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Synthesis and Characterization of Gold Nanoparticles by Aluminum as a Reducing Agent

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Abstract:

The synthesis of nanoparticles (GNPs) from the reduction of $HAuCl_4 \cdot 3H_2O$ by aluminum metal was obtained in aqueous solution with the use of Arabic gum as a stabilizing agent. The GNPs were characterized by TEM, AFM and Zeta potential spectroscopy. The reduction process was monitored over time by measuring ultraviolet spectra at a range of λ 520-525 nm. Also the color changes from yellow to ruby red, shape and size of GNP was studied by TEM. Shape was spherical and the size of particles was (12-17.5) nm. The best results were obtained at pH 6.

Key words: Gold nanoparticles, Gum Arabic, Reduction, Stabilizing agent.

Introduction:

Gold nanoparticles (GNPs) have attracted rising regard due to their unique properties in applications such as industry (1) electronics (2), catalysis (3), medicine (4), pharmacology (5) biosensor (6) and drug delivery (7, 8). Among the most significant features of the gold colloids is that thy produce a surface Plasmon group which can be used in sensors, catalysis and biosynthesis (4-10). NPs can be prepared by several physical and chemical techniques. The wet method is often utilized in the preparation of nanoparticles. In chemical synthesis, nanoparticle is developed in a liquid medium comprising different reactants mainly decreasing agents like sodium borohydride (2), potassium bitartrate (3), methoxy polyethylene glycol (4), or hydrazine (5). Various stabilizing agents including sodium dodecyl benzyl sulfate (5) or polyvinyl pyrrolidone (3) are put into the reaction mixture so as to avoid the agglomeration of metallic nanoparticles. Very frequently utilized chemical techniques are chemical reduction (6), electrochemical techniques (7) and photochemical reactions (8). Inorganic NPs and organic NPs are known to be two different kinds of NPs. Moreover, there are various kinds of inorganic metals and metal oxide NPs, which were investigated in (9-12). To cite the most significant examples of these kinds, detailed gold Au, silver Ag, zinc oxide (ZnO), palladium Pd, platinum Pt, and copper oxide (CuO) have to be mentioned (13-16) . This work deals with the synthesis of gold nanoparticles by aluminum as a reducing agent. Aluminum is regarded as a chemical element whose symbol is **Al**. Its atomic number is 13. Actually, it is the richest metal and a very powerful conductor of heat as well as electricity. It also has the characteristics of being strong but light, and an extremely reactive metal, though it is resistant to corrosion. Aluminum composes chemical compounds in the +3 oxidation state, which are commonly unreactive such as Aluminum chloride and aluminum oxide. However, it seldom composes compounds in the +1 or +2 oxidation state.

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Materials and Methods:

Chemicals and Instruments:

Chloroauric acid (HAuCl4.3H2O) from MERCK Company- Germany. Aluminum fillings from Alcoa- America. UV-Vis spectroscopy (Shimadzu, Japan), Atomic force microscope (AFM); (SPM AA 3000, USA); Transmission electron microscope (TEM); (Philips CM 10, Holland), and Zeta potential analyzer (Brook haven, USA) are used for the characterization of AuNPs.

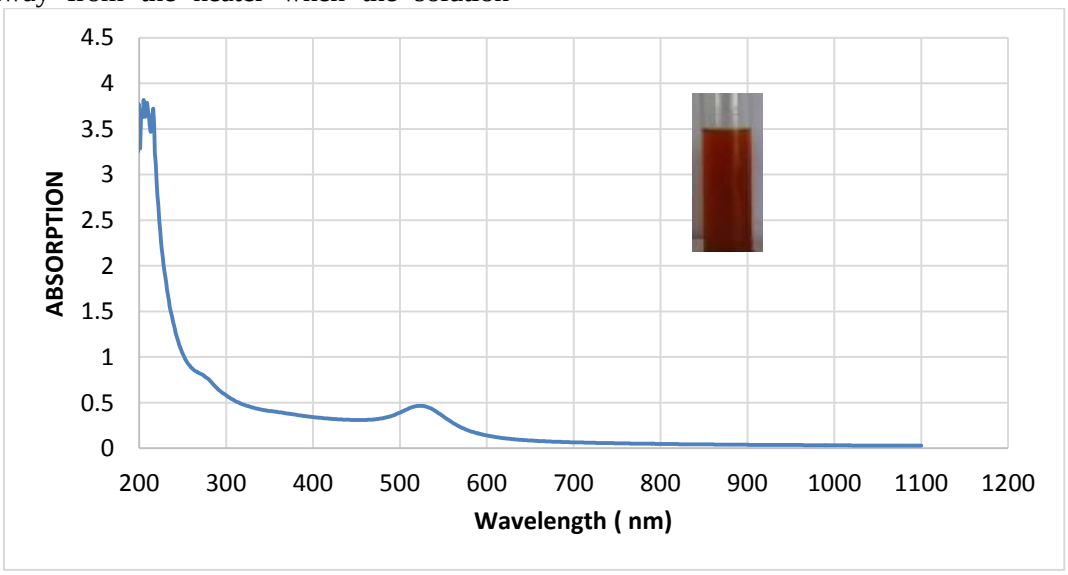
Synthesis of gold nanoparticles using Aluminum.

