BIOACTIVITY OF COLLOIDAL SILVER IS NO SURPRISE

Infectious Diseases and Nanotechnology
An Introduction by
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What is the nature of a metal colloid?
When atoms of the same atomic number (i.e. number of protons) aggregate very closely they begin to share their electron "clouds". This happens because quantum uncertainty allows the exchange of "electrons" without changing the system's total energy.
In that way the close proximity of the small number of atoms joins them together into very small particles. Such close-up sharing of their electrons produces a unique and remarkably stable, linked-atom state called a **colloidal particle**. Thus chemical bonding possibilities are greatly enhanced. The joint electron interaction and the extended electron cloud is uniquely active. Large quantities of such colloidal particles of Silver (and other metals) are now being produced. One source of Silver colloids provides a very narrow particle size distribution averaging just 9 atoms -- typically only 2/3 nm size.

How might such colloidal properties be evaluated?
Each Colloidal particle uniquely displays a surface charge – it's called the *Zeta Potential.* When dispersed in a non-ionic liquid (water) this potential causes the particles to repel each other. As a result they remain continuously suspended in the water and never settle out of solution.
True nanoparticles of a metal are composed of only a few atoms and as a result they behave *very differently* from bulk metals, or gross aggregates of metal particles. Colloids do not clump or flocculate into aggregates of material much larger in size (hundreds to millions of atoms). Such large aggregate clumps (powders) do not display either the ordering effects nor the surface charge behavior of true colloidal particles composed of very much smaller numbers of atoms.

Why should we be interested in colloidal particles?
Chemical and biological behavior of colloidal particles, being greatly affected by their particle size, are unusually effective both inside and outside biological cells.
To better understand the exceptional activity of true silver nanoparticles one needs to carefully consider the huge range of physical sizes that exist within a biological cell and its environment. Let's define this family of dimensions in relation to each other and to some larger scale.

A *nanometer* is a length of just one millionth of one millimeter. (1E-9 meter)

"Nano" materials strictly speaking, are those with dimensions in the range of just under 1 nm to about 100 nanometers (<1-100).

1 micron = 1/1000 mm. A nanometers is a very small length, just 1/1000 of the Micron dimensions so familiar with biological materials.

Typical human cells are about 10 microns diameter. The cell wall of a gram-negative bacterium is typically just 10 nm thick.

How to grasp the details of a cell's parts with such an enormous size range –10,000-to- one or less [<1 to 10,000 nm] ?
As an aid to thinking about that nano-world, consider an **IMAGE of a cell** ***expanded by one million times***, showing the details of a cell's inner micro world.
With such model a typical 10-micron human cell appears to be 10 meters in diameter. In this model a one-nanometer object **appears to be just 1 millimeter**. Those colloidal silver particles described in the first paragraph above, would appear to be **only 2/3 of a millimeter**. Very much smaller even than cells parts.

The size of most of the components within a human cell are many nanometers so this scaling just begins to present the very significant size relationships within biological cells.

Why Silver ?

Historically silver has been found to be anti-bacterial. That may be in part, reason for use in food service. It has been employed in modern times against infection in burns. Silver is one of the transition metals and, one of the three members of the 11th column of the periodic table. There is a very intriguing physical property of silver that has been little recognized, yet it may be quite significant for its bioactivity. Interestingly all the metals of the 11th column of the Periodic Table have nearly the same unusual shape of Fermi surface. One that almost encloses the atom equally in all directions from its center. Those 11th column Fermi surfaces are rather spherical! Most of the atoms in the periodic table **are not**. The others have very porous, segmented Fermi surfaces that don't provide nearly as much proportion of reactive surface. (see Fermi Surfaces Chart) Within the *entire* periodic table of elements, only the first group and, the 11th group have these spheroid properties. The 1st group have the alkali metals; Lithium, Sodium, Potassium, Rubidium, Cesium and Francium. The first three of which are biologically useful and participate in normal metabolic processes. The 11th group have Copper, Silver and Gold. Silver may be somewhat less "Noble" than Gold or Platinum. Silver has a slightly lower electro negativity value. The larger Fermi surface may improve opportunities for bonding or interchange of charges. This remains a significant research question for biological systems that seem to respond so well to silver.

More about the vast range of cell part sizes.

Returning for comparisons to the real world dimensions, from which our model is derived; the diameter of a basic DNA helix in human cells is only about 2 nanometers. This helix is coiled into yet another spiral that is the "rope" that further spirals around forming the 30 nm coil of the chromatin fiber within chromosomes. Those coils are further coiled several times to produce the complex interior of each of the various size chromosomes. Chromosomes vary in diameter from 200 nm to 750nm. Each human cell has some twenty-three pairs of chromosomes, each pair differ in size.
Biological living systems rely structurally mainly on cells. Consider all the sizes in relation to the total number of cells in a human. The human total is about 10 E 14 cells. Each of which are typically about 10 microns. Nanometer scale particles are therefore *very very much smaller* than typical human cells and their inner components.

Microbes that are infectious agents (**IA)** attack human cells in various ways**;** *by poisoning them, *by penetrating a cell's perimeter defenses, *and in a still more-difficult-to-deal-with condition, as the **IAs** change into *a dormant state* or possibly into a *drug resistant* state. [Severe troubles develop when the microbial invaders go inside cells and takeover some cell systems or nutrients for their own purposes.] Current treatment of infectious diseases has relied mainly on chemical drugs to attack and destroy infectious microbes, or to disable their cell penetrating resources. However, because **IAs** are also living things, drug strategies, over time may induce adaptive structural changes in the **IA** that can further propagate such new **IA** populations.
Those **IA** changes have precipitated the scourge of *resistant strains* and possibly *dormant resistant IA states*.[1]
One great potential of nanoparticles lies in their ability to act upon the **IA** *without inducing such defenses*.
In the case of large area burns where risk of infection and reduced tissue repair are factors, treatment with silver nanoparticles seems to offer unusual potentials. Sterile packaged vials of 100 ml of 20 PPM concentration silver nanoparticles-in-ultrapure-water have just become available for such explorations.

[1] MRSA and resistant HIV-1 are but a few examples.