

## Synthesis and characterization of Au nanoparticles for nanomedicine application

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### Abstract

Gold nanoparticles AuNPs have proven to be powerful tools in various nanomedicine applications, because of their photo-optical distinctiveness and biocompatibility. Noble metal gold nanoparticles was prepared by pulsed laser ablation method (1064-Nd: YAG with various Laser power from 200 to 800 mJ and 1 Hz frequency) in distilled water. The process was characterized using UV-VIS absorption spectroscopy. Morphology and average size of nanoparticles were estimated using AFM and X-ray diffraction (XRD) analysis which show the nature of gold nanoparticles (AuNPs). Antibacterial activity of gold nanoparticles as a function of particles concentration against gram negative bacterium Escherichia coli and gram positive bacterial Staphylococcus aureus was carried out in solid growth media. Gold nanoparticles show high antibacterial activity with zone of inhibition. Antibacterial activities of the synthesized Au nanoparticles were assessed by agar well diffusion method. The stabilized AuNPs exhibited excellent antibacterial sensitivity (12-27 mm) to E. coli and (26-38mm) to Staph aureus.

### Key words

Laser ablation, gold nanoparticles, antibacterial.

### Article info.

Received: Jun. 2017

Accepted: Jul. 2017

Published: Dec. 2017

### تحضير ودراسة خواص جسيمات الذهب النانوية في تطبيقات الطب النانوي

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### الخلاصة

ثبت أن جسيمات الذهب النانوية أداة فعالة في مختلف التطبيقات الطبية وقد تم تحضيرها بواسطة تقنية التشخيصية بليزر النديميوم ياك بطول موجي 1064 نانومتر وطاقات مختلفة لليزر. تم دراسة خصائص الذهب النانوية باستعمال مطياف الامتصاصية ودراسة الشكل ومعدل حجم الجسيمات النانوية بواسطة مجهر القوة الذرية (AFM) وحيود الاشعة السينية (XRD). جسيمات الذهب النانوية تعمل كمضاد بكتيري تجاه البكتريا السالبة والموجبة لصيغة كرام E.Coli و Staph aureus وهذا يعزى الى نسبة السطح الى الحجم الكبيرة وهو يوفر وسيلة اكثر فعالية لتعزيز النشاط كمضاد للبكتريا. جسيمات الذهب النانوية اظهرت نشاط عالي كمضادات للبكتريا حسب قياس منطقة التثبيط.

### Introduction

In recent years, nanoparticles have become a promising applicant in place of conventional materials with huge applications in the fields of science and engineering. The unique properties of Au nanoparticles (AuNPs) is due to the

higher surface-to-volume ratio and the increased number of atoms at their grain boundaries [1]. AuNPs have unique optical properties in the visible region, because of surface plasmon oscillation of free electrons [2]. Surface Plasmon Resonance (SPR), the

resonance that lay at visible frequency for noble metals as Au and Ag, given those intense colors and interesting optical properties, as reflected are due to their unique interaction with light [3]. Although Au nanoparticles are colloids, the properties at the nano scale differ greatly from their larger bulk Au counterparts [4]. Gold nanoparticles Au NPs are increasingly exploited for the design and development of novel nanomedicines, due to their easiness of synthesis, characterization, and surface functionalization [5]. Synthesize Nanoparticles are generally characterized by their size, shape and disparity. Preliminary characterization of the synthesized NPs is carried out using UV-visible spectroscopy [6]. Two main approaches are used in nanotechnology. In the “top-down” approach, nano-objects are constructed from larger entities without atomic-level control. In the “bottom-up” approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. [7,8]. Nanoparticles can be produced by short pulse laser ablation of a solid target in liquid media. This method gives a unique opportunity to solve the cytotoxic effects reported for the Nanoparticles produced by chemical synthesis [9].