Synthesis of gold nanoparticles was done by dissolving 1.0g $HAuCl_4$. $3H_2O$ in 250 ml distilled water to produce a 10 mM. $HAuCl_4$. $3H_2O$ this stock solution of gold ion (Au^{+3}) can be prepared in advance if stored in brown bottle. Rinse all glassware with pure water before starting. 3ml of $HAuCl_4.3H_2O$ solution was added to 240ml distilled water in beaker or Erlenmeyer flask on a stirring hotplate with a magnetic stir bar (1cm) at 90-100C^0. The solution is heated to a temperature between 60-70C^0. Then, quickly 1g from Aluminum fillings was added with small pieces of Arabic gum (as stabilizing agent) to the rapidly stirred solution with the pH value control of the solution, which was 5 firstly then rose. The output was good at PH 6 by seeing the color of nanoparticles. The solution was picked away from the heater when the solution turned deep red which indicate the formation of gold nanoparticles and reduce Au^{+3} to Au^0

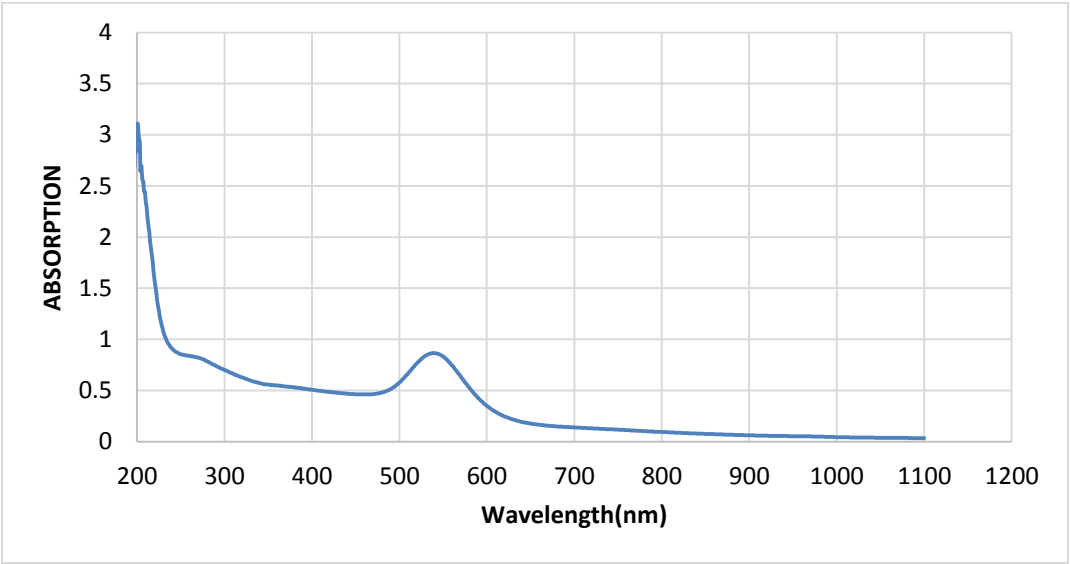
Results and Discussion

UV-Vis spectroscopy.

Normally, (GNPs) show a single absorption peak in the visible range between 500-550 nm. The surface Plasmon resonance and heavy absorption of visible light at 520 nm give brilliant red color to gold nanoparticle (GNP_S) which depend on their size. (17, 18) The UV-Vis spectrum for the colloidal solution of nanoparticles were prepared by Al as reducing agent with Arabic gum as stabilizing agent displays peak at roughly 524 nm, but UV-Vis spectrum for GNP_S prepared by using Al without any stabilizer was 538 nm. (19) (Fig.1).



