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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 nano particle 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 rang (-19, -40 mv), AFM and TEM images show two different shapes, hexagonal and spherical and the size of gold nanoparticles between 21.5nm and 29nm.

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

خصائص جسيمات الذهب النانوية المحضرة بواسطة حامض الاسكوربيك مع الصمغ العربي وهيدروكسيد الصوديوم كمثبتات

ظلال عبد الغفور [1] ،رنا محي ياس[2]* ، منى أحمد سعيد[2]
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الخلاصة
في هذا العمل ، تم تحضير جزيئات الذهب النانوية المتوافقة حيويا عن طريق اختزال كلوريد الذهب بحامض الأسكوربيك كعامل اختزال. تم تثبيت جسيمات الذهب النانوية الغروية المنتجة في هذه الطريقة بواسطةالصمغ العربيالغير السام وهيدروكسيد الصوديوم.جسيمات الذهب النانوية الناتجة خصصت من خلال تغير لون حامض الكلوروواوريكاالأصفر اللون إلى اللون الأحمر والبني أعتمادا على نوع المثبت. جسيمات الذهب النانوية المحضرة تم تمييزها بواسطة المطياف الضوئي المرئي –الأشعة فوق البنفسجية,ولوحظ بان طول موجة الذروة بين 526 و 535 نانومتر. نتائج جهدzeta وجدت مابين (–19و –40) ملي فولت ،وصورة AFM و TEM أظهرتشكلين مختلفين مثل الشكل السداسي والكروي. وحجم جسيمات الذهب النانوية مابين (21.5 –29 نانومتر).

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.

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[2]These nanomaterials have numerous purposes in various domains such as electronics, cosmetics, coatings, packaging, and biotechnology. [3-6] Due to their optical properties the colloidal solution of mineral nanomaterials is transparent, thus they are valuable in cosmetics, coatings,and packaging. [7, 8]Among metal nanoparticles, silver and gold nanoparticle has enormous usage in industry and medicine.[3]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. [9-11]The chemical methods are the commune but the use of toxic chemicals during synthesis produces toxic by-products. [12]The physical methods require large amount of energy to maintain high pressure and temperature required for the reaction. [13]Thus the chemical and physical methods have their posses limitations; these are considered expensive and unsuitable for possible ecosystem. [14]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. [15, 16]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. [17, 18] At the nanorange many effects are arises such as large surface to volume ratio, minimizing effects of gravity, quantum effects etc. [19, 20] 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. [17]

Materials and Devices

Materials:

chloroauric acid ($HAuCl_4.3H_2O$)from MERCK Company-Germany, ascorbic acid (AA) $C_6H_8O_6$, acacia gum and sodium hydroxide (NaOH).

Devices:

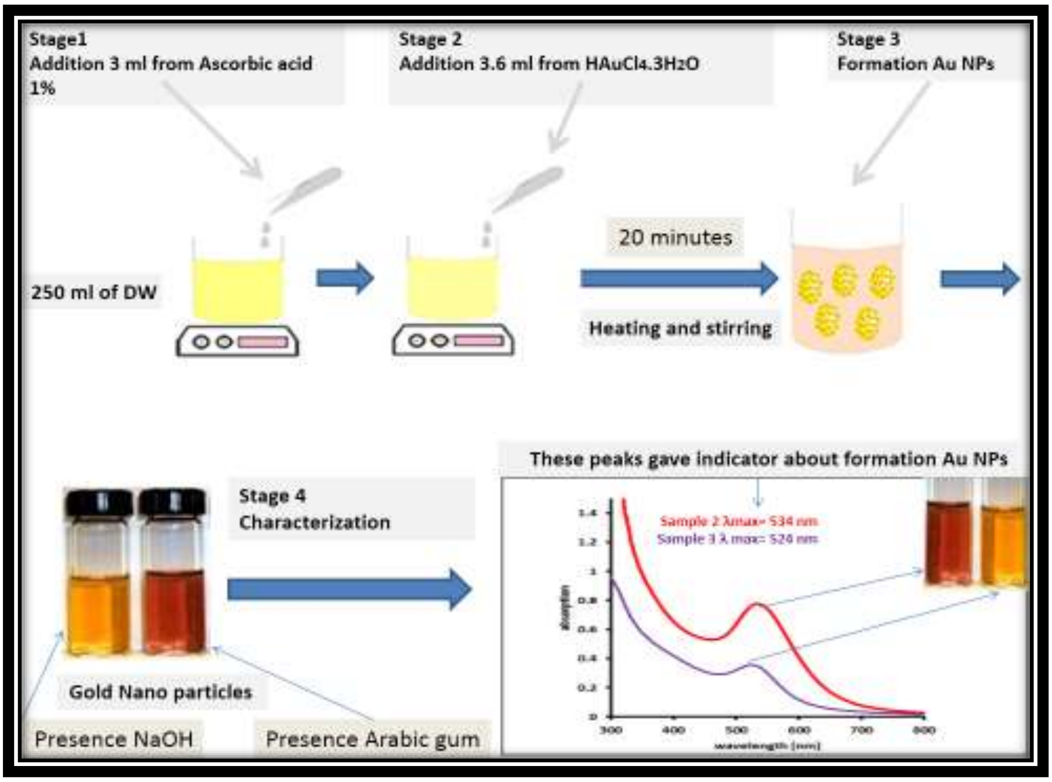
UV-Vis spectroscopy (Shimadzu, Japan), Atomic force microscope (AFM); (SPM AA 3000, USA); Transmission electron microscope (TEM); (Philips CM 100, Holland), and Zeta potential analyzer (Brook Haven ,USA)

