Iraqi Journal of Physics, 2019 *Vol.17, No.42, PP. 141-146*

DOI: 10.20723/ijp.17.42.141-146

Cu_2O nanoparticles preparation by Pulse Laser Ablation in Liquid Phase method (PLALP)

Zaydoon T. Mohammed Noori[1], Shehab A. Kadhim[2], Manal M. Abdullah[3]

[1]Department of Optics Techniques, Dijlah College University

[2]Ministry of Sciences and Technology

[3]Department of Physics, College of Sciences, University of Baghdad

E-mail: Zaydoon.tariq@duc.edu.iq

Abstract

The Nanoparticles has pulled in expanding consideration with the developing enthusiasm for nanotechnology which hold potential as essential segments for development applications. In the present work, a cuprous oxide nanoparticles are manufactured as a suspension in distilled water by bombarding a bulk copper target with laser source (532 nm wavelength, 10 ns pulse duration and 10 Hz repletion rate) via method. UV- visible absorption spectra, an AFM analysis has been done. Copper oxide nanoparticles (Cu_2O-NPs) with dark color are successfully synthesized. The Cu_2O- NPs have very high purity because the preparation was managed in aqueous media to eliminate ambient contaminations. Absorption spectrum shows peaks at 450 nm- 700 nm due to the generation of Cu Oxides-NPs.

Key words

Cu_2O- nanoparticles, laser ablation, UV-VIS Spectrum, AFM.

Article info.

Received: Mar. 2019

Accepted: Apr. 2019

Published: Sep. 2019

تحضير جسيمات نانوية لأوكسيد النحاس الأحادي بطريقة الاستئصال بالليزر النبضي في وسط مائي (PLALP)

زيدون طارق محمد نوري[1]، شهاب أحمد كاظم[2]، منال مدحت عبدالله[3]

[1]قسم تقنيات البصريات، كلية دجلة الجامعة

[2]وزارة العلوم و التكنولوجيا

[3]قسم الفيزياء، كلية العلوم، جامعة بغداد

الخلاصة

حظيت جسيمات بحجم النانو باهتمام واسع مع التطور في نشاطات تقانة النانو والتي ثبتت نفسها في قطاعات اساسية للتطبيقات التطويرية. في هذا العمل حضرت جسيمات نانوية لأوكسيد النحاس الاحادي كمعلق في وسط مائي مقطر بقصف كتلة نحاس كهدف لمصدر اشعة ليزر (532 نانومتر طول موجي، 10 نانو ثانية زمن النبضة، بمعدل تكرار 10 هرتز). أجريت فحوص طيف الامتصاص للجزء المرئي وفوق البنفسجية و تحليل مجهر القوة الذرية AFM. حضرت بنجاح جسيمات نانوية لاوكسيد النحاس الأحادي وكانت بلون غامق. وكانت الجسيمات عالية النقاوة لانها حضرت في وسط مائي من اجل منع التلوث المحيط بها. أظهر طيف الامتصاص القمم بين 450 نانومتر و700 نانومتر وهذا تبعا لتكون جسيمات نانوية الحجم لاوكسيد النحاس الاحادي.

Introduction

Synthesis of nanoparticles with controlled geometry and size is an interesting scientific field. There is no exclusive definition for nanoparticles; however those particles are defined with size less than 100 nm, where the physical properties of the material turn out to be so unique. Nanoparticles show totally new or upgraded properties

dependent on explicit attributes (shape, size, morphology, stage, and so on.), whenever contrasted and bigger particles of a similar mass material [1]. What's more, optical (light retaining/shifting) properties can be gotten in such nanoparticles which has interesting applications with regards to technology innovations. Pulse Laser Ablation in Liquids (PLALP) has turned into a main technique for preparing these particles [2]. Laser removal in fluid media is a 'top down' approach for getting nanomaterial's having desired shape, size and surfaces free from compound contamination, which are basic for further functionalization of nanomaterial's, used for detecting and sensing applications [3].