A



B

Figure 1. UV-Vis spectra of GNPs(A, aluminum with gum Arabic ,524nm),(B aluminum without gum Arabic, 538nm)

AFM (Atomic force microscopy:

Atomic force microscope (AFM) measurement is an efficient technique to offer surface topography, phase images and morphological characteristics of GNP_s. Images(A, B, C) show AFM present a two–dimensional, three-dimensional and average particle distribution for gold nano particles (GNP_s)(20). The average particle of GNP_s is measured by AFM images. It can be observed that the average particle distribution of 73nm is as shown in (Fig. **2**).

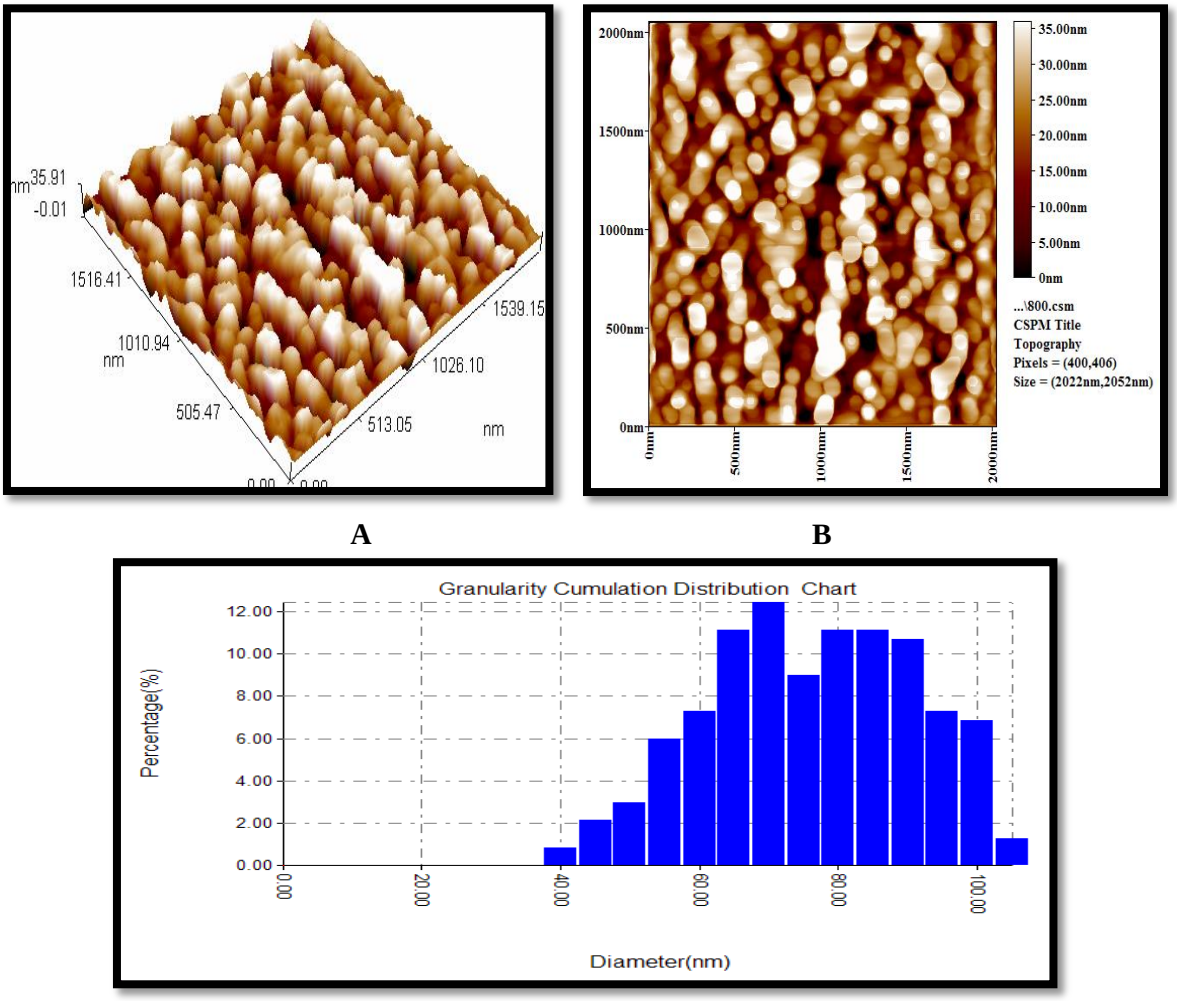


Figure 2. AFM image of GNP_s (A) 2D, (B) 3D, (C) Average particle distribution for GNP_s 73nm. By using Al as reducing agent with gum Arabic as stabilizer

TEM (Transmission electron microscopy).

