The Properties of Nano-Gold Particles Synthesized by Ascorbic Acid With Acacia Gum and Sodium Hydroxide as Stabilizers

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Abstract
In this work, biocompatible gold nanoparticles were synthesized by reducing the chloroauric acid with ascorbic acid as a reducing agent. Colloidal gold nanoparticles were stabilized through nontoxic acacia gum sodium hydroxide. Synthesizing gold nanoparticles is confirmed by the change in color of chloroauric acid from yellow to ruby red and brown color depending on the stabilizers. The gold nanoparticles were characterized by UV-Visible spectrophotometer. Where the peak of the absorbance of surface plasmon resonance (SPR) was observed between the wave length 526 and 535 nm. The results of zeta potential were found in range (-19, -40 mV), AFM and TEM images show two different shapes, hexagonal and spherical and the size of gold nanoparticles between 21.5 nm and 29 nm.

Keywords: gold nanoparticles, ascorbic acid, Acacia gum, sodium hydroxide

Introduction
Nanotechnology is the science which treats the materials with a range from (1-100) nm. [1] Nanomaterials have considerable interest due to the physico-chemical properties of the metal are changed as it reaches the nano size, their properties are different as compared to the bulk metal.
These nanomaterials have numerous purposes in various domains such as electronics, cosmetics, coatings, packaging, and biotechnology. Due to their optical properties the colloidal solution of mineral nanomaterials is transparent, thus they are valuable in cosmetics, coatings, and packaging. Among metal nanoparticles, silver and gold nanoparticle has enormous usage in industry and medicine. Because of their wide applications beneficial to humanity there is a need to develop fast and effective experimental schedule for the synthesis of nanoparticles. Various types of nanoparticles such as Ag, Au, Pt, and Pd have been synthesized in recent years by chemical, physical and biological methods. The chemical methods are the commune but the use of toxic chemicals during synthesis produces toxic by-products. The physical methods require large amount of energy to maintain high pressure and temperature required for the reaction. Thus the chemical and physical methods have their posses limitations; these are considered expensive and unsuitable for possible ecosystem. The synthesis of gold nanoparticles (AuNPs) using biological and natural material is gaining the priority as biological methods are providing, nontoxic and environmentally suitable practice. The physical and morphological advantage of metal nanoparticles is greatly influenced by the solvents and the use of reducing agents. The diversity in size, shape, and morphology impact the applications of the nanoparticles. The morphology of nanoparticles is determined by reducing agent. At the nanorange many effects are arises such as large surface to volume ratio, minimizing effects of gravity, quantum effects etc. The top down proposes the nanoparticles preparation by lithographic techniques, ball milling, etching, sputtering, etc. The great effective approach for synthesis of nanoparticles is the bottom up methods, in which nanoparticles are grown from simpler molecules and size or shape of nanoparticles can be controlled. However, still the mechanism of synthesis of nanoparticles using biomolecules is yet to be explored and hence needs much more experimentations.

Materials and Devices

Materials: chloroauric acid (HAuCl₄•3H₂O) from MERCK Company-Germany, ascorbic acid (AA) C₆H₈O₆, acacia gum and sodium hydroxide (NaOH).

Devices: UV-Vis spectroscopy (Shimadzu, Japan), Atomic force microscope (AFM); (SPM AA 3000, USA); Transmission electron microscope (TEM); (Philips CM 100, Holland), and Zeta potential analyzer (Brook Haven ,USA)

Methods

Sample 1: Ascorbic acid (1%) was prepared (0.5 g with 50 ml of distilled water (DW)), then added to 250 ml of distilled water as solvent. After two minutes 3 ml of queues HAuCl₄•3H₂O solution (10mM) was added gradually to the mixture with continuous stirring at 60-70 °C until the color of the solution was changed to ruby red to give first indicator about formation Au NPs

Sample 2: Ascorbic acid solution (3 ml) prepared in sample 1 put on conical flask 500 ml. Add little acacia gum to solution. Heat and stir the solution with the addition of 3.6 ml of chloroauric acid solution prepared in sample 1 (10mM) after color change from yellow into ruby red turn off heating and stirring.

