A Peep into What Was Behind the Incorporation of Gold Nano Particles in Nano Medicine

Editorial

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I would like to start giving a quote from the Nobel Lecture delivered by Max Planck in 1918 " *When I look back to the time, already twenty years ago, when the concept and magnitude of the physical quantum of action began, for the first time, to unfold from the mass of experimental facts, and again, to the long and ever tortuous path which led, finally, to its disclosure, the whole development seems to me to provide a fresh illustration of the long-since proved saying of Goethe's that man errs as long as he strives. An indispensable hypothesis, even though still far from being a guarantee of success, is however the pursuit of a specific aim, whose lighted beacon, even by initial failures, is not betrayed*".

Primitive man thought of sky as wonderful and mysterious, but he could not even dream of what was within the golden disk or silver points of light so far beyond his reach. The phenomenon of absorption, reflection and scattering of light always fascinated man from ages. The mysterious and curious man started exploiting his gray matter to understand the mystery of colloidal solutions when light is impinged on it. No wonder peeping into the world of metal colloids which explicitly deal with these all-pervading phenomena became a matter of excitement.

Transition metals gold as a virtue of fact is known to possess many intriguing properties and is exploited for their magnificent and lustrous attribute leading to avalanche of applications. Gold was not only known and exploited for its ornamental adornment but their souls and colloids were also a matter of excitation in the medieval age. "Soluble" gold appeared around 4th century B.C. in Egypt and China. This enigmatic behavior of Gold colloids led to the curious endeavor of using it as a pigment for coating glasses, enamel and chinaware in the mid 17th century. The big question that came to the curious scientific community was how ruby colored Gold exists and that too in a stable form?

Thanks to the painstaking efforts of colloidal giant Michael Faraday [1] who could apprehend that the ruby red color of colloidal gold stems from the agglomerations of gold atoms. He proved the stability of such solutions by actually synthesizing the colloidal solution and gave mathematical expressions evidently proving the stability of the solution. But he could not staunchly interpret his observations with any analytical armamentarium like Transmission Electron Microscope. But this brilliant work was forgotten for about 40 years which was then revived by another great Nobel Laureate Zsigmondy who combined his synthesis method with Faradays work and termed it as seed-mediated method [2,3]. He even went to an extent of analyzing the size and mobility of such nanometer sized colloidal gold by designing an ultra-microscope. Another Nobel Laureate Svedberg not only synthesized colloidal solutions but also paved a way for size and shape separation of gold nanoparticles [4].

Experimental and theoretical principles through a series of demonstrations by scientist like Gans and Mie has embodied several properties of colloidal gold nanoparticles. Nano-scale gold possess few atoms and hence exhibit dominantly statistical mechanical principles in which the energy is well quantized and discrete. This consequently leads to the dominion of surface energies due to the excited electrons of the surface atoms of nanomaterials and thus gold nanoparticles exhibits specific surface energy [5,6]. The mmagical confrontation between gold nanoparticles and light led to Mie Theory and Surface Plasmon Resonance. Moreover, Colloidal Stability of gold nanoparticles (due to the Electrical Double Layer theory) plays pivotal role in their clinical and Para- clinical applications viz. Drug delivery, hyperthermia or antimicrobial therapy. In a solution of colloidal dispersion, stability is governed by plethora of factors. Potential applications of gold nanoparticles in biomedicine include chemical sensing and imaging applications also [7,8].

While bulk gold has been deemed "safe", nanoscale particles of gold is being examined for biocompatibility and environmental impact. Several groups have examined the cellular uptake and cellular toxicity of gold nanoparticles. While nearly anything can be toxic at a high enough dose, the more relevant question is: how toxic are gold nanoparticles at the potential concentrations at which they might be used (which we estimate to be~1-100 per cell)? At present, relatively few reports have appeared in the primary literature. Control of the shape of gold nanoparticles is a recent addition on to the list of growing demand for its application in drug delivery especially for cancer therapy. The most jeopardizing situation of a cancerous cell is its impenetrability of chemotherapeutic agent due to its high diffusion rate and enhanced reticuloendothelial system (RES) clearance. This physiological change poses a hostile consequence of low retention of the drugs inside a solid tumour. This necessitates the development of tumor specific targeted drug delivery cargoes to ferry drugs, exploiting the leaky tumor microvasculature [9].

Gold nanoparticles play gigantic role in delivery of payloads to the target using specifically addressed nano-cargoes. Such nano-cargoes, due to size and surface properties can circumvent the problem of systemic toxicity of drugs. Since gold

nanoparticles exhibit distinct surface plasmon resonance bands, they are suitable for easy characterization and incorporation of functional ligands on the surface. Also, its size can be fine tuned during synthesis and its surface can be modified according to the chemistry of tethering molecule such as antibodies. Such surface orchestrated GNPs can serve as a proficient candidate for payload of drug due to its long circulation time and low Cytotoxicity [10,11].

In short it can be said that at nano-scale, the properties of the gold take a strange leap towards quantum mechanics and properties get altered such as enhanced reactivity and optical properties. Gold nanoparticles posses surface plasmon resonance (SPR) due to confinement of electrons in nano-boxes. Inception of such optical phenomenon is shape dependent. Mie scattering is used to explain the appearance of pink colour as a consequence of SPR whereas Gans theorem is used to explain colour of non-spherical gold nanoparticles (anisotropic gold nanoparticles). Surfaces of gold nanoparticles can be decorated with drugs and used in targeted drug delivery.

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