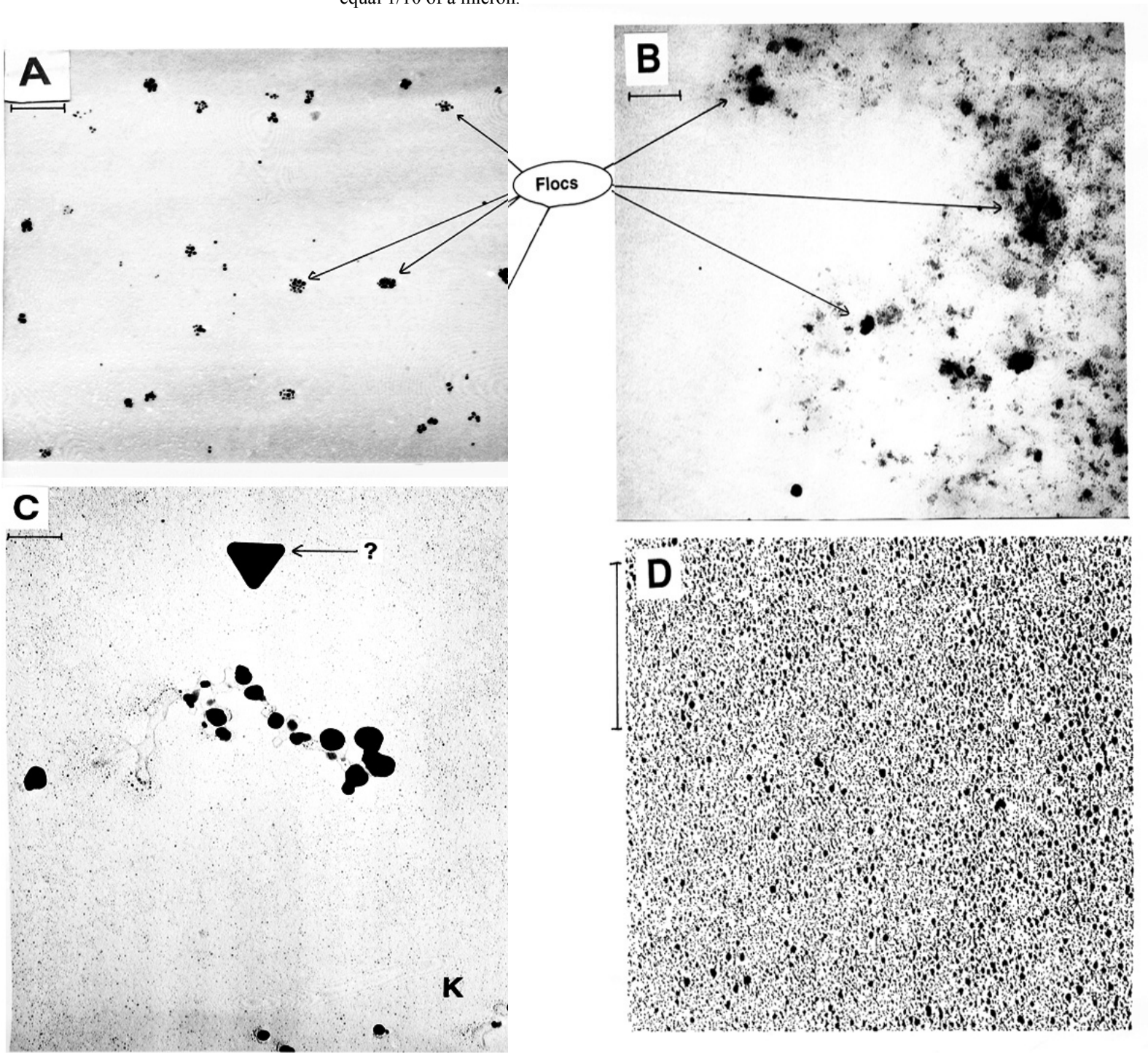
The next step in the analysis of the colloidal silver product samples examination of the six best colloidal silver suspension samples using the transmission electron microscope, with which it is possible to see colloidal particles as small as 0.001 um at the magnification utilized. The silver particles are seen as round black dots on the images. In Figure 4A the colloidal silver particles are small enough [down to 0.001 um] and, from the previous study, it would appear to be an acceptable sample, but when we looked with higher magnification using the transmission electron microscope, almost all of the silver particles were observed to be present in clusters. It should be noted that this sample also showed very few precipitated crystals between these clusters. In spite of this favorable factor, the observed clustering would materially decrease the effectiveness of the colloidal silver particles resulting in a less-than-ideal colloidal silver product.