Methods

Sample 1-Ascorbic acid (1%) was prepared (0.5 g with 50 mlof distilled water (DW)), then added to 250 ml of distilled water as solvent. After two minutes 3 ml of queues $HAuCl_4.3H_2O$ solution (10mM) was added gradually to the mixture with continuous stirring at 60-70 ^{0}Cuntil the color of the solution was changed to ruby red to give first indicator about formation Au NPs[21].

Sample 2-Ascorbic acid solution(3 ml) prepared in sample 1put on conical flask 500 ml . add little acacia gum to solution . Heat and stir the solution with the addition of 3.6ml 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 sample1 (1%) put on conical flask 500 ml and 1ml from (1% NaOH)add complete volume to 250 ml distilled water. Heat then stir the solution and add 3.6ml of chloroauric acid solution prepared in sample 1(10mM). After color change from yellow into brown color turn off heating and stirrer.



Scheme 1- Synthesis of AuNPs

The interaction equation:

$$2\ HAuCl_4 + 3C_6H_8O_7 \longrightarrow 2Au + 3C_5H_6O_5\ \text{(3-ketoglutaric acid)} + 8HCl + 3CO_2$$

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.

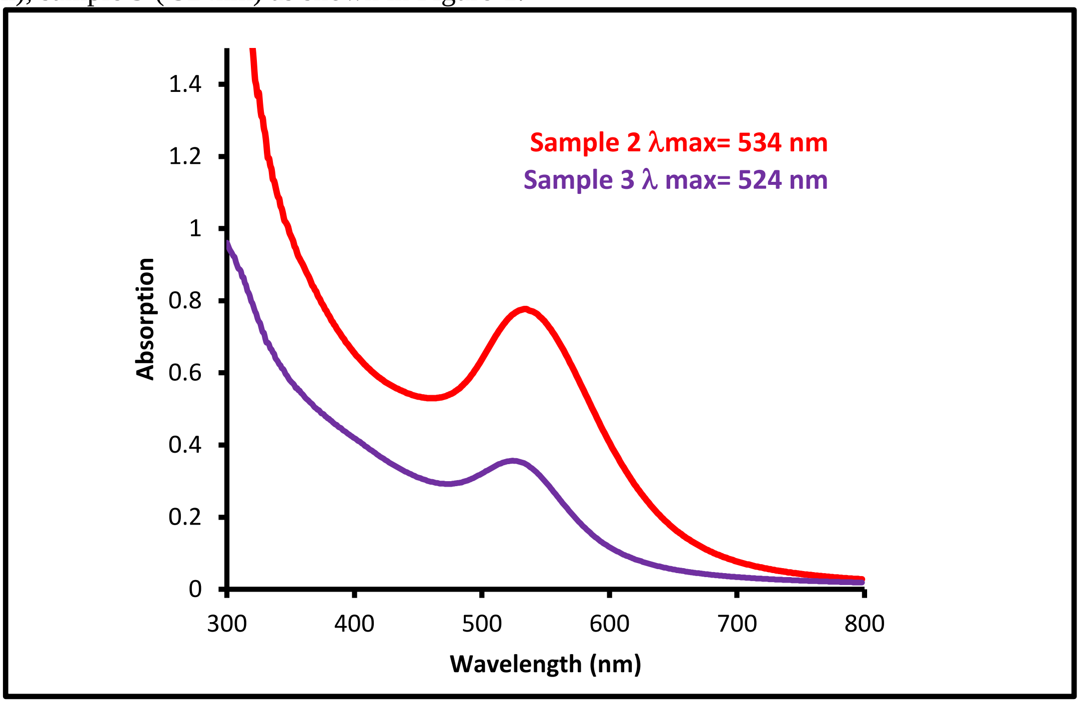


Figure 1-UV-Vis Spectroscopy of AuNPs using ascorbic acid with acacia gum(sample 2)and with NaOH(sample 3).

Zeta Potential (ζ)

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 -30mV and +30mV, 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.

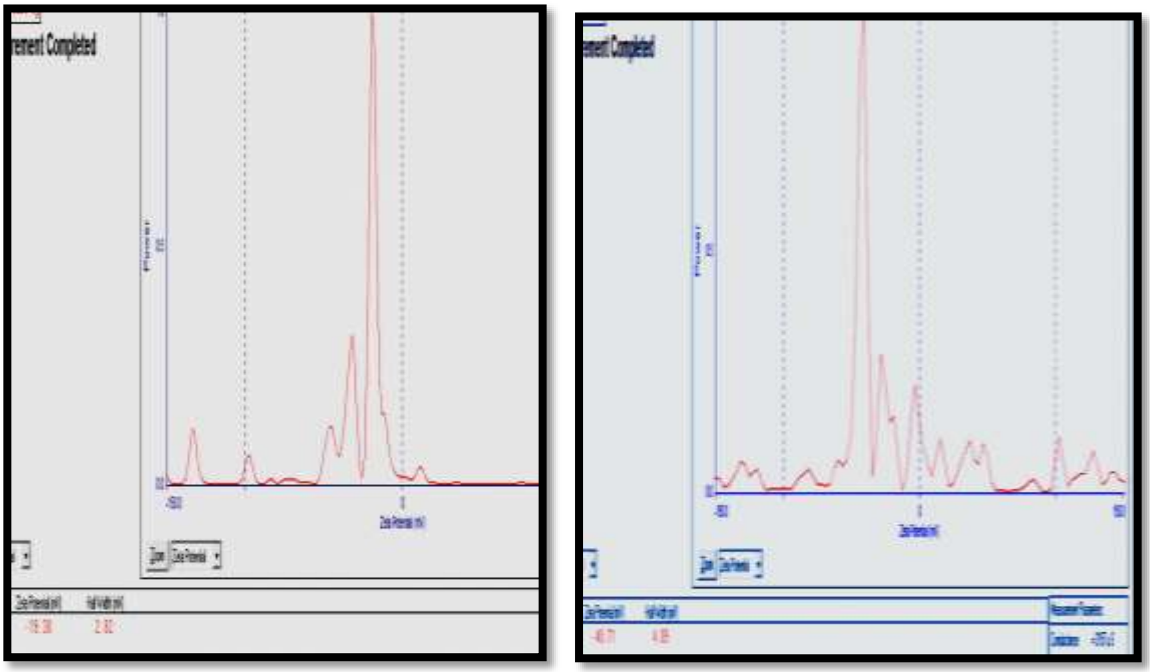
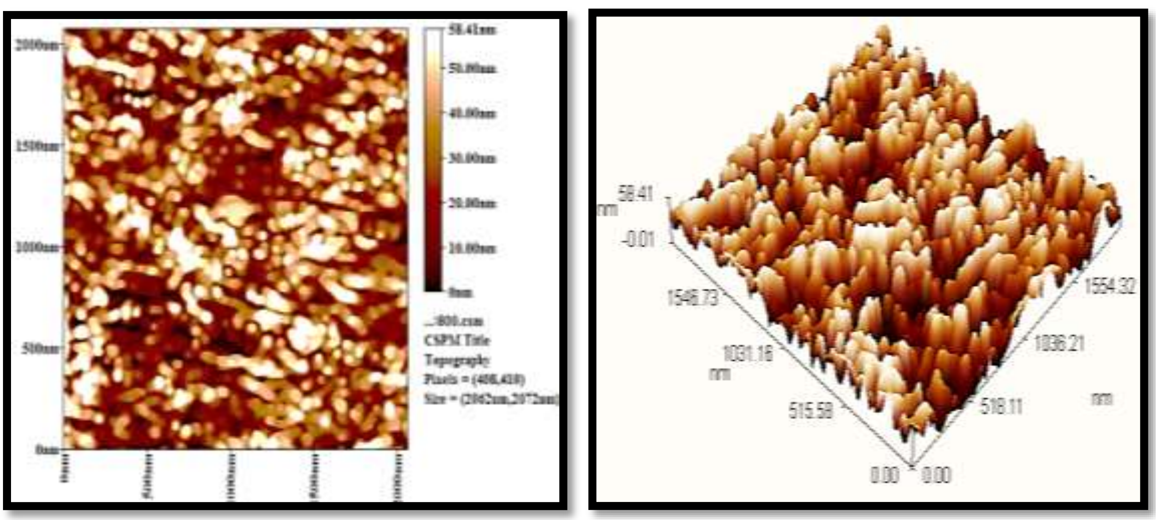


