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Effect of Laser Pulse Energy on the Characteristics of Au Nanoparticles and Applications in medicine

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Abstract

In this paper, Au NPs prepared by pulsed laser ablation in liquid (PLAL) with different laser energy (200, 360,500,660 and 800 m J) with number of pulses (1000pulse), at wavelength 1064 nm, and repetition rate of 1Hz. The structural, morphological and optical properties were discussed. XRD spectra showed the diffraction peak. AFM showed the average diameter. The optical properties showed increase absorption spectra at increase energy. Further in vitro antibacterial activities of Au NPs were investigated against Gram positive and Gram negative. *Staphylococcus aureus* and *E.Coli***.** Studied Toxicity of the synthesized Au NPs on human blood cells.

Keywords: Au NPs, laser ablation, absorption spectra, AFM, XRD, antibacterial, Toxicity.

تأثير طاقة الليزر النبضي على خواص جسيمات الذهب النانوية وتطبيقاتها في الطب

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الخلاصة

في هذا البحث، تم تحضير جسيمات الذهب النانوية بواسطة التشظية بالليزر في السائل باستخدام طاقات مختلفة لليزر (200, 360,500,660 and 800 m J) وعدد نبضات (pulse1000) وطول موجي 1064 نانومتر وتردد 1 هيرتز. تم دراسة التركيب والشكل والخواص البصرية بواسطة حيود الاشعة السينية XRD و مجهر القوة الذرية AFM وأظهرت دراسة الخواص البصرية زيادة قمة الامتصاصية مع زيادة طاقة الليزر. تم استخدام جسيمات الذهب النانوية كمضادات للبكتريا الموجبة والسالبة *Staphylococcus aureus* and *E.Coli*. وتم دراسة سمية جسيمات الذهب النانوية على خلايا دم الانسان.

Introductin

Laser ablation of target submerged in liquid environment which is simple method, recently has attracted much attention for NPs creation [1, 2] The unique physical properties of Nano scale materials have shown to have abilities to develop wide array methods for cost-effective diagnosis, fast determination of resistance of antibacterial drugs, and efficient delivery of antimicrobial agents [3]. Among the different metallic NPs, Au NPs have wide range of applications in Nano scale devices and

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technologies owing to its chemical inertness and resistance to surface oxidation [4]. Au NPs also have possible activity against microbial pathogens and it mainly depends on the size and shape of the particles. The coating of aminoglycosidic antibiotics with Au NPs has an antibacterial effect on a range of Gram-positive and Gram-negative bacteria [5]. Au NPs have been measured to be highly useful platform for the efficient drug delivery/carrier system owing to their facile and well-studied synthesis, easy surface functionalization and biocompatibility and less toxicity [6]. Also, Au NPs have shown to increase drug concentration at infected site with reduced toxicity of the drug [7].

Experimental Setup

The experimental setup for laser ablation of gold target immersed in pure distal water. The wavelength of an Nd:YAG laser are 1064nm, and repetition rate 1 Hz with 1000 pulse. Gold target was located on the bottom of glass vessel filled with pure water; glass vessel was located on a metal disk up small rotator holder moving 2 cycles per minute, even pulses distribution on all surface gold target. Different laser energy (200, 360,500,660 and 800 m J). Structural features of samples (XRD). While the optical features were investigated by UV-Vis spectroscopy. The surface roughness, size and topography of deposited thin films were studied by (AFM). Antibacterial activities of Au NPs were studied against Gram- negative bacteria (*E.Coli*) and Gram- positive bacteria (*Staph aureus*), was used for assessing antibacterial property of Au NPs. Sample preparation for SEM was carried out according to Kockro method with some modifications. Bacterial cells of *E. coli* and *S. aureus* treated with and without Au NPs. A thin mark of the suspension was then extent on a glass slide Samples were observed under a scanning electron microscope (SEM).

Hematological analysis

Blood sample of 2 ml was collected into two tubes, the 1st tube for blood with Au NPs and the 2nd tube for whole blood. Leave the blood for 1 hour. Demonstrated that Au NP didn't cause cytotoxic effects.

Results and Discussion

Optical properties has been performed using absorbance spectra of gold nanoparticles prepared PLAL. The absorption peak of gold nanoparticles prepared by (200, 360, 500,660 and 800 pulses) were found equal to (0.37, 0.76, 0.9, 1.02 and 1.07) respectively with peak position at wavelength nearly 523nm. We can note increase absorption spectra at increase laser energy. As show in Figure-1.