The ability to integrate metal nanoparticles into biological systems with general lack of toxicity has had greatest impact in medicine and biology. Among noble metal particles, have low toxicity and can be readily attached to molecules of biological interest [10]. Different studies demonstrate their excellent antimicrobial properties, with a large spectrum including Gram-positive and Gram-negative bacteria, including multidrug resistant strains [11, 12]. Due to their large surface area

to volume ratio and biocompatibility, inorganic nanoparticles are consider as ideal candidates for carrying large amounts of antibiotics with no compromising their activity [13]. The emergence of bacterial resistance to antibiotics and its dissemination, however, are main health problems, leading to treatment drawbacks for a large number of drugs [14]. \*Conventional strategies for cancer intervention include chemotherapy, surgery, and radiation therapy. Taking advantage of their unique properties, most studies of gold nanoparticle Au NPs -based cancer therapy have used photo thermal therapy for the destruction of cancer cells or tumor tissue [15].

\*The main aim of this research is to prepare gold nanoparticle by pulse laser ablation method for therapy against malignant and benign diseases.

\*Different doses of these NPs were utilized to check antibacterial mechanism against tow type bacteria gram positive and gram negative (E.coli and staph aureus ), Anti Cancer therapy.

## Experimental work

### 1. Materials

Circle Bulk of Gold, distal water, Nd-YAG Laser of wavelength (1064 nm). The experiment for antibacterial activity using different bacterial strains. Escherichia coli, and Staphylococcus aureus, Nutrient media was used for evaluating bacterial growth.

### 2. Laser ablation Synthesis of Gold Nanoparticles

Gold Nanoparticles colloid was produced by irradiating a metallic target plate immersed in distilled water at room temp. and place on a rotating sprayer (2 rotation per minute) with pulsed laser beam (department of

physics- collage of science - University of Baghdad). The ablation was performed with the (1064 nm) of a Nd-YAG laser (1000 pulses) operating at 1 Hz repetition rate, with a power (200, 360, 500, 660 and 800 mJ). The beam was focused, through a liquid layer, on the surface of the target.

### 3. Characteristics Measurements

Structural features of samples (XRD) and the optical features were investigated by UV-Vis spectroscopy. the surface roughness and topography of deposited thin films were studied by (AFM), additionally SEM was employed to confirm the NPs shape, size and particle size distribution. and The nanoparticles were centrifuged and re-dispersed in double distilled water thrice to purify them for FTIR studies.

### 4. Antibacterial activity

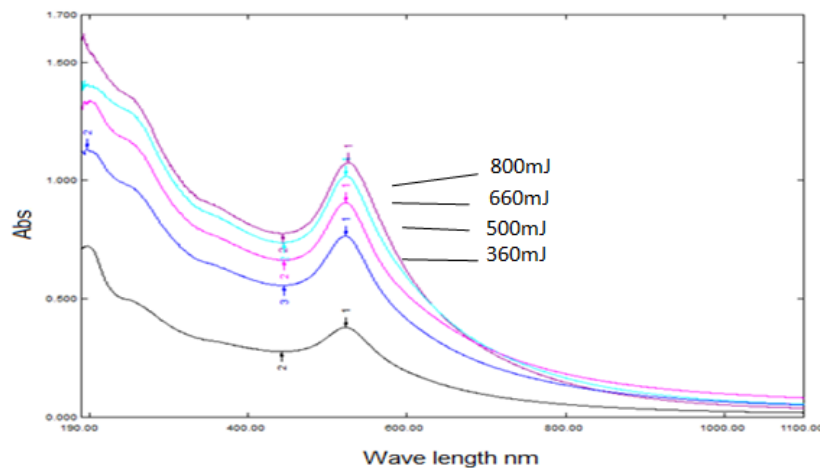
Antibacterial activities of gold nanoparticles were studied against Gram- negative bacteria (*E.Coli*) and Gram- positive bacteria (*Staph aureus*), was used for evaluating

antibacterial property of Gold nanoparticles. Antibacterial activity of nanoparticles was evaluated using, standard agar well diffusion method in which gold nanoparticles solution were used. Wells (diameter = 6 mm) were punched in the agar plates and filled with different nanoparticles solutions, samples treated with nanoparticles were spread on nutrient agar plates and after incubation at 37 °C for 24 hrs and measured the diameter of inhibitory zones in mm.

## Results and discussion

### 1. UV-Visible spectroscopy of gold nanoparticles

Optical property of nanoparticles is an important property which gives specific information of shape, size, concentration, agglomeration state, etc., near the surface of the particles. These particles interact with specific wavelength of light and show maximum absorption at a seartin wavelength. The UV-Vis spectra of the synthesized Au nanoparticle are presented in Figs. 1.