Figure 2-Zeta potential values of AuNPs for sample 2 and sample 3 (-19.30mV). (-40.71) respectively

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 8micrometers [25]. Glass slides were cleaned by distilled water ,ethanol and acetone then dried in the oven for 1 hour at 35 C^0 , then added 2-3 drops of samples on the slides and dried in oven at 35 ^oC to measured by AFM instrument. The particle size distribution for the synthesized gold nanoparticles was (70m) as shown in Figures-(3 ,4)

A B



C

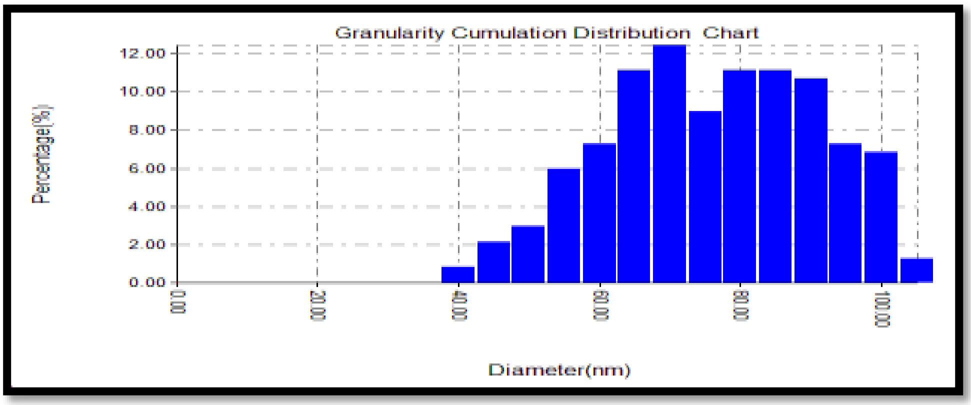


Figure 3-AFM image (2D and 3D) and a distribution chart of synthesis AuNPs. Average particle distribution for GNPs 61 nm and diameter 60 nm in Sample (2)

