Optical and Morphological Property of Ag Nanoparticles by Laser Ablation in Double Distilled and Deionized Water

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ABSTRACT

Noble metal silver NPs was synthesized by pulsed (Q-switched, 1064 nm Nd : YAG) laser ablation of silver metal plates immersed in double distilled and deionized water DDDW.

The formation efficiency of PLAL process was quantified in term of the surface Plasmon extinction SPE peaks. The SPE spectra show a sharp and single peak around 400 nm, indicating the production of pure and spherical Ag.

UV-Visible absorption results confirmed formation of silver particles prepared and atomic force microscope (AFM) indicates the size in nanometer (nm) range.

Keyword: Ag Nanoparticles; Laser Ablation; Optical; Morphological.

تحضير ودراسة الخواص البصرية والتركيبية لجسيمات الفضة النانوية بواسطة الازالة الليزرية في الماء اللاايوني ثنائي التقطير

الخلاصة

حضرت الجسيمات النانوية من معدن الفضة باستخدام ليزر الياك النبضي ذو الطول الموجي 1064 nm، بطريقة التشظية بالليزر لقطعة معدنية فائقة النقاوة من الفضة مغمورة في ماء لا أيوني وثنائي التقطير يعرف بـ DDDW.

اطياف الامتصاصية تظهر قمم امتصاص حادة ومنفردة حول القيمة 400 نانومتر والتي تدل على توليد جسيمات نانوية نقية وكروية الشكل من الفضة.اثبتت نتائج الامتصاصية في منطقة فوق البنفسجية والمنطقة المرئية من الطيف تكوين دقائق الفضة المحضرة ونتائج المجهر القوة الذري يشير الى ان حجم الدقائق بمدى النانومتر.

INTRODUCTION

Colloidal particles are increasingly receiving attention as important starting points for the generation of micro and nanostructures. These particles are under active research because they possess interesting physical properties differing considerably from that of the bulk phase.Ag nanoparticles can be synthesized

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using various methods: chemical, electrochemical, γ-radiation photochemical, laser ablation etc [1].

Laser ablation plasma is formed above the surface of the solid target when an intense laser beam strikes the target. Laser ablation provides a simple and contaminant-free method which can be used for a large number of materials [2, 3].

One advantage of this method compared to other is producing pure colloids, which will be useful for further applications. With using UV-Vis absorption spectra we can characterize the nanoparticles prepared by laser ablation and survey their stability [4].

The fabrication of metal NPs has been studied extensively because of their characteristic optical absorption by surface Plasmon resonance. The nanomaterials initially prepared by PLAL were metalnanoparticles, and controlled formation of metal NPs has been achieved using aqueous surfactant solutions [5].

The Surface Plasmon Resonance SPR in metal nanoparticles is an oscillation Plasmon absorbs or scatters light resonantly of certain wavelength, also is known as surface Plasmon extinction (SPE), localized surface Plasmon resonance (LSPR), polar ton resonance or Mie resonance [6].

In general, the SPR peak of metal nanostructure should include both scattering and absorption components. If the frequency of the incident light is in resonance with this surface Plasmon oscillation of metal electrons, results in strong enhancement of absorption and scattering of electromagnetic radiation [7].

EXPERIMENTAL DETAILS

Solid metal target immersed in water or aqueous solution, which includes two lasers, Nd-YAG laser 1064nm wavelength was used for laser ablation process. The Nd-YAG laser beam was focused by using a lens onto a metallic target (0.8*0.8 cm). The ablation process was typically done for 1 min at room temperature. The target is fixed by a holder at the bottom of a quartz container (1ml of DDDW).Q-switched Nd/YAG laser system type HUAFEI providing pulses of 1064nm wavelength with maximum energy per pulse of 1000 mJ, pulse width of 10 ns, repetition rate of 10 Hz and effective beam diameter of 5 mm, was used for laser ablation. The laser is applied with a lens with 110 mm focal length is used to achieve high laser flounce.

Absorbance spectra (SPE spectra) of NPs solution were measured by UV-VIS double beam spectrophotometers, CECIL C.7200 (France) and SHIMADZU. All spectra were measured at room-temperature in a quartz cell with 1 cm optical path.

The morphological characteristics of Ag nanoparticles have been studied by the atomic force micrographs type A Solver P-47H (Digital Instruments Nanoscope NT-MDT SOLVER P47H-PRO).

RESULTS AND DISCUSSION

As the particles increase in size, the absorption peak usually shifts toward the red wavelengths. Increase of absorption indicates that amount of silver nanoparticles increases. The stable position of absorbance peak indicates that new particles do not aggregate. One can understand that since the silver colloidal particles possessed a negative charge due to the adsorbed citrate ions, a repulsive force worked along particles and prevented aggregation. Absorption peak of silver nanoparticles at 410 nm Figure (1).