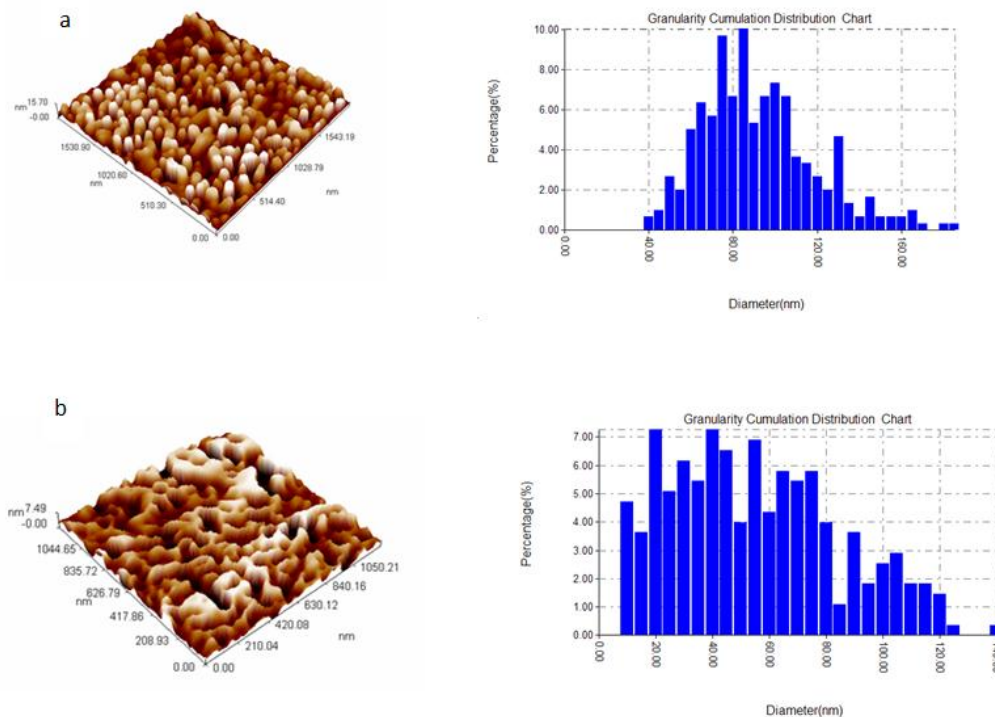
**Fig.1:** Absorbance spectra of Au Nps obtained by laser ablation with various laser energy.

Laser energy (mJ)	Wave length( nm)	Abs
200	523	0.379
360	523	0.765
500	523	0.906
660	523	1.018
800	526	1.075

## 2. AFM analysis of gold NPs

The AFM is a scanning probe microscope describe a profile while maintaining the force or electric current between the tip and sample constant. By scanning the sample line

by line and using a calibration file for each scanner a topography image of the surface is reconstructed and can be used in particle imaging and sizing. The size of the gold NPs of samples have range between 40-89 nm Fig. 2.

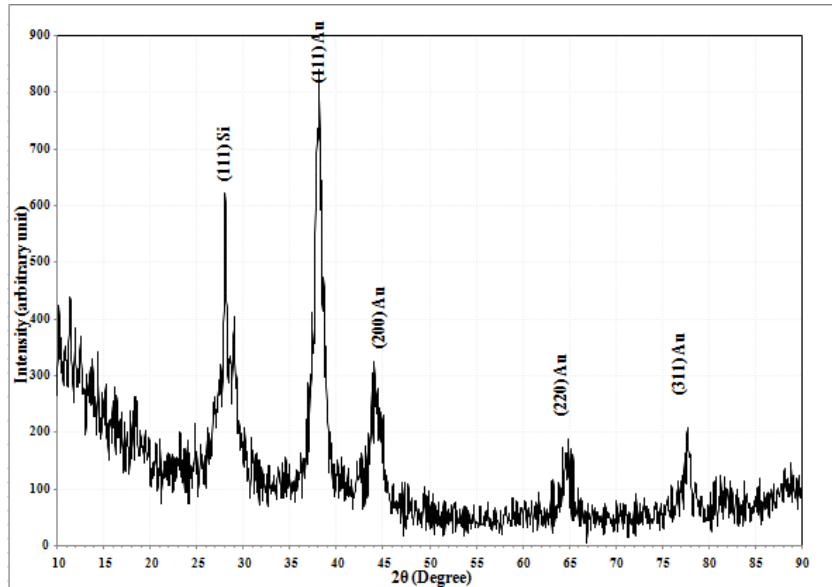


**Fig. 2:** 3D AFM images and histogram of Au Nps, produced by laser ablation. The laser energies are a: 200mJ and b: 360 mJ.