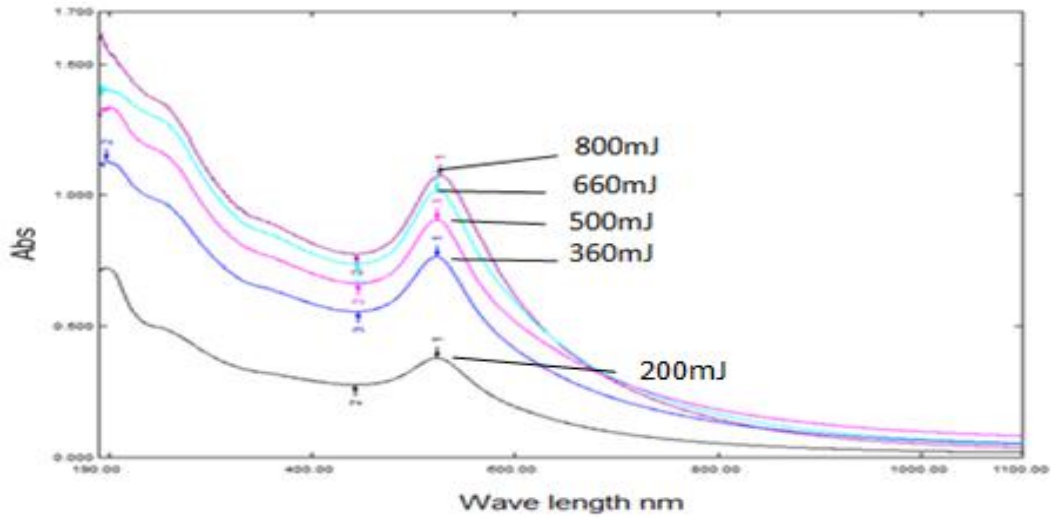

Figure 1- Absorption spectra of Au NPs.

The surface morphology of production Au NPs was explored using atomic force microscope (AFM). We have studied the surface morphology properties of the Au NPs prepared by pulsed laser ablation in liquid. The surface morphology of Au NPs samples that prepared with different power, at constant number of pulses (1000 pulse). The images in Figure-2 showing shape Au NPs from graphical 3D image at deposited on silicon slides.

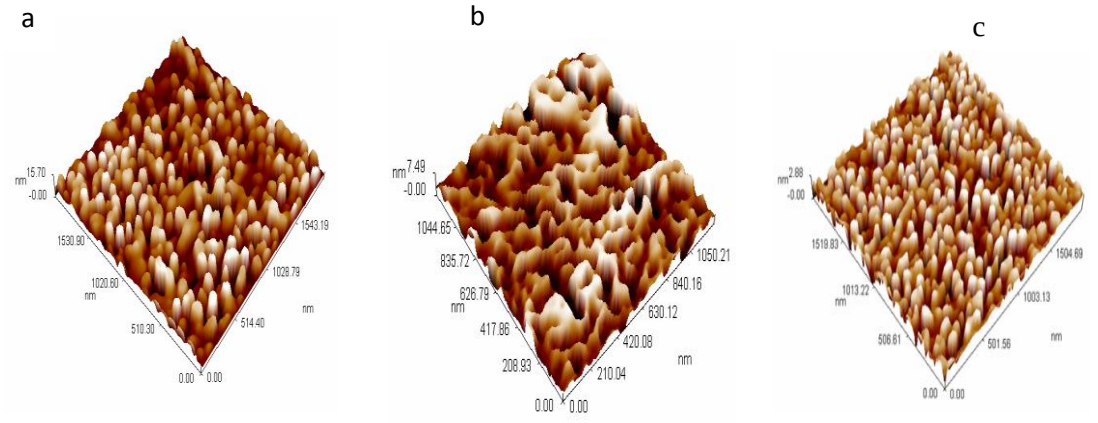

Figure 2- 3D AFM image of Au NPs with (a) 200, (b) 360, and (c) 500 m J.

Crystal structure of Au NPs is demonstrated by XRD as shown in Figure-3. The diffraction peaks of Au NPs are observed at 38.140, 44.060, 64.920 and 77.70, representing the index as (111), (200), (220) and (311), respectively, and thus matched the literature [8].

