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GOLD PARTICLES: ALNALYSIS AND APPLICATION ON NANOMETER SCALE

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ABSTRACT

In this paper, we have explained basic principle of change of properties of substance at their nano level. The Bhasmas particle, when analysed microscopically through SEM and TEM, fell under the range of nanoparticle of contemporary science.

In nanoscience, the materials of very small dimension in the range of 1-100 nm studied, when at least one of the dimension of any type of materials is reduced below 100 nm., it's mechanical, thermal, optical, magnetic and other properties change at some size characteristics of that material. The optical and electronic properties of gold nano particles are tunable by changing the size, shape, surface chemistry or aggregation state.

Keywords; Gold Bhasmas, Particle size, Nanotechnology, Wavelength and colours

I. INTRODUCTION

Colloidal gold Nanoparticleshave been utilized for centuries by artists due to the vibrant colors produced by their interaction with visible light. More recently, these unique optical-electronics properties have been researched and utilized in high technology applications such as organic photovoltaics,sensory probes, therapeutic agents, drug delivery in biological and medical applications, electronic conductors and catalysis.

The development of RASASHASTRA (7^{th} century AD) has revaioutionised Ayurvedic system of medicine. Many new pharmaceutical techniques are developed like Shodana, jarana& marana by which metals and minerals are converted into very very fine, absorbable, therapeutically most effective and least or non toxic form of medicines known as Bhasmas.

II. NANOTECHNOLOGY

Nanotechnology based on nanoscience is the technology of 21^{st} century; the term nanotechnology and nanoscience are often used synonymously. The literal meaning of 'nano' is 'dwarf' or an abnormally short person. However in scientific language it is a billionth (10^{-9}) part of some unit scale example nano meter or nano second means 10^{-9}meters or 10^{-9}seconds respectively i.e. in 1 meter making 1,000,000,000 parts and picking up 1 part is 1 nano. Nanoparticles are 1 crore times smaller than a hair.

In 1875, Michal Faraday synthesized stabled gold colloidal particles of nano size (magneta red colour solution) is the mile stone in nano science.

Nano Technology is thus the technology of materials dealing with very small dimension materials usually in the range of 1-100 nm.When at least one of the dimensions of any type of material is reduced below ≈ 100 nm,it's

mechanical, thermal, optical, magnetic& other properties change at some size characteristic of that material. Thus within the same material one can get a range of properties.

Example: Consider CdS semiconductor whose normal colour is red. Through the below chart we can observe that assize of CdS changes to different nano levels, the colour also changes accordingly. We can see the detail in table 2.

Also the melting point decreases as the particle size decreases.

Why nano particles are special? Why are the properties different? We can see the specialty in figure 1.By reducing the size of the sphere from 1m to 1 nm,the surface area to volume ratio increase by a factor of 10^9.Also in fig.2 we can understand the size and property relationship of nano particles. The increase in the surface area to volume ratio increases the dominance of quantum effects and increases the dominance of the surface of a particle over that of those of interior. Thus high surface area is the key for catalyzing the medicine.

Therefore by changing the particle size of a material one can achieve a range of properties which are used in the different fields.

The development of nano technology is made possible through the marked development in analysis technique with the help of specialized microscope like

- Transmission Electron Microscope (TEM)
- Scanning Tunneling Microscope(STM)
- Atomic Force Microscope(AFM)

2.1 Optical & Electronics Properties of Gold Nanoparticles

Gold nanoparticles interaction with light is strongly dictated by their environment, size and physical dimensions. Oscillating electric fields of a light raypropagating near a colloidal nanoparticle interact with the free electrons causing a concerted oscillation of electron charge that is in resonance withthe frequency of visible light. These resonant oscillations are known as surface plasmons.

For small (~30nm) monodisperse gold nanoparticles thesurface plasmon resonance phenomena causes an absorption of light in the blue-green portion of the spectrum (~450 nm) while red light (~700 nm)is reflected, yielding a rich red color. As particle size increases, the wavelength of surface plasmon resonance related absorption shifts to longer,redder wavelengths. Red light is then absorbed, and blue light is reflected, yielding solutions with a pale blue or purple color (**Figure 1**). As particle sizecontinues to increase toward the bulk limit, surface plasmon resonance wavelengths move into the IR portion of the spectrum and most visiblewavelengths are reflected, giving the nanoparticles clear or translucent color. The surface plasmon resonance can be tuned by varying the size orshape of the nanoparticles, leading to particles with tailored optical properties for different applications.