## 3. XRD analysis of gold NPs

The crystal structure of gold NPs is demonstrated by XRD as shown in Fig. 3. Samples are prepared by the drop-casting of gold sol on a selenium surface. The diffraction peaks of gold NPs are observed at  $38.14^\circ$ ,  $44.06^\circ$ ,

$64.92^\circ$  and  $77.7^\circ$ , representing the index as (111), (200), (220) and (311), respectively, which verified the polycrystalline face-centered cubic structure, and thus matched the literature [16].

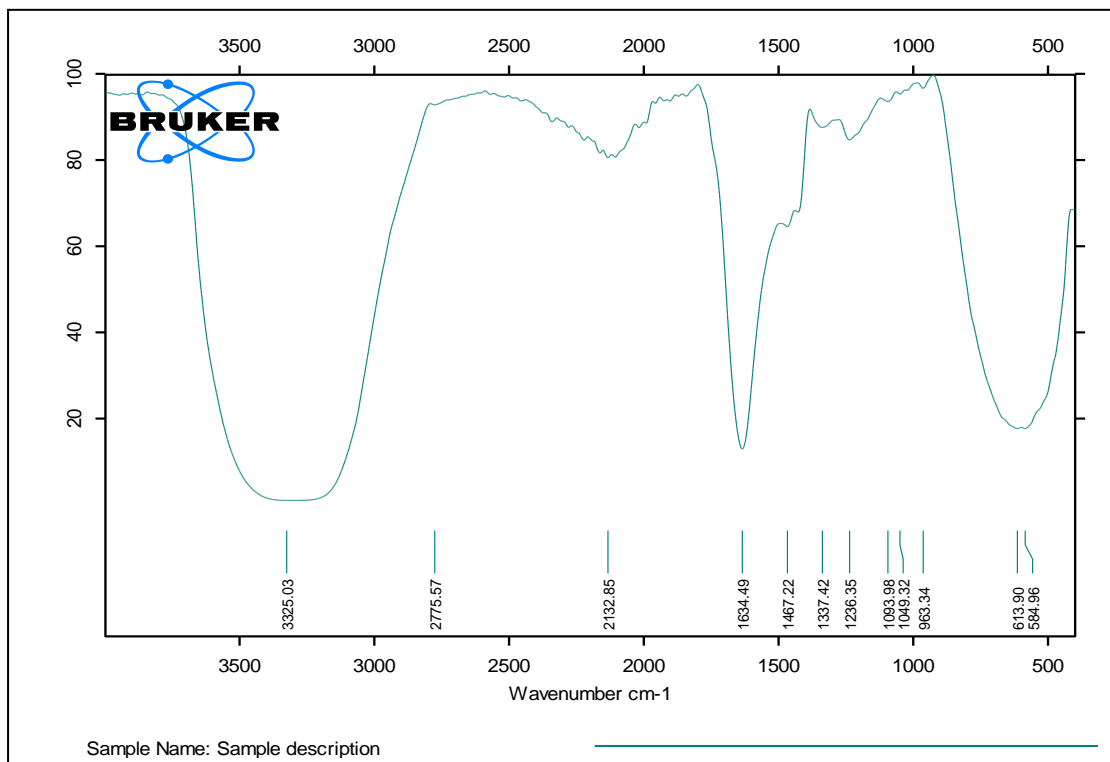