The colloidal silver suspension sample in Figure 4B appeared to be acceptable following the confocal microscope examination but when investigated using the high magnification of the transmission electron microscope a larger amount of precipitated material coming from solution was observed. The precipitated material overwhelmed the colloidal silver particles, making this sample unacceptable as an ideal colloidal silver suspension.

The colloidal silver suspension sample in Figure 4C had a variety of medium size colloidal particles present, somewhat clustered together in flocs, but its most striking feature observed using a transmission electron microscope was the presence of the triangular crystals that had precipitated. The combination of these unknown crystals, the clustering particles and the generally lower concentration of colloidal particles cause this sample to be considered unacceptable as an ideal colloidal silver product.

One colloidal silver suspension product sample examined using the transmission electron microscope [Figure 4D] exhibited very little precipitated material between the colloidal particles, a size range of the colloidal particles that is acceptable and a concentration of these particles that is in the desired range. This sample would be

Figure 4. Photomicrographs of colloidal silver particles using a transmission electron microscope. The lines on each photograph equal 1/10 of a micron.



considered an acceptable colloidal silver suspension.

Discussion

Of the fifteen colloidal silver suspension product samples examined using the confocal microscope to study samples in water and dried, with acceptable samples further analyzed using the transmission electron microscope, none of the samples studied met the ideal colloidal level. One sample was found to be nearly acceptable on all counts with another relatively acceptable, and all others deemed unacceptable on the basis of impurities, bacteria, floc clustering of particles, and various dissolved material precipitates, all either contaminating the suspensions or diluting them from the ideal colloidal silver suspension we should hope to find.

Related Issues

Measuring turbidity

A great deal of discussion regarding measuring the concentration of silver particles in suspension in water that causes turbidity [the cloudiness of the sample] is available. Unfortunately, much of the material published is oversimplified to the point of being misleading. The main discussions focus around using optical methods [light scattering] to measure the concentration of particles in water. These light scattering techniques range from using a flashlight to observe the turbidity with the unaided eye to using electronic turbidity meters. The amount of light scattered observable by optical methods is a function of:

1. the concentration of the particles
2. the size of the particles
3. the degree of coagulation of the particles.

A book entitled *Suspended solids in water* [Gibbs, 1974] contains several articles that discuss this problem in greater detail and show the difficulties in using optical methods alone. Great care must be used to obtain turbidity readings that accurately reflect the concentration of particles in the water.

An optical test often referred to in the literature as the *Tyndall* effect occurs when a strong beam of light is passed through a silver colloidal suspension. The beam

illuminates the silver suspension indicating that colloidal particles are present, but tells us only that the particles are present and nothing of the concentration or size distribution of the particles.

Yellow color of products

An issue often discussed in the literature and in advertising on colloidal silver products is that the product should have a "yellow color." Particles in suspension in water can scatter light to produce color; however the sizes of silver particles that allow this observation range from 0.2 to 1.2um [Orr and Dallavalle, 1959]. The wavelengths of light are from 0.4 to 0.7um. Since these observations reflect particles large in size compared to the colloidal particles we want to observe, a yellow color indicates that the material has particles larger than are desirable.