Figure 1.Colors of various sized monodispersed gold nanoparticles

This phenomenon is also seen when excess salt is added to the gold solution. The surface charge of the gold nanoparticle becomes neutral, causing nanoparticles to aggregate. As a result, the solution color changes from red to blue. To minimize aggregation, the versatile surface chemistry of gold nanoparticles allows them to be coated with polymers, small molecules, and biological recognition molecules. This surface modification enables gold nanoparticles to be used extensively in chemical, biological, engineering, and medical applications. Typical properties of gold nanoparticles are presented in **Table 1**.

Diameter	Nanoparticles/ml	Peak SPR Wavelength	Molar Ext M-1cm-1)
5 nm	5.47 x 1013	515-520 nm	1.10 x 107
10 nm	5.98 x 1012	515-520 nm	1.01 x 108
15 nm	1.64x1012	520 nm	3.67x108
20 nm	6.54 x 1011	524 nm	9.21 x 108
30 nm	1.79 x 1011	526 nm	3.36 x 109
40 nm	7.15 x 1010	530 nm	8.42 x 109
50 nm	3.51 x 1010	535 nm	1.72 x 1010
60 nm	1.96 x 1010	540 nm	3.07 x 1010
80 nm	7.82 x 109	553 nm	7.70 x 1010
100 nm	3.84 x 109	572 nm	1.57 x 1011

Applications

The range of applications for gold nanoparticles is growing rapidly and includes:

1. **Electronics** - Gold nanoparticles are designed for use as conductors from printable inks to electronic chips.1 As the world of electronics become smaller, nanoparticles are important components in the chip design. Nanoscale gold nanoparticles are being used to connect resistors, conductors, and other elements of an electronic chip.

2. **Photodynamic Therapy** - Near-IR absorbing gold nanoparticles (including gold nanoshells and nanorods) produce heat when excited by light at wavelengths from 700 to 800 nm. This enables these nanoparticles to eradicate targeted tumors.2 When light is applied to a tumor containing
gold nanoparticles, the particles rapidly heat up, killing tumor cells in a treatment also known as hyperthermia therapy.

3. **Therapeutic Agent Delivery** - Therapeutic agents can also be coated onto the surface of gold nanoparticles.3 The large surface area-to-volume ratio of gold nanoparticles enables their surface to be coated with hundreds of molecules (including therapeutics, targeting agents, and antifouling
polymers).

4. **Sensors** - Gold nanoparticles are used in a variety of sensors. For example, a colorimetric sensor based on gold nanoparticles can identify if foods are suitable for consumption.4 Other methods, such as surface enhanced Raman spectroscopy, exploit gold nanoparticles as substrates to enable the measurement of vibrational energies of chemical bonds. This strategy could also be used for the detection of proteins, pollutants, and other molecules label-free.

5. **Probes** - Gold nanoparticles also scatter light and can produce an array of interesting colors under dark-field microscopy. The scattered colors of gold nanoparticles are currently used for biological imaging applications.5 Also, gold nanoparticles are relatively dense, making them useful as probes for transmission electron microscopy.

6. **Diagnostics** - Gold nanoparticles are also used to detect biomarkers in the diagnosis of heart diseases, cancers, and infectious agents.6 They are also common in lateral flow immunoassays, a common household example being the home pregnancy test.