A **B**

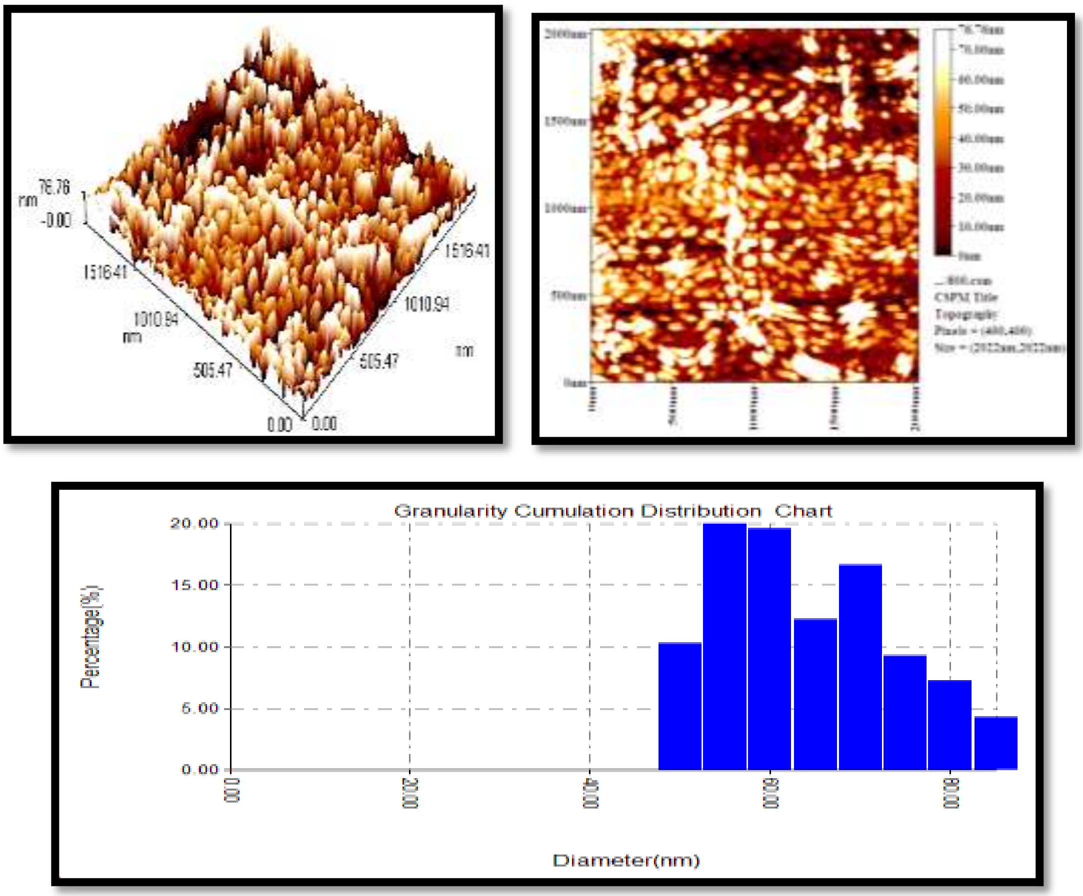


Figure 4-AFM image (2D and 3D) and distribution chart of synthesis AuNPs. Average particle distribution 63 nm anddiameter 55 nm in Sample (3).

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 14-25nm.

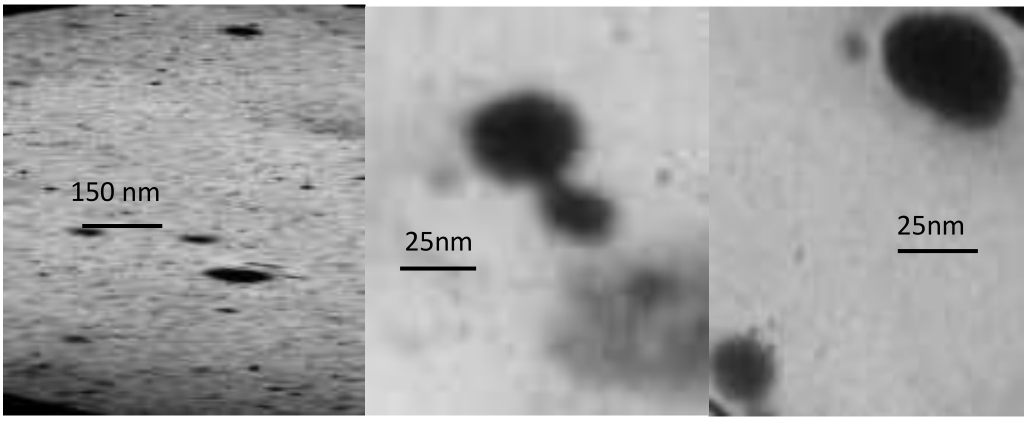


Figure 5-TEM images of AuNPs synthesized using AA and GA .With chloroauric acid. Size particle is21 nm in sample 2