Another proposition set forth is that the silver particles in suspension are oxidized by light to give this yellow color. To test the concept that the yellow color indicates the photo oxidation of the colloidal silver particles a test was performed for our study. Four of the best samples of colloidal silver products were exposed to strong sunlight in a 5 mm.-thick layer for two hours; none of the samples produced a yellow color. If this strong treatment with the ultraviolet light from a noonday sun does not produce a yellow color, obviously the yellow color is coming from another source. If a yellow color is present in the product it is probably indicating that some other unwanted substance is present causing the color, or that the particles are too large, either way indicating that the colloidal silver product is not acceptable nor is of the highest quality. The highest quality colloidal silver products tested were all colorless.

AC- or DC- produced colloidal silver

In the marketplace today are found advertisements for colloidal silver products produced using alternating current [AC] and direct current [DC] or devices to make colloidal silver. The DC-produced colloidal silver products that we have tested for this study had the highest value of ionic [dissolved] silver present [up to 17 ppm] and did not have highly rated colloidal silver. All of the highest 4-star rated colloidal silver products tested were produced utilizing the AC process.

Silver proteins

Another group of silver products on the market and that may not be clearly understood is identified as silver proteins. These products are generally made by mixing silver nitrate, sodium hydroxide and gelatin. They have been available as a mild silver protein [19 – 23% silver] or a strong silver protein [7.5 – 8.5% silver]. The lower value product actually is a strong silver protein. Remember that a 10% solution of silver is equal to 100,000 ppm compared to only 10 ppm for the colloidal silver. The use of silver protein products can cause argyria, a slate-blue silver lining resulting from the deposition of metallic silver and sulfides from their high concentrations of silver

[Fung & Bowen,1996]. Even if these products are diluted to a useful concentration, they still pose several disadvantages: [1] having the silver enclosed in a protein gelatin mass making it difficult to reaction with the bacteria and [2] provides food and an ideal surface for the growth of bacteria Fig 3A. For all the reasons given above these products should be avoided.

Effectiveness Study

Do they kill bacteria?

In evaluating a colloidal silver product we must evaluate its effectiveness in achieving the purpose for which it is being taken, that is, actually killing the bacteria. The bacteria we selected for our effectiveness study is critical because the resistance of various bacteria can vary by a factor of up to a thousand. It would be pointless to select a bacteria that is easy to kill because the colloidal silver product used would not then have been truly evaluated.

The bacteria *pseudomonas aeruginosa* was selected for our effectiveness study because it is a common infectious bacteria that has an intermediate resistance to being killed. To evaluate the effectiveness of various colloidal silver products in killing *pseudomonas aeruginosa,* a known amount of each of the colloidal silver products was mixed with a standard concentration of the bacteria. As the colloidal silver products killed the bacteria, the live bacteria that remained at various times were monitored. This procedure was designed to test

[1] how fast each colloidal silver product would kill the bacteria,
[2] whether the bacteria would be completely killed and
[3] if the bacteria would be able to recover.

The specific procedures utilized in the colloidal silver/*pseudomonas aeruginosa* evaluation are given in the section describing the methods used.

Rating colloidal silver products

The results of testing the effectiveness of various colloidal silver products in killing the bacteria *pseudomonas aeruginosa* are presented in Figure 5. In looking at this figure, follow each line from left to right as it changes with increasing time. At the beginning [left side top at 0] we see that all the samples have 500 bacteria colonies. The line labeled “water” identifies the bacteria mixed with distilled water, as a control for the study showing that the mixture of water and bacteria does not change as time increases; that is, the water does not affect the bacteria. The line labeled “ideal” on the left-hand side of Figure 5 represents what we would expect when an Ideal colloidal silver product is used to kill the bacteria. This ideal colloidal silver suspension would be given a five star rating. All of the of various colloidal silver products analyzed for this study have effectiveness results that fall between the ideal effectiveness and the control mixture of water [with no colloidal silver] and bacteria. The most effective of the colloidal silver products analyzed decreased the bacteria from 500 colonies to ten colonies in 1.4 hours and to the