Laser beams collides the surface of solid material (target) which immersed in liquid causes vaporization of both the target material and a little amount of the fluid media.

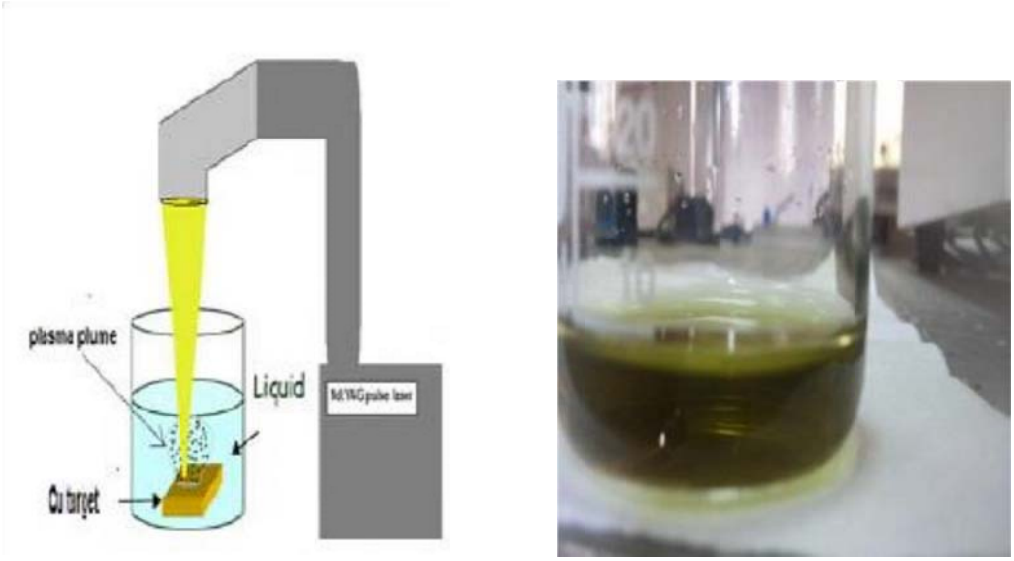
The removed species and particles in the fluid species are exceedingly energized, both electronically and transitionally [4]. Because of the imprisonment impact of the fluid, these catapulted species structure a thick district in the region of the solid– fluid interface. This stage is like that happens in a vacuum or low weight gas, where the laser creates a plasma plum. In liquid phase laser removal, the plasma is limited by the fluid and actuates shockwave transmitted into the objective. The plasma extends adiabatically at supersonic speed, making reflection and discharging of the shockwave started by the plasma weight from the back and front surfaces of the solid target. This stun wave incites an additional, immediate weight as it goes through the fluid. This laser–prompted weight results in the expansion in the temperature of the plasma [5, 6]. The most well-known technique utilized for the fabrication of metal nanoparticles is the minimizing of metal particles arranging [7]. Control size and shape at the nanometer level is an important issue, [8].

Copper Oxides nanoparticles have just been arranged and examined because of their potential innovative applications in different fields like catalysis, oils, hardware etc [9].

Experimental

Laser ablation has shown itself as one of the most efficient physical methods for nanofabrication. In general, copper is very reacting, and laser ablation of a copper target in water initiate generation of copper oxide.

The simple set-up used to perform PLALP experiments consist of a (Nd:YAG) laser model (VS301), Q switched pulses; operating at second harmonic 532 nm, pulse width 10 ns and 10 Hz repetition rate . The target is (99.90 %) the shape of copper is circular, dimensions are 12 mm diameter and 0.6 mm thickness. The target is immersed in 30 ml of twice distilled water DDW. The laser spot size on the surface has been varied in the range (1-3 mm) of diameter to get energy density on the target of around (2 J/cm^2). Observations show a clear double layer having particles suspended on the top of the irradiated zone only.
Experimental setup, Fig.1, illustrates the target in the vessel bottom, and irradiation of the laser beam is vertically directed to the sample surface.



(a) (b)

Fig.1: A block scheme experimental setup of the (PLALP) (a) for preparing (Cu_2O- NPs) in liquid media (b).

