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Silver's Connection with the Environment and in particular Pathogens and the most likely Mechanisms for their Eradication.

A silver 'nano' bullet for Super Bugs. A hypothesis on its mechanisms

Abstract
Silver, gold and copper as bulk metals all have something in common: a single unpaired outer (valence) electron, located in the 5th shell, 6th shell and 4th shell respectively. To a lesser extent in both gold and copper, silver excels as a metal on which bacteria and other pathogens cannot survive for long when exposed to its surfaces. This mechanism is loosely referred to as the oligo-dynamic effect. However as things go mostly, "the devil is in the detail" and nothing is ever that simple. For a start, silver is superior to other metals in both electrical and thermal conduction. This is brought about by its outer unpaired electron. This is by virtue of it being unpaired and well in the outer region of the silver atom. At a greater distance from the protons in the nucleus than the other electrons, it is able to move about in relative freedom. Under specific conditions this 'lone' electron is able to escape the confines of its atom altogether. As such, it may in fact be seen as a free radical causing harm to any pathogens in close proximity. Producing pico and nanometre sized atomic silver clusters from stable silver dimers and larger clusters at dimensions below 10nm, the surface area to volume ratio becomes extremely high. This enables nano silver very close contact with the environment and pathogens. This short essay will show that In addition to the so-called oligo-dynamic effect, many other properties of silver augment their ability to eradicate pathogens, as atomic cluster sizes approach the realm of quantum physics.

Key words: quantum confined electrons and confined water. Photo-electric effect, Local Plasmon Resonances, polaritons, 420nm and Photon Electron Transfer.

Introduction

Silver's unique properties as a metal and a substance are extremely diverse and in particular allowing electrical current and thermal heat to flow much higher compared to other conducting metals such as copper. For that reason silver is used in just about all electronic applications. Its high photo-sensitivity in the photographic industry using silver halides, mirrors for domestic and industrial applications and in particular as coatings on astronomical optics. However a whole new realm opens up with Local Plasmon Resonances, Photon Electron Transfer and quantum confined electrons providing blue shifting of incoming photons when silver becomes very small.

There is a concept that my parents taught me. Whatever colour an object has, It will always appear the colour it reflects plus the colours it absorbed and emits, usually accompanied by a redshift. In the case of silver, it has a non-descript appearance, that of a 'silvery' look. That tells us that it reflects virtually all visible colours. The colour that it absorbs is also a visible colour of violet at 420nm but very close to the end of our visible range at 400nm, where it becomes Ultraviolet.

Silver has many unusual properties, the most unusual of these is its high sensitivity to light and in particular violet light at 420nm, known for this as the only part of the visible spectrum where it absorbs light instead of reflecting it. All of the other wavelengths/frequencies of the visible spectrum are reflected, all 97 % of it. We could call the absorbing colour violet, although it is not a word or description often. Generally it is incorrectly called 'blue light' for some obscure reason. Depending on the purity of silver, violet light at 420nm may actually be the refractive index of silver at 3%, although I have never heard or read about this anywhere. Often when the concentration of neutral silver atoms exceeds a certain criteria, or the particles (the term is used loosely) are of a size between 20 and 40nm, the silver in an aqueous medium displays a yellowish tinge or even darker toward an amber colour. This is an indicator and proof that the colour violet has been absorbed, giving the mixture its distinctive colour. Quite the opposite happens with a cloudless sky that turns blue away from the sun, by absorbing all colours of the visible spectrum, or as many would say "the colours of the rainbow". This phenomena is called 'Raleigh Scattering" (of light).

Silver also absorbs heat carrying wavelengths of light, but as a good conductor of heat it is able to release that heat by re-radiating that heat fast and remaining relatively cool, an advantage if used as jewellery. If this absorption and release of heat is also part of its reflective index has not been raised as an issue. However more is going on that few know anything about: The responses to light, in particular light of longer wavelengths such as green (made up of blue and yellow) yellow orange and red, possess much lower energy levels and can only cause thermal agitation. This thermal vibration will only shake the atom and jostle its outer electrons (below around 2.5 eV). Shorter wavelengths however possess an ionising energy at 2.6eV and higher at even shorter wavelengths respond with a quantum physics effect called Local Plasmon Resonances. Such a LPR or SLPR Surface Local Plasmon Resonance, are caused by an incoming photon or photons colliding with a surface electron or electrons at the so-called skin-depth of the silver and causing a local (brief duration) oscillation. Referred to as a polariton, an electron possessing the energy of a photon for a brief moment, that when the oscillation ceases, an energy altered photon is released again. Generally, as with most substances, a photonic absorption and re-emission is associated with an energy loss, referred to as 'redshift', i.e. lower electron volt value than the incoming photon. However in the case of very small atomic silver clusters (in water) in a size range of 10^{-9} and 10^{-10} referred to as nano metre and pico metre respectively , the conducting electrons that could normally move about in bulk metal, are forced to occupy a reduced area and are effectively 'Quantum Confined'. The result of this 'quantum confinement' is an additional electrical charge. When during an encounter with a collision from an incoming photon which is absorbed and causing the local oscillation, the subsequent release (re-emission of this photon), a blue-shifting will occur. This increase in energy is expressed in electron volts (eV) or fractions thereof.