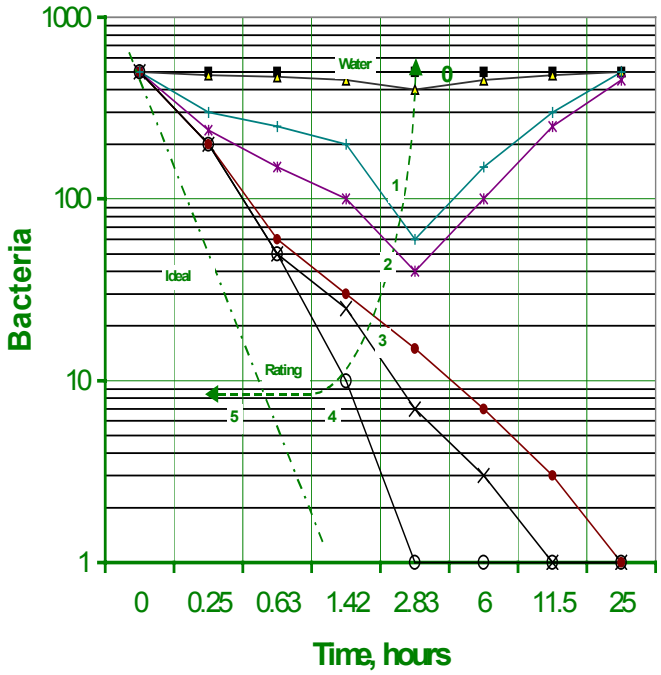


Figure 5. Variation of live bacteria colonies in colloidal silver suspension mixtures having effectiveness ratings of 0 to 5 stars ; with time.

bottom line; that is, all the bacteria had been killed in 2.8 hours. Relative to our "ideal" colloidal product, the effectiveness of this product would be rated as four stars. The colloidal silver product least effective in killing the bacteria is given a rating of zero stars with its effectiveness actually near to that of the control mixture of water and bacteria, plotting just below the curve labeled "water." In Figure 5 this least effective product shows only a slight decrease in the bacteria count in 2.8 hours with a subsequent increase back to the original bacteria level before treatment, indicating that the bacteria are reproducing rapidly again after 2.8 hours of treatment, having overcome the effect of the colloidal silver. Actually when we performed one experiment using tap water instead of the colloidal silver suspension we obtained about the same results as a zero-star colloidal silver product. Apparently the residual chlorine in the tap water is just as effective as the zero-star colloidal silver product. This zero-star colloidal silver product is, therefore, not effective and cannot be recommended.

The colloidal silver products slightly better than the zero-star product are rated as one- or two-star products and show a marked decrease in the bacteria level from 500 colonies down to 40 to 60 colonies in the first 2.8 hours followed, however, by a sharp recovery by the bacteria with reproduction reaching the original level of 500 bacteria colonies in 25 hours. The remarkable ability of bacteria to shake off the effects of treatment is demonstrated, or perhaps the bacteria simply use up the available colloidal particles of these low-rated colloidal

silver products and start reproducing again. The bacteria must be killed completely or they will return: they are not "partly killed."

Several intermediate colloidal silver products used to treat the bacteria, were given an intermediate three star rating and show a progressive decrease in bacteria level but this rate of decrease is much slower than that of the colloidal silver product rated as four stars. These three-star products took 12 to 25 hours for the bacteria to be killed. This time period may be too long as a result of dilution and other factors discussed later. These three-star products are more effective than the zero-, one- and 2-star products but they cannot be recommended as effective products because of the significant time delay in killing the bacteria.

Concentration / dilution factor

Factors that need to be evaluated to determine the effectiveness of colloidal silver products in killing bacteria are:

1. the starting concentration of the colloidal silver
2. the dilution of the colloidal silver during use
3. the change in the colloidal silver concentration by a second addition of colloidal silver.