**Fig.3:** X-ray diffraction pattern of gold nanoparticles, produced by laser ablation. The laser energies are 800 mJ.

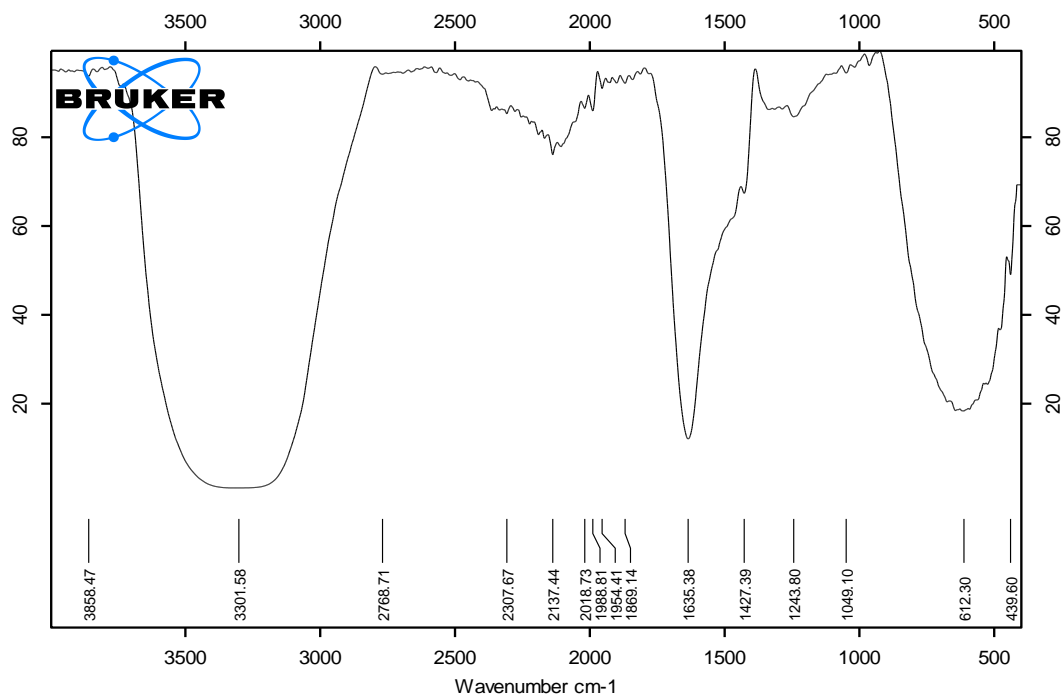
**4. FTIR analysis of gold NPs**

Inspection other analytical techniques such as FTIR spectroscopy type (The PerkinElmer Spectrum 100 Series FT-IR spectrometer) is used to

study the adsorption of organic species on the metal oxides nanoparticles. FTIR spectra were measured at room temperature with the spectrometer using the KBr Pellet technique.