Sometimes, something more peculiar than that occurs, when the incoming photon is of longer wavelength than the particle size is able to accommodate. It is like trying to fit a soccer ball into an empty match box. In classical physics that task would seem impossible, but for some reason not in the realm of quantum physics governed by the so-called "Uncertainty principle". It just starts to resonate at a much higher frequency in order to release the cumbersome lower wavelength. This strategy actually created a more energetic energy than the incoming wavelength, sometimes by many factors. This mechanism is still not fully understood.

Linear polarization effects (confirming and identifying silver) and getting small sizes in perspective.

Following on from the reflection and absorption of the visible spectrum of light in a ratio of 97:3%, silver displays another peculiarity in that it uses this tiny portion of the refractive index at the edge of visibility of 420nm (with visibility for humans ceasing at 400nm), to distinguish itself from other substances and materials that do have refractive indexes in most of the visible light.

Materials or things that possess a reflective index at visible wavelengths reflect part of that light and absorb or pass the remainder. A very simple test with a linear polarising filter will quickly tell if anything that you are looking at with a linear polarising can be polarised or not. It works this way: Hold a linear polarising filter in front of one eye and look at a shopfront window. You will see your own reflection. The same occurs when looking at fish in a pond, it reflects the sky above and also partially obscures a proper vision of the fish. Both the glass of the shopfront window and the surface of the water in the pond present a refractive index, meaning part of the light is reflected back and part is allowed to go through. Now rotate the polarising filter to a point where suddenly your own reflection in the shopfront disappears and you can better see the merchandise displayed behind the glass. The same will happen at the pond as you will suddenly see the fish more clearly. However before we take this further, let us take a look at the subject of light scattering techniques and why it is more and more used for detecting and identifying small objects.

Light scattering techniques enable nano metre sized materials to be seen. A high quality optical laboratory microscope is able to resolve objects down to 500nm (0.5 micron) most bacteria are between 2 and 0.5 microns (1 millionth of a metre). Our eyes can distinguish objects as small as $1/10^{th}$ of a mm. That is 1/10 thousands of a metre. Viruses and some very primitive life starts at 17 to 40nm and requires the use of an electron or scanning electron microscope. Light scattering techniques are able to go down as small as that as well, provided a 405nm laser diode is used for such small objects.

A second test will be more complicated and will require a pair of linear polarising filters. One will be called the polariser and the other the analyser. You will also need a small glass container and filled with a liquid such as colloidal silver. You will also need a white light LED Torch, preferably with a strong focussing facility. Some years ago a short paper caught my attention. Its title was: **Depolarization of silver nanoparticles, by physics professor Zygmunt Gryczynski. Chemical Physics Letters 2006 Elsevier.** In this paper, Gryczynski describes an experiment with two containers inside one another, i.e. a test tube containing colloidal silver and fitted into a glass beaker filled with colloidal silica. He uses a torch to shine through a linear polarising filter into both cells and using a second polarizing filter held at a right angle. Rotating the analyser, he shows that by rotating the analyser 90^0, the light scattered from the colloidal silica is extinguished, but not that from the colloidal silver.

I have rebuild this design in a number of ways and determined there is no need for more than on container, i.e. various materials can be mixed and still show extinction separation between matter high in refractive index at visible wavelengths and metals such as silver and aluminium that do not. The interesting part is that by using a spectrophotometer tuned to 420nm, the silver due to its absorbance at that wavelength, also disappears from view. Using a sensitive wideband photodiode coupled to a precision solid state operational amplifier and panel meter, can accurately quantify the light scattering values of all three materials. But now for our own experiment:

Switch on the torch and shine the focussed light through the polariser and into the glass cell holding the sample. Place the analyser in front of one eye, watch the light scattering from a right angle to the light and slowly rotate the analyser. At some point you will see a substantial reduction in the scattering of the light. What you have actually done is extinguish the scattering from anything but the silver. Its scattering of the light has remained, proving that you cannot polarise silver. The technical reason for this is that silver does not have a refractive index at visible light like other materials such as glass and water. Other matter does have a substantial refractive index at visible light and has been effectively polarised out and can no longer been seen. Such a polarising system augmented with photo sensors can with some accuracy determine the silver to other matter ratio.