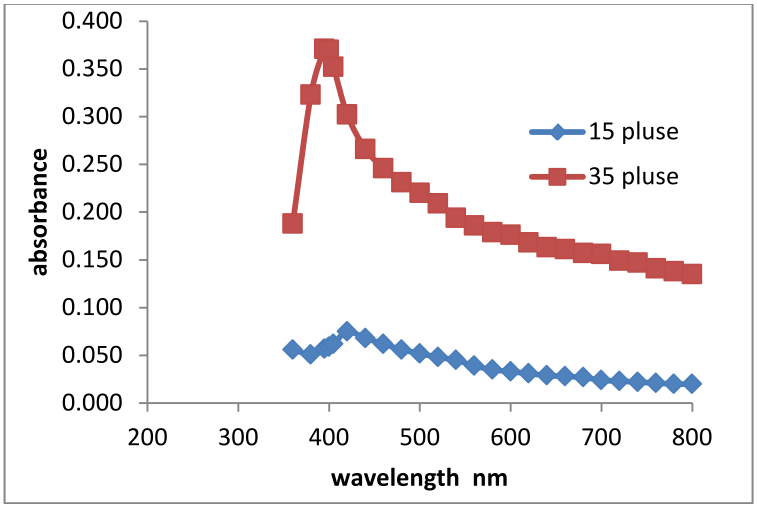


Figure (1) The SPE spectra of the plasmon band of Ag NPs obtained by laser shots15 & 35 pulses at laser energy of 800 mJ and λ=1064 nm.

Figure (2) Shows the spectra exhibit characteristic absorption bands with peaks located at 400 nm for silver nanoparticles at laser energy 600 mJ, absorption peak shifted from 402 nm to 410 nm at laser energy 700 mJ and 800 mJ respectively due to influence of small-sized nanoparticles [4].

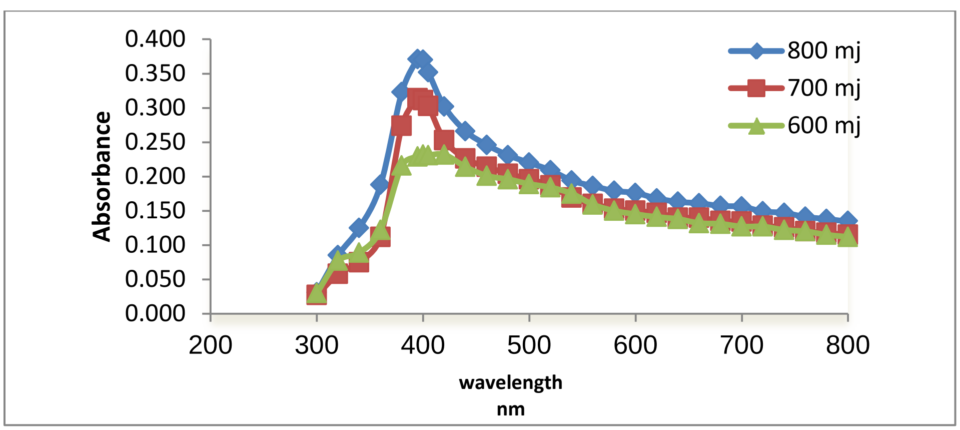


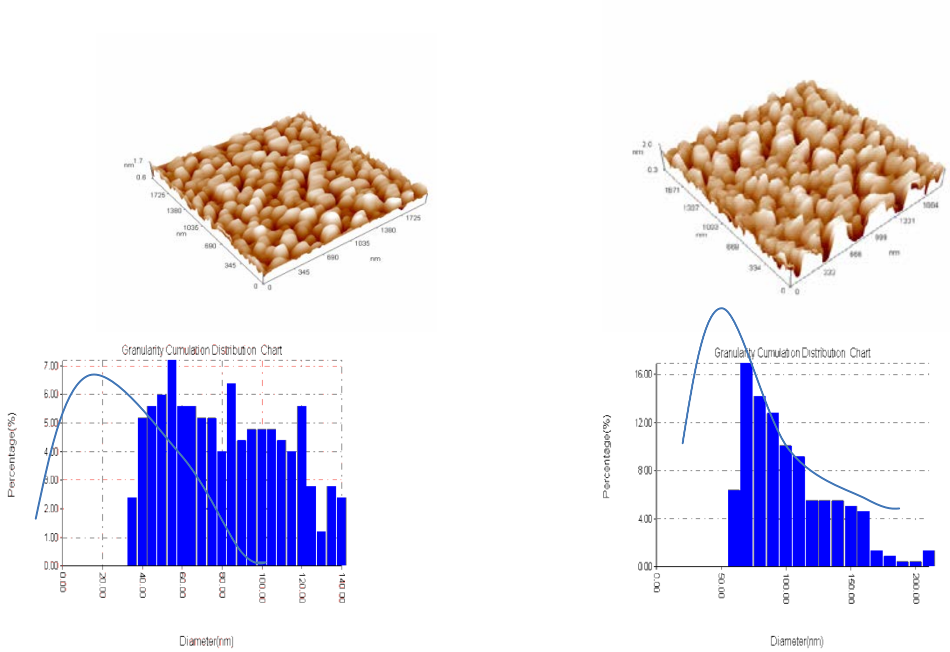
Figure (2) shows Ag NPs obtained by laser energy of 600, 700, 800mJ, Laser shots of 35 pulses and wave length is 1064 nm of Nd-YAG laser.