**Fig. 4:** a Ftir spectra of AuNps, produced by laser ablation. The laser energies are 200 mJ/pulse.



Sample Name: Sample description

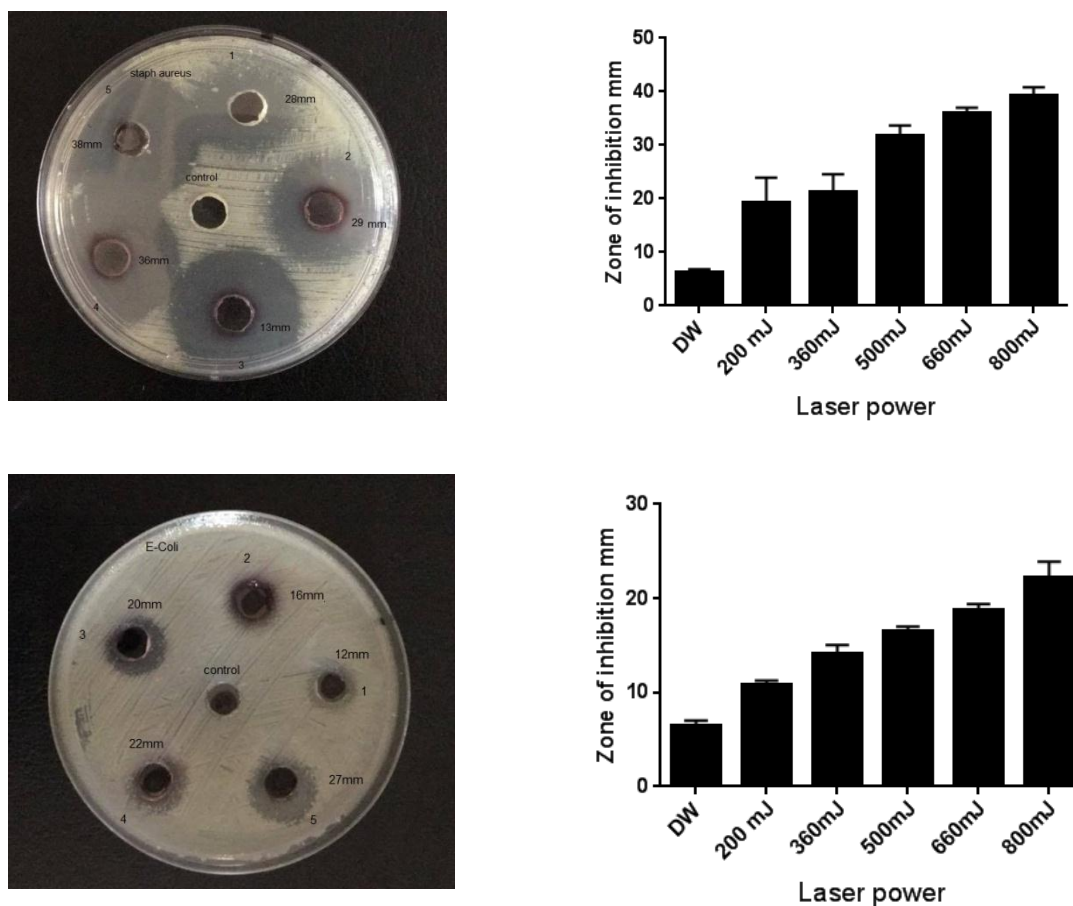
**Fig.4: b** Ftir spectra of Au Nps, produced by laser ablation. The laser energies are 360 mJ/pulse.

The FTIR spectrum of synthesized gold nanoparticles is shown in Fig.4. peak at  $3325.03\text{ cm}^{-1}$  assigned as N-H stretching of amide (II) band. The peak at  $1634.49\text{ cm}^{-1}$  was O-H stretching vibration of alcohols and phenols. The band located at  $1337.42$  and  $1093.98\text{ cm}^{-1}$  was because of C-N stretching vibration of aromatic and aliphatic amines, respectively. C-Br stretching vibration was shown in  $584.96\text{ cm}^{-1}$ .

### 5. Antibacterial mechanism of gold nanoparticles

Antibacterial activity test of gold nanoparticles were studied against Gram- negative bacteria. Standard

strain of *Escherichia coli*, and Gram-positive (*Staph aureus*) was used for evaluating antibacterial property of Gold nanoparticles. Antibacterial activity of nanoparticles was evaluated using, standard agar well diffusion method in which gold nanoparticles solution were used. The bacterial strain used in test was grown on Broth at  $37\text{ }^{\circ}\text{C}$ . Wells (diameter = 6 mm) were punched in the agar plates and filled with different nanoparticles solutions. Samples treated with nanoparticles were spread on nutrient agar plates and after incubation at  $37\text{ }^{\circ}\text{C}$  for 24 hrs the number of CFU were counted.



**Fig.5:** Well diffusion method of (70 micro letter) five sample with various laser energy of Au NPs against *E.coli* and *S.aureus*. DW in the control.

### Conclusion

Gold nanoparticles were successively prepared by laser ablation in water. The energy of laser beam affected on the prepared nanoparticles as the energy increases the size of nanoparticles decreases until they reached their critical size below which the particle not sensitive to the laser energy. As the energy increases above this value the nanoparticles begin to agglomerate again and the size increases. Gold nanoparticles have revolutionized the field of medicine because of its wide spread applications in targeted drug delivery, imaging, diagnosis and therapeutics due to their extremely small size, high surface area, stability, non-cytotoxicity and tunable optical, physical and chemical properties.

It was more influential against Gram-negative bacteria. The antibacterial mechanism of gold NPs against four pathogenic bacteria demonstrated that gold NPs can be the next therapy against this enteric bacterium, the maximum zone of inhibition for Au NPs against *E. coli* and *S. aureus* is 27 mm and 38 mm respectively.

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