Characteristics of silver that differ from other matter

Silver is a metal that has 47 electrons with the 47^{th} electron on the perimeter of the atom, unpaired in the 5^{th} shell. It is the conduction or valence electron. Silver is a lustrous metal capable of reflecting most visible light for around 97%. Only at around 420nm (part of the colour violet) it is absorbing and where perhaps its reflective index coincides. It is a rather malleable metal that can be bend and twisted easily and not enjoying the rigidity of metals like iron. It is generally found with many other elements such as copper, lead, arsenic and iron. In its native state Silver exist in two separate stable isotope, [107] Silver and [109] Silver in an almost 50:50 ratio. Most of the other 40 or so silver isotopes are considered unstable. The short segment on the use of Linear polarising filters and their ability to distinguish silver from other matter, even at very small sizes, was purposeful. Nano sized objects are simply too small to be observed my optical microscopes that are limited to observing objects at just 0.51 micron (½ a millionth of a metre), about 50 times larger than 10nm. That is the physics of light scattering. However much more is happening. A summary of a number of special attributes of quantum nano silver smaller than 10nm are:

SPECIAL NOTE!
There are many contenders, aspects of quantum silver, that either on their own or in combination with other aspects of silver are being considered as elements capable of eradicating pathogens or severely reducing their numbers. This occurs at surprisingly very low concentrations from around 3.3 to 0.6ppm, albeit in an almost indiscriminate way. Clinical trials done on this material have predominantly been of the 'in vitro' kind and only once a trial 'in vivo' on a small group of individuals, including the researching professor. All apparently without any obvious ill or side effects. It is also interesting to note that due to the very low MIC (minimum inhibitory concentration), the arsenic content was found to be less than 10ppb.

Water and water containing suspensions of colloidal silver are very difficult to test absolutely. This is mainly due to these materials existing at such subtle quantum physics levels that any technical and scientific determination requires highly specialised instrumentation. Water for instance can change its watery structure at time scales of 10^{-18} seconds according to N. Ernest Dorsey, in his 1953 Monograph, titled "Properties of Ordinary Water Substances". There is also a number of quantum effects that will have to be taken into consideration, such as the 'Blue Shift' phenomena, for this read the research of Jonathan A. Scholl et al in the Nature article Quantum plasmon resonances of individual metallic nano particles in 2012. Reference: doi.10.1038/nature 10904.

Concepts of Zeta Potential, Stern Potential as well as Nernst Potential and other characteristics like it must form part of the measurements in order to accurately assess what is happening at these quantum levels. Ref: Chemical Fixation and Solidification of Hazardous Wastes by Jesse R. Connor, 1990 ISBN 0-442-20511-2, Van Nostrand Reinhold. These varied aspects of unconventional behaviour of silver are listed below:

Phenomena of classical and quantum chemistry physics.
1. Atomic silver clusters at sizes of 10nm and below are no longer subject to gravity as compared to objects still part of classical physics that do.

2. These small sized atomic clusters possess quantum confined electrons that have only limited movement and are unable to move freely such as their counter-parts in conventional bulk silver are able to.

3. Incoming photons colliding with electrons on the surface of nano or pico sized atomic clusters (so-called photo-electrons) , electrons in the the 'skin depth' will cause brief local oscillations that will when ceased release a photon that can either be red or blue shifted. This phenomenon, referred to as Plasmon Resonance, or when a photon strikes an electron, (SLPR or Surface Local Plasmon Resonance) initial understood to occur if the incoming photon was in some way coincident with the wavelength of the surface electron. Within the realm of quantum physics it can be visualised that a particular wavelength or frequency of a photon can be reflected/scattered when the object of the collision is either of the same dimension or larger. It becomes more difficult for an electron, single atom or in the case of atomic silver clusters to reflect or scatter light that has a wavelength longer

than it can accommodate, i.e. a photon of a 700 nm wavelength on an object only measuring 400nm. In the realm of classical physics that cannot be done, e.g. trying to squeeze in an orange through a 1 inch diameter metal pipe. It will get squashed. When this happens at a quantum physics level, it would appear that there is a mechanism which modifies the long wavelength into a much shorter one that could theoretically be many times higher in electron volt (eV) level than the original incoming long wavelength and cause a blue shift. In such a case and in combination of confined electrons possessing extra energy virtually produce Ultra violet light from visible light. Ultraviolet light having sanitising/ionising properties, would have the ability to kill pathogens.