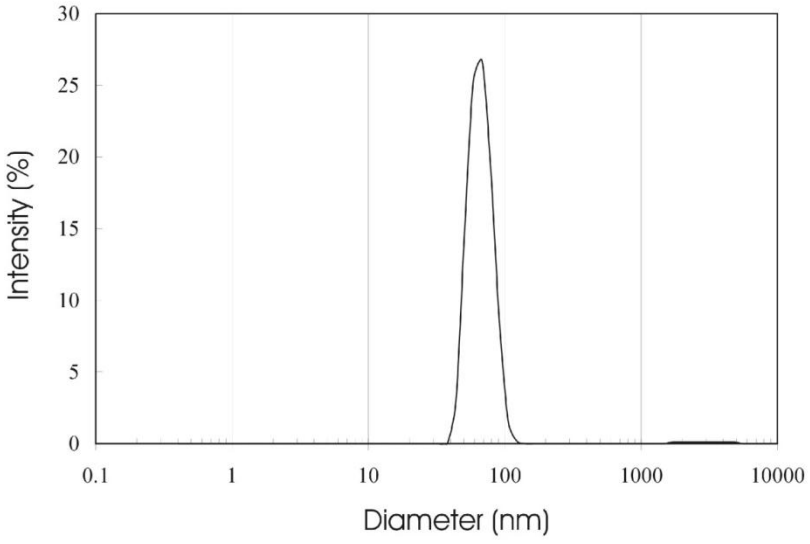
7. **Catalysis** - Gold nanoparticles are used as catalysts in a number of chemical reactions.7 The surface of a gold nanoparticle can be used for selective oxidation or in certain cases the surface can reduce a reaction (nitrogen oxides). Gold nanoparticles are being developed for fuel cell applications. These technologies would be useful in the automotive and display industry.

2.2 Quality Advantage

Aldrich Materials Science, in conjunction with Cytodiagnostics, is proud to offer a broad portfolio of gold nanoparticles geared specifically for hightechnologyapplications within the fields of life science and materials science. Gold nanoparticles are available in sizes ranging from 5 nm to 400 nmin diameter with numerous surface functionalities in a variety of solvent compositions.

While spherical gold nanoparticles are traditionally synthesized using reducing agents such as sodium citrate or sodium borohydride, Cytodiagnostics has a propriety process and formulation that leads to the preparation of highly spherical gold nanoparticles, without harsh reducing agents. Whencompared to other gold nanoparticles, these nanoparticles have the many advantages, including:

1. **Narrow size distribution** - based on Dynamic Light Scattering (DLS) and TEM analysis. Each batch is verified by DLS and UV-Vis spectroscopy



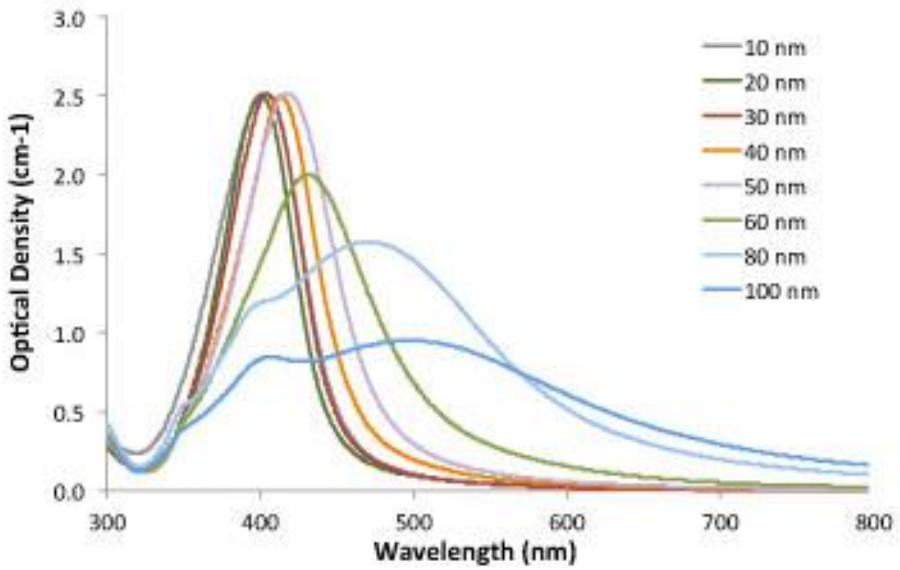
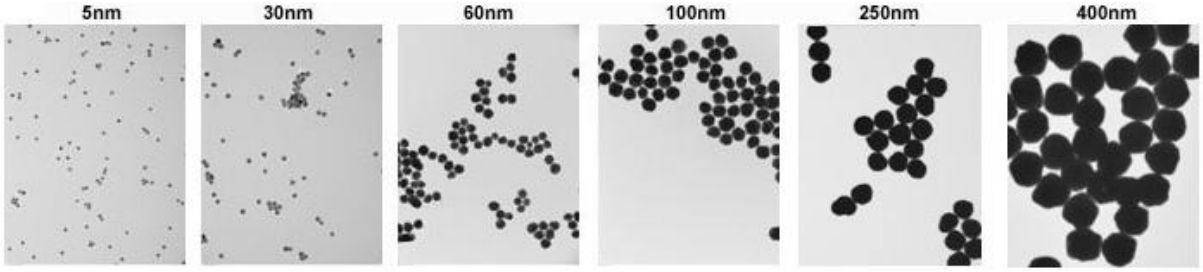


Figure 2.DLS & UV-Vis spectra showing precise gold nanoparticles from Cytodiagnostics.