Results & discussion

1- Optical study

References show the range of copper nanoparticles absorption in the range 500-600 nm [10, 11]. In this work, the absorption spectrum of Cu material

NPs prepared by PLALP method is examined by UV-Vis Spectrophotometer from Thorlabs.

Immediately after the synthesis of Cu Oxides particles, test is recorded. The peak is situated at 590 nm, which proves the production of nanoparticles. The produced suspension of the sample is referred to the surface plasmon resonance (SPR), where metals have this phenomena because of presence of free electrons in the metallic structure. Such properties are seen in Cu, Ag and Au because of quality of free electrons. The result is shown in Fig.2 [12].

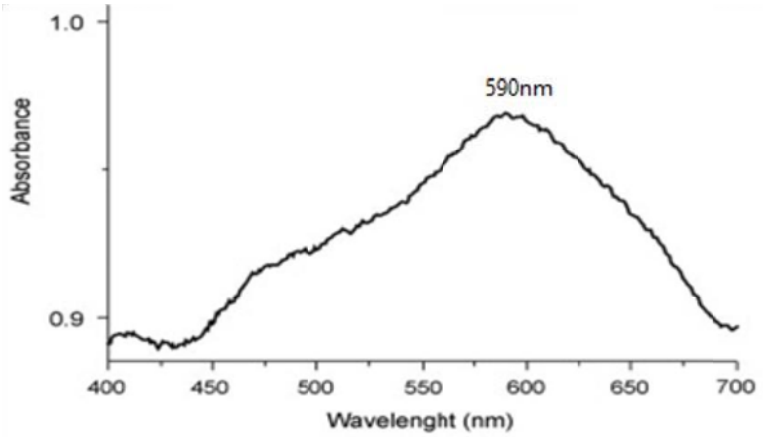


Fig.2: UV-VIS absorption spectrum of as synthesized suspension of copper Oxides nanoparticles in distilled water by laser ablation.

The reliance of optical absorption on photon energy explains the band structure and the type of electronic transitions. The optical absorption coefficient (α) is determined from transmittance utilizing Tauc relation. The best direct relationship is acquired by plotting $(\alpha h\nu)^2$ vs. photon energy (Fig.3). The band gap of colloidal nanoparticles is found from the intercept of the straight line at $\alpha = 0$. The band gap is 2.3 eV. The optical band gap is direct allowed transition.

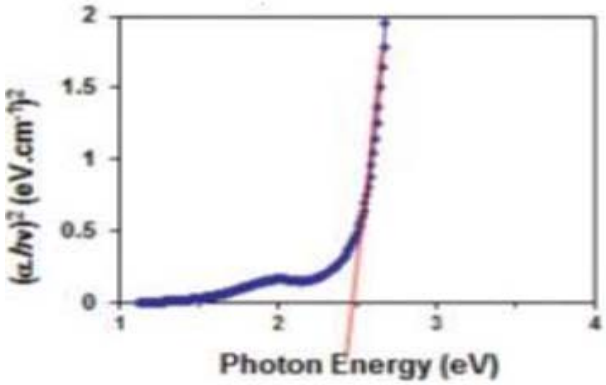


Fig.3: Tauc plot of UV-VIS absorption data of as synthesized colloidal Cu_2O-NPs for calculation of bandgap energy.

2- SEM and FEM study

An image of copper Oxides nanoparticles samples obtained via SEM is illustrated in Fig. 4. The fig. shows semi spherical shapes of prepared nanoparticles in nano size range. The averages diameter measured with this analysis is R=33.4 nm.