The starting concentration [Item 1 above] is restricted by what is deemed the "accepted safe colloidal silver concentration" and is about ten milligrams of silver per liter of water [ppm]. All the products tested had safe-range concentrations of 3 to12 ppm, but be careful there are some 30 ppm and higher products of available in the marketplace.

To understand the effect of dilution and/or the decrease of colloidal silver particles associated with killing the bacteria when using colloidal silver products, the following experiments were conducted on colloidal silver suspensions having a four-star effectiveness rating. The effects observed on the bacteria in these experiments are shown in Figure 6. One hour after the bacteria were mixed with the colloidal silver suspension, the one-to-one mixture showed a bacteria count reduced from 500 colonies to about 150. The mixture of one part bacteria to two parts colloidal silver suspension had about 30 bacteria colonies present. Similarly lower numbers of colonies were observed as smaller portions of bacteria were mixed with colloidal silver until the one part bacteria mixed with 20 parts colloidal silver showed less than one bacteria colony present. Any time we add colloidal silver suspensions to bacteria -containing fluid, dilution of the colloidal silver suspension must be considered, with the resulting decrease in effectiveness. The numbers presented in Figure 6 give us some idea how dilution can have an impact on the effectiveness of colloidal silver suspensions in killing bacteria. We can observe in Figure 6 that only the mixtures of one part bacteria to four parts colloidal silver, one part bacteria to 9 parts colloidal silver and one part bacteria to 20 parts colloidal silver are effective in killing bacteria.

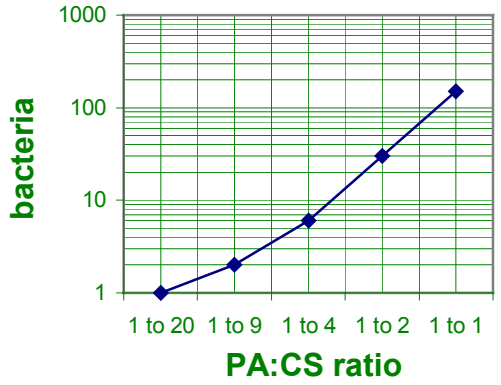


Figure 6. Variation of live bacteria colonies with the volume ratio of bacteria [PA] to colloidal silver [CS].

Our next study in examining the effect dilution of the silver colloidal suspension has on killing bacteria is presented in Figure 7. When each of the mixtures was monitored for up to 11.5 hours, the bacteria can be seen to decrease slowly at first then overcome the effect of the colloidal silver and began growing again in the mixture of one part bacteria to one part colloidal silver suspension. The mixture of one part bacteria to four parts colloidal silver suspension requires up to six hours for the bacteria to decrease to one colony. We must recognize that in six hours additional dilution of the colloidal silver suspension may occur from natural processes, making this 1 to 4 ratio mixture of marginal effectiveness. The 1 to 9 and 1 to 20 dilutions can be seen to decrease the bacteria to lower levels in much shorter times, making these mixtures a more effective dilution to use. In other words, adding one drop of colloidal silver suspension to 4 drops of bacteria-laden fluid is not effective: we must add 9 to 20 drops of colloidal silver suspension to one drop of bacteria-laden fluid. We must recognize that the effectiveness of a mixture will be related to the concentration of the bacteria in the fluid.

The reverse of dilution can work in our favor when the colloidal silver is concentrated by evaporation. This would occur when colloidal silver is used in a topical fashion as on burns, abrasions and cuts. This effect was not evaluated quantitatively in this study.