Gold Nano Urchins

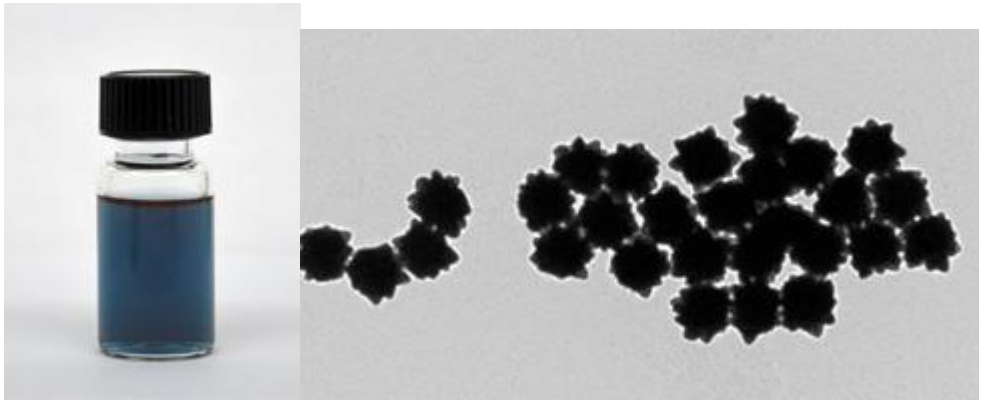


Figure 4.TEM of 100 nm Gold NanoUrchins

Gold NanoUrchins have unique optical properties compared to spherical gold nanoparticles of the same core diameter. The spiky uneven surfacecauses a red shift in the surface plasmon peak and a larger enhancement of the electromagnetic field at the tips of the Gold NanoUrchin spikescompared to that of a spherical particles. As an example, 100nm spherical gold nanoparticles have an SPR peak at 570nm while 100nm GoldNanoUrchins have a SPR peak at around 680nm, **figure 4**.

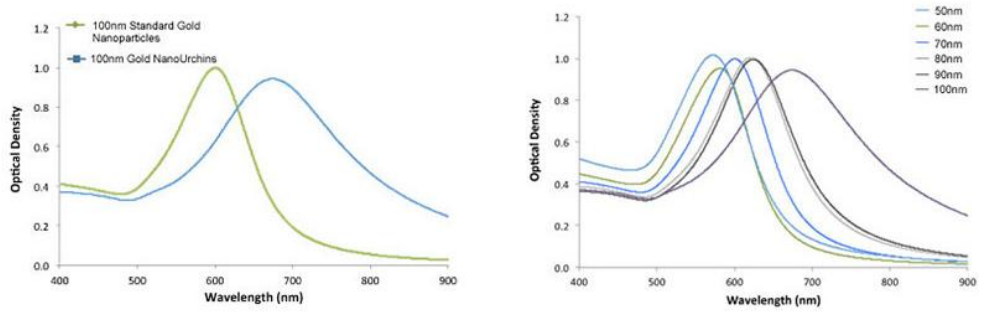


Figure 5. Left - UV-VIS spectra of 100nm Gold NanoUrchins (blue) and 100nm standard goldnanoparticles (green). Note the red-shift in the SPR-peak.

Right - UV-VIS spectra of Gold NanoUrchins ranging in size from 50nm to 100nm in diameter.

III. OUTLOOK

Gold nanoparticles are versatile materials for a broad range of applications with well characterized electronic and physical properties due to welldevelopedsynthetic procedures. In addition, their surface chemistry is easy to modify. These features have made gold nanoparticles one of the mostwidely used nanomaterials for academic research and an integral component in point-of-care medical devices and industrial products world-wide.

The broad offer of gold nanoparticles by Aldrich Materials Science, accessible to the global research community, serves to increase their adoption inhigh-technology applications.

IV. CONCLUSION

Thuswe draw a conclusion that, the study of particles in different nano scale shows different characteristics. We finds changes in terms of colour, remidal qualities.

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