

# SYNTHESIS AND CHARACTERIZATION OF COLLOIDAL GOLD NANOPARTICLES

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## ABSTRACT

*Colloidal gold, a sol comprised of nanoparticles of Au<sup>0</sup>, has been used as a therapeutic for the treatment of cancer as well as an indicator for immunodiagnostics. This work outlines the development of a colloidal gold nanoparticles and there characterization. Due to the unique optical, electronic, and molecular-recognition properties of gold nanoparticles, they are the subject of substantial research, with applications in a wide variety of areas, including electron microscopy, electronics, nanotechnology, and materials science.*

**Keywords – Gold Nanoparticles, Colloidal Gold, TEM, Reducing Agents**

## I. INTRODUCTION

Colloidal gold is a suspension (or colloid) of sub-micrometre-sized particles of gold in a fluid — usually water. The liquid is usually either an intense red colour (for particles less than 100 nm), or a dirty yellowish colour (for larger particles). Due to the unique optical, electronic, and molecular-recognition properties of gold nanoparticles, they are the subject of substantial research, with applications in a wide variety of areas, including electron microscopy, electronics, nanotechnology, and materials science. Properties and applications of colloidal gold nanoparticles depends upon shape. For example, rodlike particles have both transverse and longitudinal absorption peak, and anisotropy of the shape affects their self-assembly. Known since ancient times, the synthesis of colloidal gold was originally used as a method of staining glass. Modern scientific evaluation of colloidal gold did not begin until Michael Faraday's work of the 1850s. A so-called Elixir of Life, a potion made from gold, was discussed, if not actually manufactured, in ancient times. Colloidal gold has been used since Ancient Roman times to colour glass intense shades of yellow, red, or mauve, depending on the concentration of gold, and in Hindu Chemistry, for various potions. In the 16th century, the alchemist Paracelsus claimed to have created a potion called Aurum Potabile (Latin: potable gold). In the 17th century the glass-colouring process was refined by Andreas Cassius and Johann Kunckel. In 1842, John Herschel invented a photographic process called Chrysotype (from the Greek word for gold) that used colloidal gold to record images on paper. Paracelsus' work is known to have inspired Michael Faraday to prepare the first pure sample of colloidal gold, which he called 'activated gold', in 1857. He used phosphorus to reduce a solution of gold chloride. For a long time the composition of the Cassius ruby-gold was unclear. Several chemists suspected it to be a gold tin compound, due to its preparation. Faraday was the first to recognize that the color was due to the minute size of the gold particles. In 1898 Richard Adolf Zsigmondy prepared the first colloidal gold in diluted solution. Apart from Zsigmondy, Theodor Svedberg, who invented ultracentrifugation, and Gustav Mie, who provided the theory for scattering and absorption by spherical particles, were also interested in understanding synthesis and properties of colloidal gold.

## **II. HEALTH AND MEDICAL APPLICATIONS**

### **2.1 Chrysotherapy and Chrysiasis**

Chrysotherapy (or aurotherapy), often self-administered allegedly by alchemists and snake oil vendors before modern medicine isolated effective compounds, relates to the intake of gold salts and or colloidal gold . Although colloidal gold has been successfully used as a therapy for rheumatoid arthritis in rats, one noticeable side-effect in humans to whom are administered gold based DMARDs is the coloring of the skin in shades of mauve to a purplish dark grey when exposed to sunlight, if the salts are taken on a regular basis over a long period of time . Excessive intake of gold salts and colloidal gold while undergoing chrysotherapy result -through complex redox processes- in the saturation by relatively stable gold compounds and colloidal gold of skin tissue and organs (as well as teeth and ocular tissue in extreme cases) , a condition known as chrysiasis , similar to a certain extent to argyria which is related to silver salts and colloidal silver. Chrysiasis can ultimately lead to acute renal failure (such as tubular necrosis, nephrosis, glomerulitis ) , severe heart conditions, hematologic complications(leukopenia, anemia) while some effects can be healed with moderate success, the pigmentation of the skin is considered permanent.

### **2.2 Experimental Medication for Alzheimer's Disease**

An in vitro experiment has shown that the combination of microwave radiation and colloidal gold can destroy the beta-amyloid fibrils and plaque which are associated with Alzheimer's disease. The possibilities for numerous similar radiative applications are also currently under exploration.

### **2.3 Drug Carrier**

Gold nanoparticles are being investigated as carriers for drugs such as Paclitaxel. The administration of hydrophobic drugs require molecular encapsulation and it is found that nanosized particles are particularly efficient in evading the reticuloendothelial system.