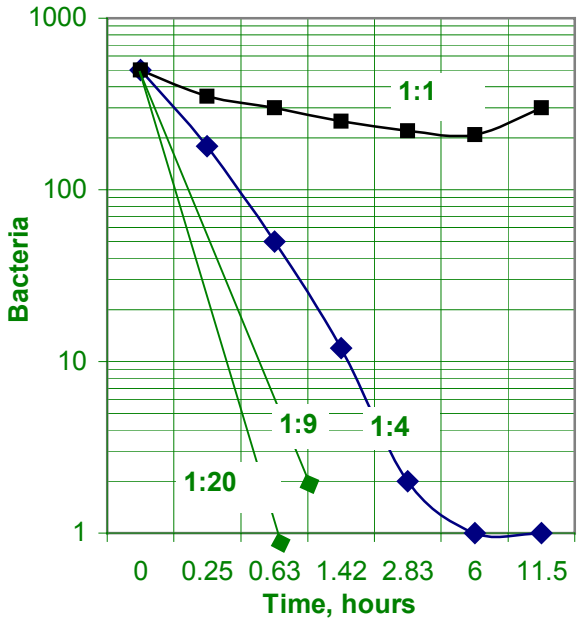


Figure 7. Variation of live bacteria colonies at different ratios of bacteria to colloidal silver, with time.

Multiple additions of colloidal silver

We have seen that colloidal silver suspensions lose effectiveness either by dilution or, possibly, when they are being used up in the process of killing bacteria. Since the test tube experiments conducted do not reflect the dilution that might occur during natural use the loss in effectiveness in this case must be attributed only to the colloidal silver suspension being used up during the killing of the bacteria.

A possible resolution to the problem of the dilution factor would be the addition of more colloidal silver suspension after a period of time. In demonstration of this Figure 8 shows the results from an experiment in which an additional four parts of four- star colloidal silver suspension were added to the bacteria/colloidal silver suspension mixture after 42 minutes. The line labeled “without addition”[of colloidal silver] in Figure 8 shows that the number of bacteria colonies decreases slowly in the mixture we started with and that even after two hours the number of bacteria colonies is still quite significant. After an additional four parts of four-star colloidal silver suspension is added to the mixture at the time marked “addition” [of colloidal silver] on Figure 8, a noticeable decrease in the number of bacteria colonies to zero bacteria colonies in a little more than one hour is observed. Addition of more colloidal silver suspension to a mixture is an interesting means of overcoming the losses of colloidal silver being used up during the killing of the bacteria. This technique deserves future research.

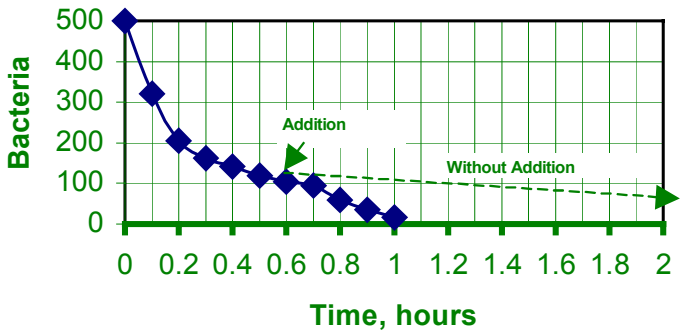


Figure 8. Variation of live bacteria colonies with and without additional four stars colloidal silver with time.

Conclusions

Many of the antibiotics available on today's market are no longer effective in killing multi-drug resistant [MDR] bacteria. This is, indeed, becoming a serious problem. The results of our microscopic and effectiveness studies have permitted us to evaluate the various colloidal silver products and devices for making them. Based on these evaluations a rating of the products could be given. Only those colloidal silver products with the highest ratings should be used.

Silver Colloids Update

If you are interested in keeping informed of the latest world-wide developments, research, and legislation on colloidal silver and on the latest news and research on MDR bacteria, the newsletter *Silver Colloids Update* may be of interest to you. There are both email and paper/mail versions. For more information or to order more books,

1. Write to: R. Gibbs, 14 Amherst Dr., Newark, DE 19711, USA

2. Email to: colloids @ usa.net

Methods

The fifteen samples of colloidal silver products investigated in this study were obtained from a wide variety of sources. Each was thoroughly mixed to obtain a representative sample for analysis in this study. A confocal Zeiss LSM 510 microscope using the 488 nm line of a Krypton Argon laser was utilized. For detection of live bacteria a 500 nm-long pass emission filter was used to detect fluorescence of SYTO 13 [a live cell nucleic acid stain]. This concoal microscope has a resolution down to 0.2 um, permitting an extensive survey of the sample. It was utilized for initial examination of the colloid in the sample water and after drying. In order to better visualize the images from a confocal microscope, the images were photo-reversed using Adobe Photoshop software.