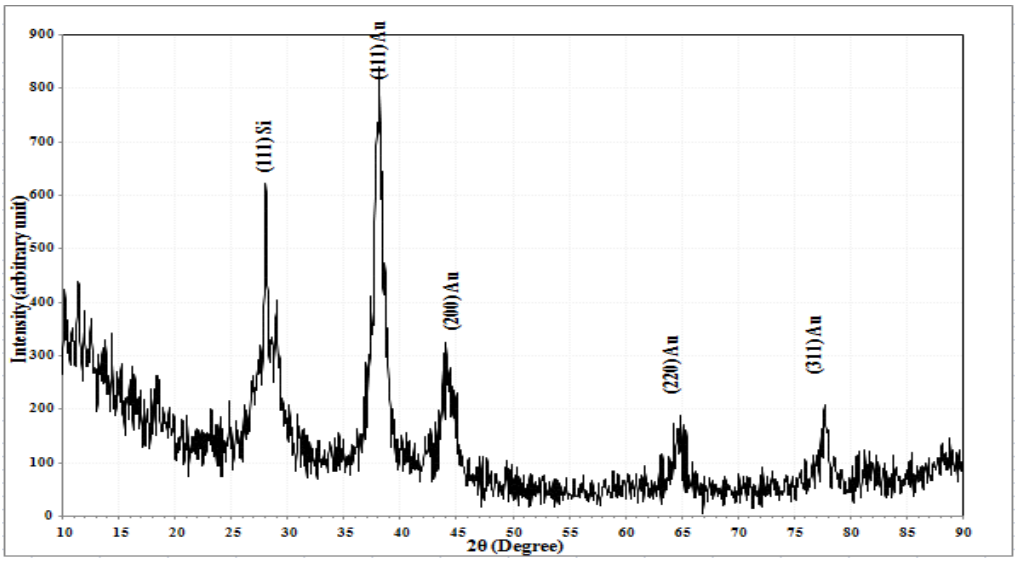

Figure 3- X-ray diffraction pattern of Au NPs at laser energy 800 mJ/pulse.

Table 1- XRD peaks of Au NPs.

2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std.(Å)	hkl	Phase	card No.
38.1400	0.8906	2.3577	9.4	2.3500	(111)	Cub. Au	96-901-2431
44.0600	1.5376	2.0536	5.6	2.0352	(200)	Cub. Au	96-901-2431
64.9200	0.5987	1.4352	15.7	1.4391	(220)	Cub. Au	96-901-2431
77.7000	0.7847	1.2280	13.0	1.2273	(311)	Cub. Au	96-901-2431

The samples were prepared for analysis of X-ray diffraction by deposition of Au particles on a slide of Silicon. The average grain size was determined from Scherrer equation [9].

$$D = \frac{K\lambda}{\beta \cos\theta} \quad \ldots\ldots (1)$$

Where D is the average grain size, K constant, β the Full Width at Half Maximum (FWHM) of the diffraction peak, λ the X-ray wavelength and ɵ the Bragg diffraction angle.

SEM imaging for Cell morphology

The antibacterial actions are thought to be linked to interactions of the biocides with the cell membrane of the microorganisms. This ultimately reasons the death of the cell. Figures-(4, 5) shows that the activity of Au NPs (prepared by laser energy 800mJ) on the bacterial cell and both bacterial strains were examined using SEM analysis to look for structural changes in outer-membrane of the cells.