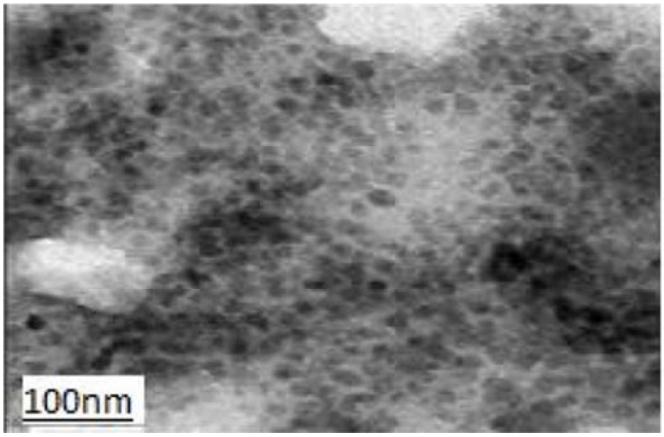


Fig.4: SEM photo for Cu nanoparticles prepared by PLALP method.

Fig.5(a) shows a 3D topographical view obtained by FEM technique. However, the magnified photo shows copper Oxides nanoparticles agglomerated and disagglomerated. Fig.5(b) shows the particle size distribution of copper oxides nanoparticles, the distribution shows a Gaussian distribution. Particles are obtained in different sizes ranging from 100 to 350 nm.

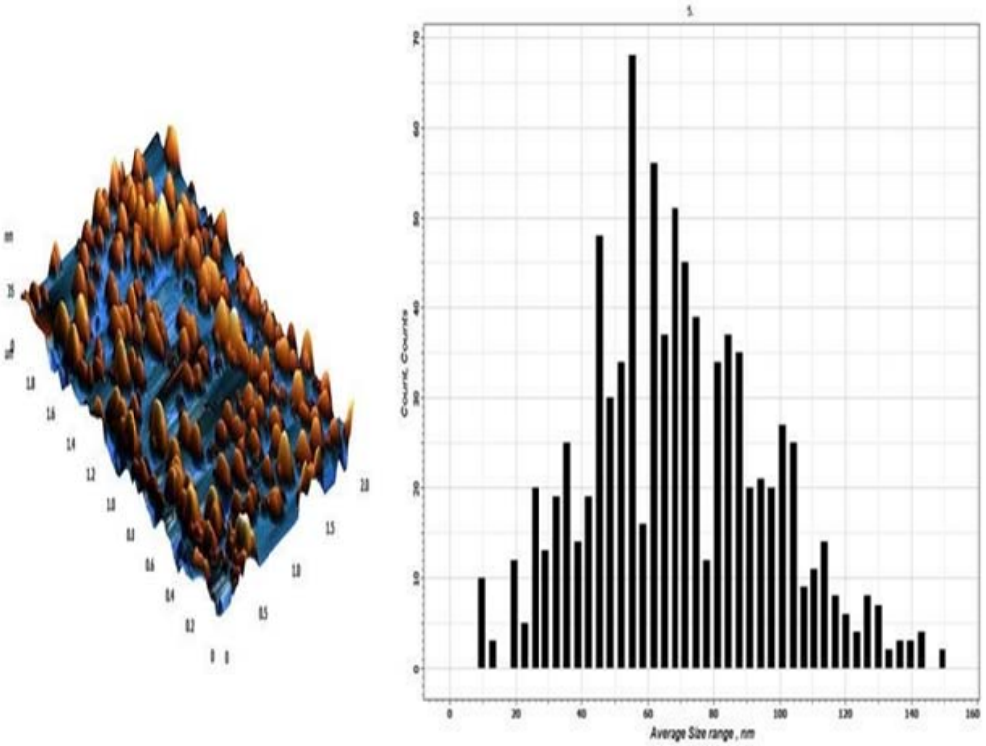


Fig.5: (a) 3- D topographical view, (b) particle size distribution via FEM for copper oxide nanoparticles.

3- X-ray studies

3-1 XRD chart analysis

The x-ray chart for the prepared sample of Copper Oxide nano powder is shown in Fig.6. Data is taken for 2θ from10 to 80 degrees with a stage of 0.02 degree. Three crests at 2θ are clear: 43.640 ^{o}, 50.800 ^{o}, and 74.420^{o} relating to (111), (200), and (220) planes. The result is compared to the standard diffraction card JCPDS, copper document No. 04– 0836. The result shows that the obtained particles are (FCC) Copper Oxide nano powder. Table 1. demonstrates the interplanar spacing (d), Miller Indices (h k l).