MORPHOLOGICAL PROPERTIES

Figure (3) shows the AFM images of silver nanoparticles produced by laser ablation of a silver plate immersed in 1 ml of DDDW, at 600 mJ (a) and 800 mJ (b), respectively. The Nd-YAG laser of 1064 nm and number of pulses of 35 pulses was used.It is observed that the average diameter and size distribution was increased from79.47nm to 98.41nm with the increase of the laser energy from 600mj to 800mj respectively. It is clear that when the incident laser energy increases, the amount of the absorbed energy in the target increases, which leads to an increase in the ejected particles toward the liquid. These ejected particles have higher kinetic energy when higher laser energy is absorbed and ultimately increase the particles density released on the liquid.

The rough surface systematically observed on the samples is not the result of droplets directly transferred from the Ag target, but is due to the formation of aggregated particles. Increases which leads to an increase in the ejected particles toward the liquid filling the cavities at the surface.

The droplets of material shown in Figure (3) are formed from the target as a consequence of transient melting of the subsurface and expelled by the recoil of the shockwave. These droplets can be avoided at pressures in the torr regime largely by positioning the collection substrate off the vapor plume axis and relying on the higher diffusion mobility of the smallerparticles for deposition [8].



(a) (b)

Figure (3) 3D AFM images and size distributions of silver nanoparticles the laser shots 35 pulse at different laser energy(a) 600 mJ and (b) 800 mJ.

CONCLUSIONS

1**.** There is an agreement in the PLAL efficiency was quantified in term of the SPE peaks as well as of the concentration of Ag NPs.

2. The SPE properties as peak position and peak intensity is reliable indicator for identify the size and concentration.

3. It is observed that the average diameter and size distribution was increased with the increase of the laser energy.

REFERENCES

[1]. Ratyakshi and R.P. Chauhan, Colloidal Synthesis Of Silver Nano Particles, Asian Journal of Chemistry Vol. 21, No. 10 (2009), S113-116.

[2]. Tarasenko, N.V. V.S. Burakov, A.V. Butsen, Laser Ablation Plasmas In Liquids For Fabrication Of Nanosize Particles, Publ. Astron. Obs. Belgrade No. 82 (2007), 201-211

[3].Raheem Gaayied Kadhim,AbdulrahmanKhalafAli,MaryamfalahNoori,nanofabrcation and characterization of gold metal by plused laser ablation in sds solution,optics and laser technology, vol.11 ,(2012), .

[4]. SomayeBaset, HosseinAkbari, HosseinZeynali, MortezaShafie, Size Measurement of Metal And Semiconductor Nanoparticles Via Uv-Vis Absorption Spectra, Digest Journal of Nanomaterials And Biostructures, Vol. 6, No 2, April - June,(2011), P. 709 – 716.

[5]. Takeshi Sasaki, Yoshiki Shimizu, Naoto Koshizaki, Preparation of Metal Oxide-Based Nanomaterials Using Nanosecond Pulsed Laser Ablation In Liquids, Journal of Photochemistry And Photobiology A: Chemistry 182 (2006) 335–341.

[6]. Huang, X. M. A. El-Sayed (Gold Nanoparticles: Optical Properties and Implementations in Cancer Diagnosis and Photothermal Therapy) Journal of Advanced Research 1 (2010) 13–28.

[7]. D. B. Sanchez (The Surface Plasmon Resonance of Supported Noble Metal Nanoparticles: Characterization, Laser Tailoring, And Sers Application), Phd Thesis, Madrid University (2007).

[8]. Chrisey and G. K. Hubler, D. B. Pulsed Laser Deposition of Thin Films, Copyright © By John Wiley & Sons, Inc (1994).