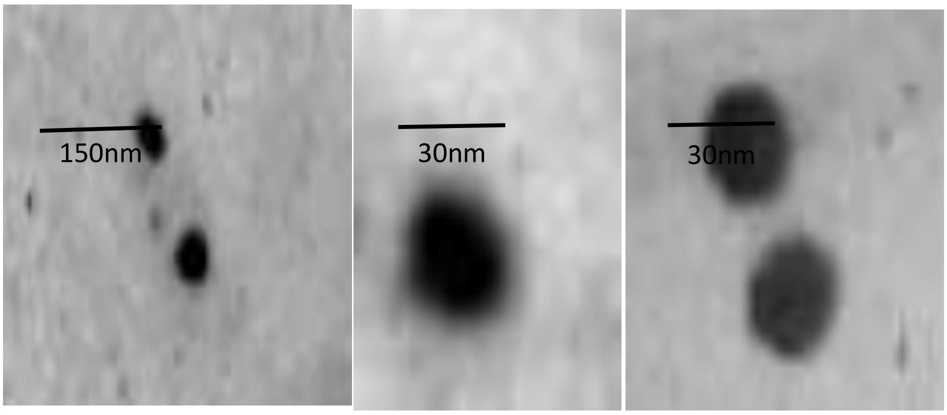


Figure 6-TEM images of AuNPs synthesized using AA and NaOH .With chloroauric acid . Size particle is(29 nm)and hexagonal form with an median size(357nm) in sample3.

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 andNaOH a stabilizing agent for the preparation of AuNPs in water. The UV-Vis Sample 2 (534nm) , sample 3-(524nm) ,zeta potential sample 2 and sample 3 (-19.30mV). (-40.71) respectively, AFM and TEM results display that as prepared Au NPs are poly disperse nature, quasi-spherical and hexagonal form with an 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

1. Alanazi, FK., Radwan, AA., Alsarra, IA. **2010.** Biopharmaceutical applications of nanogold. *Saudi Pharm J*, **18**: 179-193**.**
2. Thomas, S., Harshita, B.S.P., Mishra, P. and Talegaonkar, S. **2015.** Ceramic nanoparticles: fabrication methods and applications in drug delivery. *Curr. Pharm. Des*. **21**: 6165–6188.
3. Eustis, S. and Elsayed, M. A**. 2006.** (Why gold nanoparticles are more precious than pretty gold: noble metal surface plasmon resonance and its enhancement of the radiative and nonradiative properties of nanocrystals of different shapes). *Chem. Soc. Reviews*, **35**: 209-217**.**
4. Olejnk, M. Bujak, L. and Mckowski, S. **2012.** (Plasmonic molecular nanohybrids- Spectral dependence of fluorescence quenching), *Int. J. Mol. Sci*., **13**: 108-1028.