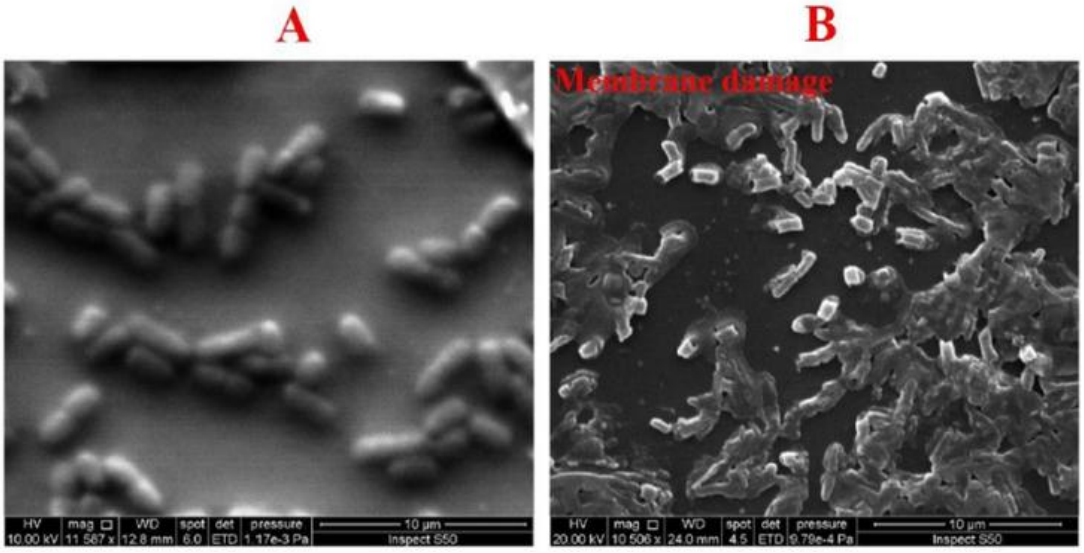

Figure 4- SEM image of *E.coli* A: before Au NPs, B: imaged after reaction with Au NPs.

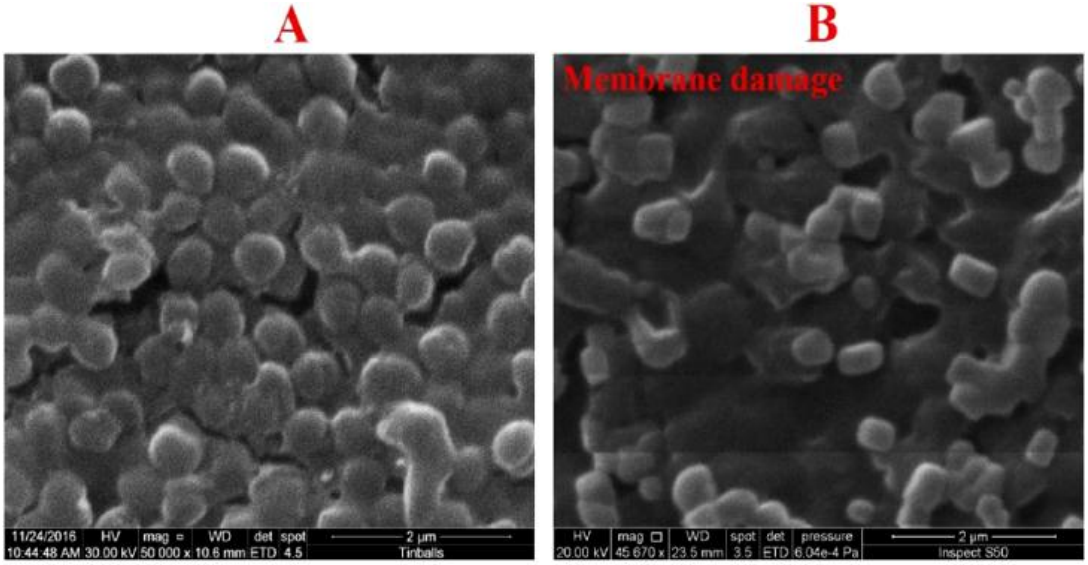

Figure 5- SEM image of *S.aureus* A: before Au NPs, B: imaged after reaction with Au NPs.

Hematological analysis

Figure-(6, 7) shows a comparison between groups of treatment with control positive in RBCs. There was follow up in RBCs count in treatment groups, a significant difference between them expect in PTT group, in which, no significant difference of treatment in comparison with control positive.

Figure-8 shows comparison between groups of treatment with control positive on WBCs. no significant difference of treatment in comparison with control positive.

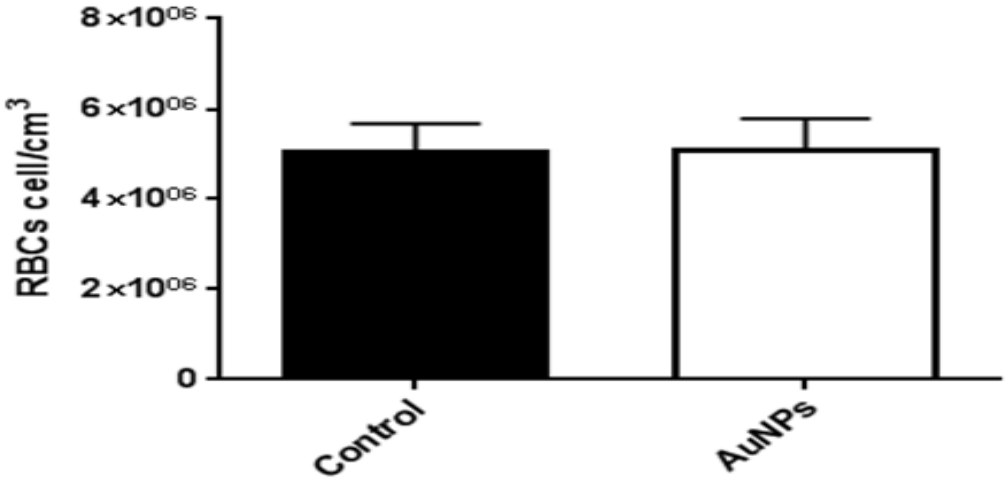

Figure 6- RBC in human blood after Au NPs (800mJ laser energy) compared with the control.