4. The Zeta potential factor. Silver being hydrophobic creates a natural barrier against water by forcing the water molecules to polarise themselves and have the hydrogen atoms orientate themselves to the slightly negative silver atomic clusters. These form from ionic silver starting out as dimers (two atoms) in size at around 0.6nm .This layer of hydrogen atoms or what is more often the case protons or hydrogen ions creating the so-called Stern layer and potential. It should be noted that a neutral single atoms is unable to stay that way and soon reverts back to ionic silver. It could very well be that neutral silver consists of pairs of atoms (dimers) that form clusters of atoms in order to stay neutral. However when measuring the electrical conditions, the cluster will outwardly still appear negative, but that no doubt will be caused by the Oxygen portion of the water molecule that is the negative aspect of dipolar water. In between the Stern layer and the Oxygen layer, a potential forms and referred to as the Zeta potential. This can range between zero (iso-electric point) and minus 100mV. From about minus 25 mV, the strength of the Zeta potential is high enough to become a repelling force and has overcome the attractive force of the naturally occurring **van der Waals force inherent in** all matter. There is no doubt that the Zeta potential may be a contender for the killing of pathogens as well. -100mV is 1/10 of a 1 volt. The other electrical charges such as the Stern and Nernst have a significantly lower amplitude of voltage and may not contribute in any way in any actions against pathogens. However I stand to be corrected.

Size, diminishing dimensions and increasing surface areas.
The comparison of curvature between the earth and a tennis ball is extreme and so is it the case between an exercise ball and a nano sized silver below 10nm. In the case of a pico metre it will be 10^{-12} to 1 metre in size ratio. As matter gets smaller its comparative surface area will rise exponentially. For pico and nano particles that means closer and more intimate contact with the environment and pathogens due to its increased ratio between surface area and volume.
Conclusion: small size does matter!

Hydrated electrons, a generation of free radicals?
During colloidal silver production using electro-photochemistry, the combined current flow and voltage potential across the cathode and anode, causes the extraction of silver atoms that instantly become ionic silver in the forms of cations that are attracted to the cathode. Delays in that procedure and high irradiation of violet light can produce neutral silver. Prior to this happening, for each silver ion produced there must be at least, if not more free electrons in the water as solvated or hydrated electrons. Due to the application of a voltage potential exceeding the equilibrium voltage of water at 1.23 volt DC there must be a copious number of free oxygen and protons (Hydrogen ions) as well. This a rather potent mix that cannot be conducive for pathogens to cope with this. Free oxygen for instance may have an oxidising effect and protons may be harmful as well.

Ionic silver kills pathogens as well but perhaps in a different way.
Ionic silver by itself is the final product of most people trying to produce colloidal silver in broad daylight or artificial light inside. It simply does not work. To neutralise ionic silver of any type, i.e. Silver nitrate, Silver acetate, Silver sulphate and exclusively Ionic silver requires a reducing light of no

less than around 2.6 electron volt (violet light) as do Silver halide coatings on Black and White film materials. The problem with any ionic silver combined with another chemical is instability. In particular this is the case with Silver nitrate that when reduced is unlikely to last long and stay toxic as well. Such was the case some years ago at a local university and a team of researchers attempting to keep bacterial infections from spreading by applying Silver nitrate on the skins of burn victims. It worked alright but so seriously affected the skin of patients, that the project was abandoned. I contacted the leading professor and suggested the use of neutral colloidal silver, but he would not even come to the phone or contact me by email.

Ionic silver is an atom minus one or more electrons and will make any attempt to retrieve the missing electron (s) at any cost, even from Chlorine compounds and form Silver chloride. Some doubted my words on how ions behave and I asked for a small bottle of the purest Silver nitrate that is commonly reduced by Sodium borohydride, and placed in in full sunlight for ten minutes. It did not take long for the violet and ultraviolet light reducing most of the mixture to a colloid. The problem with the remaining light of a thermal nature caused aggregation, i.e. turning newly formed particles into ever larger particles. At some stage gravity takes over. To actually ingest any form of ionic silver is bound to have an adverse effect such as combining with chlorine, particularly in the stomach full of Hydrochloric acid as well as being considered a carcinogenic substance.

CONCLUSION:

Most of the foregoing text is speculative and hypothetical but perhaps closer to the truth than mere guessing. So far there have been few and far between any suggestions what the properties of quantum nano silver are. This is specifically evident by the many papers sighted that seem ‘hell bent’ to never test colloidal silver in its own but always adding some form of other chemistry and furthermore not identifying the silver substance, the object of their research other than as AgNPs. If ever we are going to take so-called colloidal silver serious and make it legitimate, those wrongful tendencies will have to be replaced by proper scientific studies. And what about the silver ‘nano’ bullet? It is very small, uses stealth and gets up close for electrocution of the ‘bugs’. Rather than being considered a medicine, it is more akin to an instrument. Like a scalpel blade cutting out cancer tissue and for that reason out of the ‘medicine’ domain and beyond its jurisdiction.

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