TEM is considered as a very well-known method for the characterization of nanoparticles. An actual image of nanoparticles is taken with several magnifications in this technique to develop an extra comprehensive or broad shape of nanoparticles (21). The TEM images (Fig. 3). Show the GNPs in spherical shapes. The size of the particles ranged from 12-17.5 nm.

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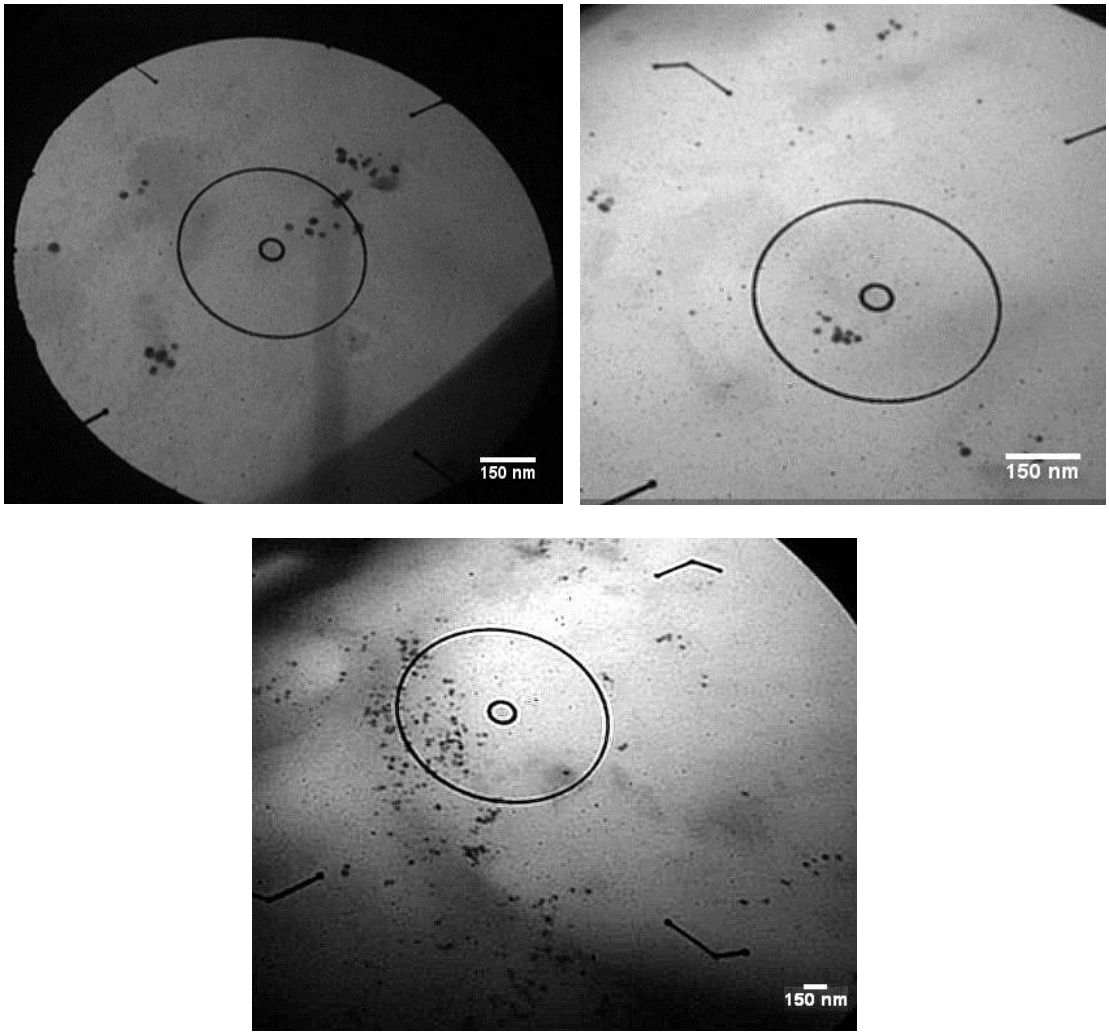

Figure 3.TEM images of GNPS synthesized using Al with GA .Size particle is 12- 17.5 nm (scale bar is 150nm)

Zeta potential:

Zeta potential is a significant indication of the stability of colloid solution. The solution will resist flocculate. In case the potential is limited, attractive power + .7 might surpass this repulsion and the dispersion might break and aggregation. Colloids with high zeta potential (negative or positive) are electrically steadied, while colloids with low zeta potentials have a tendency to aggregation. (22, 23) The zeta potential of the GNP_S colloidal solution was -17.5 mV which is very stable as shown in (Fig. 4).