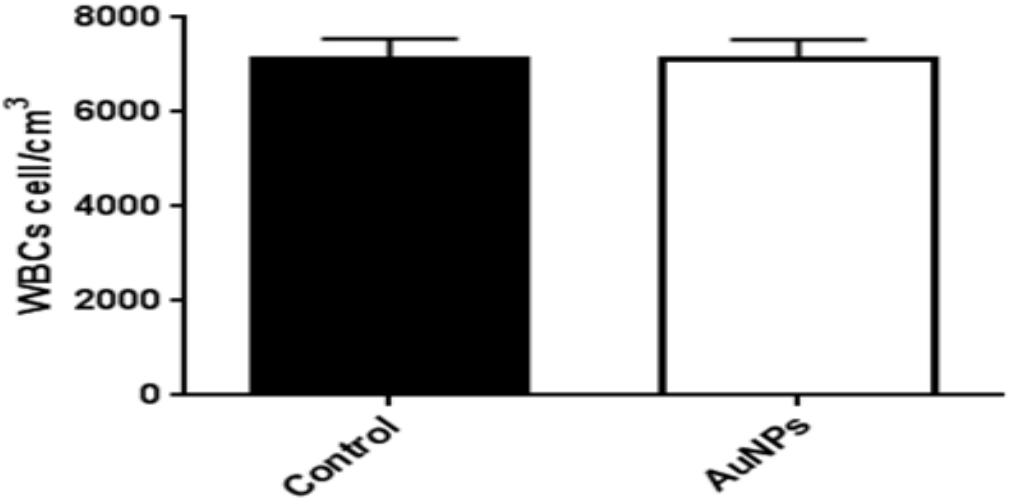

Figure 7- WBC inhuman blood after Au NPs (800mJ laser energy) compared with the control.

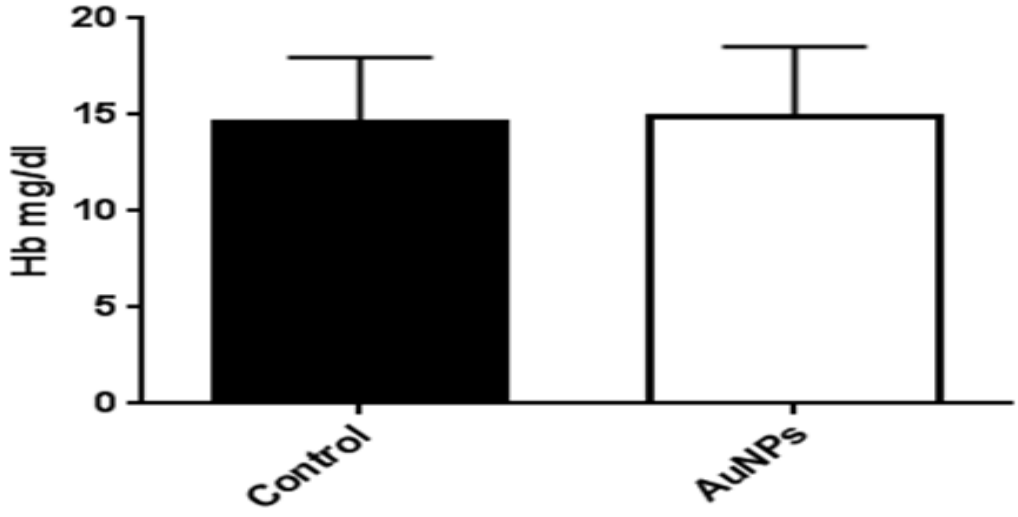

Figure 8- Hb in human blood after Au NPs (800mJ laser energy) compared with the control.

Conclusions

Au NPs were successively prepared by laser ablation in water. The effect of laser energy was clearly shown on optical characteristics, absorption peaks of Au NPs increased with increase laser energy, Au NPs showed a noteworthy inhibition on tested pathogenic bacteria. The laser energy of Au NPs affected the antibacterial activity. The results established that Au NP did not cause cytotoxic effects on human blood cells.

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