Sample 3: Ascorbic acid solution (3 ml) prepared is sample 1 (1%) put on conical flask 500 ml and 1 ml from (1% NaOH) add complete volume to 250 ml distilled water. Heat then stir the solution and add 3.6 ml of chloroauric acid solution prepared in sample 1 (10mM). After color change from yellow into brown color turn off heating and stirring.
The interaction equation:

\[ 2 \text{HAuCl}_4 + 3\text{C}_6\text{H}_8\text{O}_7 \rightarrow 2\text{Au} + 3\text{C}_3\text{H}_6\text{O}_5 (3\text{-ketoglutaric acid}) + 8\text{HCl} + 3\text{CO}_2 \]

**Results and Discussion**

AuNPs produced from the reduction of gold ions by ascorbic acid, were characterized by UV-Vis spectroscopy. The absorption of (SPR) peak at 526 nm. [22] This is identical to what has been reported elsewhere. [23] Theoretically, AuNPs absorb visible light between (500-600 nm), Sample 2 (534nm), sample 3-(524nm) as shown in Figure-1.

![Scheme 1- Synthesis of AuNPs](image)

**Figure 1**-UV-Vis Spectroscopy of AuNPs using ascorbic acid with acacia gum(sample 2)and with NaOH(sample 3).
Zeta Potential ($\zeta$)
1 ml of sample was taken and diluted by 1 ml of distilled water. The zeta potential of a colloidal solution is a tool used to measure the stability of such solutions. Between -30 mV and +30 mV, the colloidal solution is considered to be unstable. If it's recorded zeta potentials were in the range -30 mV and +30 mV. A high value, positive or negative, of zeta potential means a higher repulsion between the particles. Therefore, colloidal suspensions are considered stable when their zeta potentials are more positive than +30 mV or more negative than -30 mV[24]. In this work, zeta potential value of synthesized AuNPs solution was found to be (-40 mV) as shown in Figure-2. This value indicates its stability and coinciding with other works.

![Figure 2-Zeta potential values of AuNPs for sample 2 and sample 3 (-19.30mV), (-40.71) respectively](image)

Atomic Force Microscopy
Atomic force microscopy (AFM) offers the capability of 3D conception and both qualitative and quantitative information on many physical properties such as size, morphology, surface texture and roughness. A wide range of particle sizes can be characterized in the same scan, from 1 nanometer to 8 micrometers [25]. Glass slides were cleaned by distilled water, ethanol and acetone then dried in the oven for 1 hour at 35 °C, then added 2-3 drops of samples on the slides and dried in oven at 35 °C to measured by AFM instrument. The particle size distribution for the synthesized gold nanoparticles was (70m) as shown in Figures-(3, 4)
Figure 3 - AFM image (2D and 3D) and a distribution chart of synthesis AuNPs. Average particle distribution for GNPs 61 nm and diameter 60 nm in Sample (2).

Figure 4 - AFM image (2D and 3D) and distribution chart of synthesis AuNPs. Average particle distribution 63 nm and diameter 55 nm in Sample (3).

Transmission Electron Microscopy
Transmission electron microscopy (TEM) is one of the most frequently used techniques for the characterization of nanoparticles. In this technique, a real image of nanoparticles is taken with different magnifications to develop a more detailed or general shape of nanoparticles [26]. The TEM images (Figures 5, 6) show the AuNPs in variable shapes. The size of the particles extends from 14-25 nm.
Figure 5-TEM images of AuNPs synthesized using AA and GA. With chloroauric acid. Size particle is 21 nm in sample 2

Figure 6-TEM images of AuNPs synthesized using AA and NaOH. With chloroauric acid. Size particle is (29 nm) and hexagonal form with a median size (357 nm) in sample 3.

Conclusion
This paper describes the facile and rapid synthesis of gold nanoparticles by a novel biochemical route. The new method (reverse method) was used by adding the Au$^{3+}$ solution to the reducing agent with heating and stirring. Control of the used amount of gold salt and the reducing agent and also an easy way to follow-up the gold nanoparticles formation through the red color of solution. In conclusion, it is inspected that use of AA as reducing agent with gum Arabic and NaOH a stabilizing agent for the preparation of AuNPs in water. The UV-Vis Sample 2 (534 nm), sample 3-(524 nm), zeta potential sample 2 and sample 3 (-19.30 mV), (-40.71) respectively, AFM and TEM results display that as prepared Au NPs are poly disperse nature, quasi-spherical and hexagonal form with a median size from (21, 29). The solutions are very stable even after one year the plasmon absorbance remained at same wavelength and no aggregation. Both samples can also be used in industrial and biological applications, due to high particle stability.

References