### **2.4 Tumor Detection**

In cancer research, colloidal gold can be used to target tumors and provide detection using SERS (Surface Enhanced Raman Spectroscopy) in vivo. These gold nanoparticles are surrounded with Raman reporters which provide light emission that is over 200 times brighter than quantum dots. It was found that the Raman reporters were stabilized when the nanoparticles were encapsulated with a thiol-modified polyethylene glycol coat. This allows for compatibility and circulation in vivo. To specifically target tumor cells, the pegylated gold particles are conjugated with an antibody (or an antibody fragment such as scFv), against e.g. Epidermal growth factor receptor, which is sometimes overexpressed in cells of certain cancer types. Using SERS, these pegylated gold nanoparticles can then detect the location of the tumor.

### **2.5 Photothermal Agents**

Gold nanorods are being investigated as photothermal agents for in-vivo applications. Gold nanorods are rod shaped gold nanoparticles whose aspect ratios tune the surface plasmon resonance (SPR) band from the visible to near infrared wavelength. The total extinction of light at the SPR is made up of both absorption and scattering. For the smaller axial diameter nanorods (~10 nm), absorption dominates, whereas for the larger axial diameter nanorods (>35 nm), scattering can dominate. Consequently, for in-vivo applications, small diameter gold nanorods are being used as photothermal converters of near infrared light due to their high absorption cross

sections. Since near infrared light transmits readily through human skin and tissue, these nanorods can be used as ablation components for cancer, and other targets. When coated with polymers, gold nanorods have been known to circulate in-vivo for greater than 15 hours half life.

### III. Experimental

#### 3.1 Materials

Hydrogen tetrachloroaurate ( $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$ )

Trisodium citrate ( $\text{Na}_3\text{C}_6\text{H}_5\text{O}_7 \cdot 2\text{H}_2\text{O}$ )

Erlenmeyer flasks

Stirring hotplate

Distilled water

#### 3.2 Synthesis and Method

Generally, gold nanoparticles are produced in a liquid ("liquid chemical methods") by reduction of chloroauric acid ( $\text{H}[\text{AuCl}_4]$ ), although more advanced and precise methods do exist. After dissolving  $\text{H}[\text{AuCl}_4]$ , the solution is rapidly stirred while a reducing agent is added. This causes  $\text{Au}^{3+}$  ions to be reduced to neutral gold atoms. As more and more of these gold atoms form, the solution becomes supersaturated, and gold gradually starts to precipitate in the form of sub-nanometer particles. The rest of the gold atoms that form stick to the existing particles, and, if the solution is stirred vigorously enough, the particles will be fairly uniform in size.

To prevent the particles from aggregating, some sort of stabilizing agent that sticks to the nanoparticle surface is usually added.

#### 3.3 Turkevich Method

The method pioneered by J. Turkevich et al. in 1951 and refined by G. Frens in 1970s, is the simplest one available. Generally, it is used to produce modestly monodisperse spherical gold nanoparticles suspended in water of around 10–20 nm in diameter. Larger particles can be produced, but this comes at the cost of monodispersity and shape. It involves the reaction of small amounts of hot chloroauric acid with small amounts of sodium citrate solution. The colloidal gold will form because the citrate ions act as both a reducing agent, and a capping agent. We used  $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$  to produce colloidal gold nanoparticles solution. The very first thing to remember is to avoid any  $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$  and metal contact because  $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$  is very corrosive and can immediately react with the metal. A glass spatula should be used instead of a metal spatula. All the glassware must be thoroughly cleaned with aqua regia (3:1 ::  $\text{HCl}:\text{HNO}_3$ ), rinsed with DI water, and dried under a stream of nitrogen gas to avoid unwanted nucleation during the synthesis, as well as aggregation of gold colloid solutions. Here's the procedure:

Prepared ~2% trisodium citrate aqueous solution: Add 2 g sodium citrate dihydrate to 200 ml DI water.

1. Prepared ~1%  $\text{HAuCl}_4$  aqueous solution: Add 1 g  $\text{HAuCl}_4$  to 100 ml deionized (DI) water.
2. Mixed the solutions prepared in step 1 and step 2 properly.

The solution turns dark red. The solution container is labeled and stored in a refrigerator until use.



**Aqueous Colloidal Gold**

#### IV. RESULTS

##### Characterization of the Colloidal Gold Nanoparticles

Interrogation of our colloidal gold preparations by TEM dual-angle light scattering, and differential centrifugal sedimentation revealed that the size of the particles in the colloidal gold preparations were very close to their theoretical size of 32–36 nm. The particles were homogenous in size with a mean particle diameter of  $34.6 \pm 3$  nm and a poly dispersity measure averaging 0.100 for 6 L scale preparations. Particles show uniformity according to the image. The colour of the solution after preparation of the particles was red. TEM images of the particles also show a better uniformity.

Method of interrogation	Mean particle size(nm)	Polydispersity (%)
DLS	32.2 (+,-)4	0.098 (+,-)0.02
DSC	32.8 (+,-)2	1.104 (+,-)0.05



**IMAGE - Transmission Electron Microscopy of the Colloidal Gold Nanoparticles. Colloidal Gold Nanoparticles Were Manufactured As Described In The Materials And Methods**

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