A second microscope was also used: a transmission electron microscope Zeiss CEM 902 operated at 80 kV. Samples were specially mounted on a Formvar-coated grid to obtain a layer from a know volume of sample. Magnification at 95,000 to 200,000 times permitted resolution as low as 0.001 um or better.

Each of the fifteen colloidal silver product samples was examined in the sample water with the confocal microscope and was then dried and reexamined as the first step in elimination of unacceptable samples. Samples that passed the confocal microscope test were then analyzed using the transmission electron microscope.

The efficiency study was performed on the bacteria, *Pseudomonas aeruginosa*, ATCC strain 27853, by mixing one unit of 10^8 colony-forming units per milliliter with the various mentioned colloidal silver samples. This mixture was then allowed to react at 25° C. for the various test times. Samples were taken at these various times, diluted with distilled water and placed on agar media in Petri dishes. The samples were then cultured at 35° C. for up to 24 hours. The live colonies per unit area were then counted.

References and recommended reading*

Becker, Robert O., 1985, *The Body Electric*, William Morrow, New York.

Brentano, Loreno, Harry Margraf, William W. Monafo, and Carl A. Moyer, 1966. "Antibacterial efficacy of a colloidal silver complex," *Surgical Forum*, 17:76-78.

Crookes, Henry, 1910, *The use of colloidal of silver,* London, England.

Fung, Man C. & Debra L. Bowen, 1996. "Silver products for medical indications: risk-benefit assessment," *Journal of Toxicology: Clinical Toxicology*, 34:119.

Gibbs, Ronald J., ed., 1974, *Suspended Solids in Water*, Plenum Press, New York, NY, 320 pp.

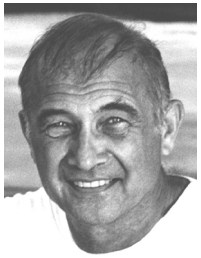
*Hiemenz, Paul C., 1977. *Principles of Colloid and Surface Chemistry*, J. J. Lagowski, ed., Marcel Dekker, Inc., New York, NY, 516 pp.

*Orr, Jr., Clyde and J. M. Dalla Valle, 1959. *Fine Particle Measurement: Size, Surface, and Pore Volume*, The Macmillan Company, New York, NY, 353 pp.

*Searle, Albert B., 1920, *The use of colloids in health and disease*, Constable & Company LTD, London, England.

*Simpson, W.J. & R. Tanner Hewlett, Experiments on the germicidal action of colloidal silver. *Lancet*, Dec.12, 1914.

ISBN 0-9676992-0-7



About the Author

Professor Ronald J. Gibbs has been the director of the Center for Colloidal Science at the University of Delaware since 1981. He has published over 85 reviewed journal articles and 5 technical reports, edited 14 books, and presented 61 talks at national and international meetings. His research and teaching deal with a wide variety of topics involving colloidal materials covering how to analyze them, what they are composed of, and what happens to them in nature. A related specialty involves studies of metals associated with colloidal particles, their toxicity and benefits to man. Dr.Gibbs' interest in colloidal silver arises from observing an abundance of incorrect and misleading opinions in advertising and related literature, coupled with the lack of availability of correct and useful information.

The Purpose of the Book

The objective of this presentation is to provide a clear, thorough understanding of what to look for and what to avoid in choosing good colloidal silver products. Do they work? & which ones? The growing threat of multi-drug resistant bacteria is good reason to think about colloidal silver. Information presently available about colloidal silver products is sometimes confusing and is often misleading. Much of the advertising and "literature" about colloidal silver is written by non-experts and is slanted toward promoting a particular product or particular devices to make it.