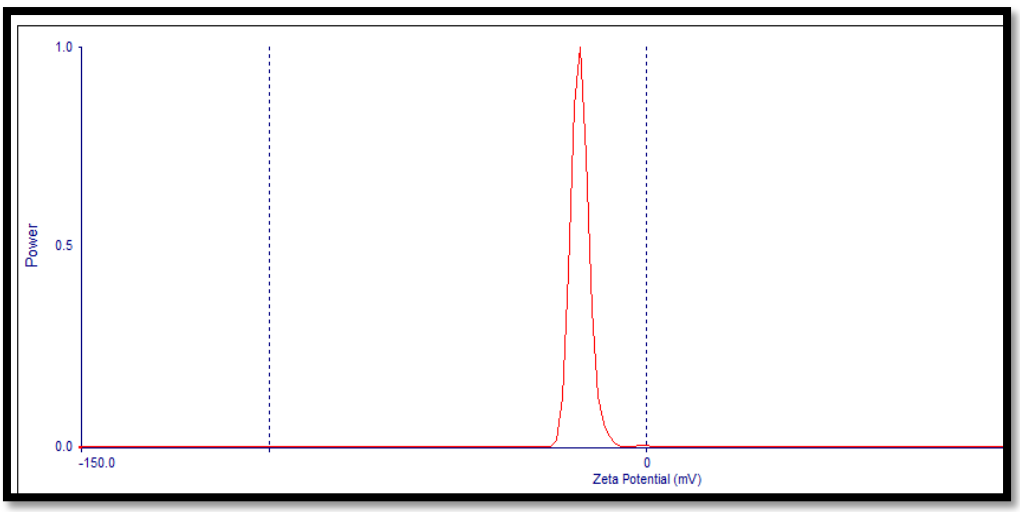

Figure 4. Zeta potential values for GNP_S -17.5 mV

Conclusion:

In conclusion nanoparticles are homogenous and mainly have spherical shapes and good stability in solution, the UV-Visible wavelength nanoparticles with 524 nm surface Plasmon resonance behavior and the auric acid with reducing agent show various color changes. The present work defines the facile and rabid synthesis of gold nanoparticles by a chemical method. GNPs with average diameter range 12-17.5 nm have been synthesized from the reaction of Al with $HAuCl_4.H_2O$ in aqueous solutions at 60-70 degree centigrade temperature with the presence of the reducing or dispersing agent.

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Conflicts of Interest: None.

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تحضير وتشخيص جسيمات الذهب النانوية باستخدام الالمنيوم كعامل مختزل

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الخلاصة:

تحضير جسيمات الذهب النانوية عن طريق اختزال ايون الذهب الموجود في حامض $HAuCl_4.3H_2O$ الاوريك بواسطة استخدام الالمنيوم كعامل مختزل اجري التفاعل في محلول مائي مع استخدام قطع من الصمغ العربي كعامل مثبت (عامل استقرار) لجسيمات النانو ، ثم تم تشخيص الجسيمات المتكونة بواسطة كل من التقنيات التالية، المجهر الالكتروني النافذ، مجهر القوة الذرية، وجهد زيتا ، عملية الاختزال تمت مراقبتها عن طريق تغير طيف الاشعة فوق البنفسجية مع الوقت وكان معدل الطول الموجي لاعلى قمة بين 520- 525نانومتر وكذلك مراقبة اللون اثناء تغيره من الأصفر الى الأحمر حيث يشير الى تكون الجسيمات النانوية و شكل وحجم الجسيمات تمت دراستهما من خلال صور المجهر الالكتروني النافذ حيث كان شكل الجسيمات كروي وحجمها بين 12-17.5 نانومتر. وان افضل النتائج كانت في مقياس حموضة (الاس الهيدروجيني) 6 .

الكلمات المفتاحية: جسيمات الذهب النانوية، الصمغ العربي، الاختزال، عامل مثبت.