5. Deyev, S., Proshkina, G., Ryabova, A., Tavanti, F., Menziani, M.C., Eidelshtein, G., Avishai, G., Kotlyar, A**. 2017.** Synthesis, Characterization, and Selective Delivery of DARPin-Gold Nanoparticle Conjugates to Cancer Cells. *Bioconj. Chem*, **28**: 2569–2574**.**
6. Sobczac-Kupiec A., Malina D., Zimwska M. and Wzorek Z. **2011.** (Characterization of gold nanoparticles for various medical applications), *Dig. J. NanomaterBios*., **6**(2): 803-808**.**
7. Khutale, G.V. and Casey, A. **2017.** Synthesis and characterization of a multifunctional gold-doxorubicin nanoparticle system for pH triggered intracellular anticancer drug release. *Eur. J. Pharm. Biopharm*. **119**: 372–380**.**
8. Suganthy, N., Sri Ramkumar, V., Pugazhendhi, A., Benelli, G. and Archunan, G. **2017.** Biogenic synthesis of gold nanoparticles from Terminalia arjuna bark extract: Assessment of safety aspects and neuroprotective potential via antioxidant, anticholinesterase, and antiamyloidogenic effects. *Environ. Sci. Pollut. Res*.
9. Mallick, K., Witcomb, MJ. **2004**. ScurrellMS**.** (Polymer stabilized silver nanoparticles: a photochemical synthesis route). *J Mater Sci*, **39**(14): 4459–4463**.**
10. Prabu, J.H. and Johnson, I. **2015**. Plant-mediated biosynthesis and characterization of silver nanoparticles by leaf extracts of Tragiainvolucrata, Cymbopogon citronella, Solanumverbascifolium and Tylophoraovata , *Kar. Int. J. Mod. Sci*. **1**: 237–246**.**
11. Nalawad, P., Mukherjee, P., Kapoor, S**. 2014.** Biosynthesis, characterization and an- tibacterial studies of silver nanoparticles using pods extract of Acacia auri- culiformis , *Spectrochim. Acta, Part A* **129**: 121–124.
12. Song JY., Kim BS**. 2009.** Rapid biological synthesis of silver nanoparticles using plant leaf extracts. *Bioprocess BiosystEng*, **32**: 79-84.
13. Rajasekharreddy P, Rani PU, SreedharB **.**Qualitative assessment of silver and gold nanoparticle synthesis in various plants: A photobiological approach. *J Nanopart Res*, **12**: 1711-1721(2010) .
14. Kumar V, Yadav SK**. 2009.** Plant-mediated synthesis of silver and gold nanoparticles and their applications. *J ChemTechnol Biotechnol*, **84**: 151-157.
15. Tripathy A, Raichur AM, Chandrasekaran N, Prathna TC, Mukherjee A **2010.** Process variables in biomimetic synthesis of silver nanoparticles by aqueous extract of Azadirachtaindica (Neem) leaves. *J Nanopart Res***, 12**: 237-246**.**
16. Makarov VV, Love AJ, Sinitsyna OV, Makarova SS, Yaminsky IV, et al. "Green" nanotechnologies: Synthesis of metal nanoparticles using plants. *Acta naturae*, **6**: 35.
17. Banerjee P, Sau S, Das P, Mukhopadhyay, A**. 2014.** Green synthesis of silvernanocompositefor treatment of textile dye. *Nano sci Technol*, **1**: 1-6.
18. Khatoon, N., Mazumder, JA. and Sardar, M. **2017.** BiotechnologicalApplications of Green Synthesized Silver Nanoparticles. *J Nano sci Curr Res*, **2**: 107**.**
19. Jagpreet S, Tejinder S, Mohit R. **2017.** Green Synthesis of Silver Nanoparticles via Various Plant Extracts for Anti-Cancer Applications. *Glob J Nano***. 2**(3): 555590.
20. O'Neal DP., Hirsch LR., Halas NJ., Payne JD. **2004.** West JL**.** Photo-thermal tumor ablation in mice using near infrared-absorbing nanoparticles. *Cancer Lett*, **209**(2): 171-176**.**
21. Dhelal, A. **2016.** Synthesis And Identification Of Gold Nanoparticles By Different Reducing agent And Their Applications PhD. Thesis University of Anbar, Iraq.
22. Choudhury, A., A. Malhotra, P. and Bhattacharjee, G. S. **2014**. Prasad**.** Facile and *rapid* thermo-regulated biomineralization of gold by pullulan and study of its thermodynamic parameters" *Carbohydrate Polymers*. **106**(5): 154-159**.**
23. Owen , Tony **1999**. "Fundamentals of modern UV-Visible spectroscopy" *J. Chem. Ed*. **76**(7): 949-955**.**
24. Raj, V. Sreenivasan, K. **2010**. "Selective detection and estimation of C-reactive protein inserum using surface – functionalized gold nano – particles" *Anal. Chim. Acta*, **662**(2): 186–192**.**
25. Vasenka, J., Manne, S. Giberson, R., T. Marsh, T. E. Henderson, E. **1993**. "Colloidal Gold Particlesas an Incompressible AFM ImagingStandard for Assessing the Compressibility ofBiomolecules" *Biophys J*. **65**: 992-997**.**
26. Wang, Z., Mohamed, M., Link, S., El-Sayed, M. **1999. "**Crystallographic facets and shapes ofgoldnanorods of different aspect ratios" *Surf. Sci*. **440**(1): 809- 814**.**