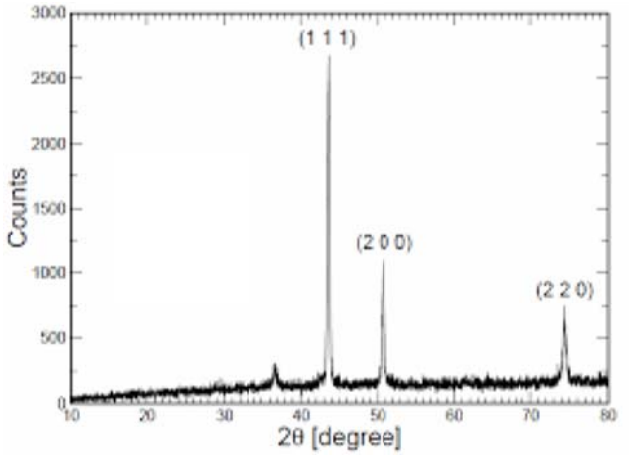


Fig.6: X-ray diffraction pattern for Cu_2O nanoparticles.

3-2 Particle size

From above investigation, utilizing Debye-Scherrer equation, average particle size has been estimated [12, 13].

$D = 0.9 \lambda / \beta \cos \theta$ where λ is wavelength of X-Ray (0.1541 nm), 'β' is FWHM (full width at half maximum), 'θ' is the angle of diffraction point and 'D' is the particle diameter. Results are arranged in Table 1.

3-3 Inter planar spacing (d)

The very well-known Bragg's Law is applied to indicate d value.

$2d\sin\theta = n \lambda$

Results are summarized in the next table (Table 1).

Table 1: The results of x-ray diffraction method for Cu_2O Oxide nanoparticles prepared by PLALP method.

2θ	D	Hkl	D nm
43.641	2.071	111	25
50.80	1.789	200	23.6
74.41	1.27	220	24.8

Conclusions

Laser ablation method has shown itself as one of the efficient physical methods for Copper Oxide nano powder fabrication. It can be applied easily with almost unlimited materials and solvents to generate nanoparticles. The absorbance peak of the synthesized nano copper colloids in liquid is located at 588 nm. The plasmon resonance emission showed green color. The particle size and their distribution showed particles obtained in different sizes ranging from 100 to 350 nm .the energy gap is 2.3.

References

[1] D.P. Chattopadhyay, Textiles, 33 (2006) 21-24.

[2] B.H. Patel and D.P. Chattopadhyay, The Indian Textile Journal, 118 (2007) 23-31.

[3] D.P. Chattopadhyay and B.H. Patel, Indian Journal of Fiber& Textile Research, 34 (2009) 368-373.

[4] S. Link, C. Burda, B. Nikoobakht, M. A. El-Sayed, J. Phys.Chem., B104 (2000) 6152-6163.

[5] P.V. Kazakevich, V.V. Voronov, A.V. Simakin, G.A. Shafeev, Quantum Electron, 34 (2004) 951-956.

[6] A. Henglein, J. Phys.Chem., 97 (1993) 5457-5471.

[7] P. Mulvaney, Langmuir, 12 (1996) 788-800.

[8] M. Raad, H. Abeer, Asian Journal of Applied Sciences, 02 (2014) 3013-3020.

[9] S.H. Park, C.H. Kim, Y.C. Kang, Y.H. Kim, Control of size and morphology in Ni particles prepared by spray pyrolysis, J. Mater. Sci. Lett. 22 (21) (2003) 1537-1541.

[10] P. Rahimi, H. Hashemipour, M. Z. Ehtesham, S. Ghader, Int. J. Nanosci. Nanotechnol, 6, 3 (2010) 144-149.

[11] B. P. Rama, P. S. Prajna, P. M. Vinita, S. Pavithra, Adv. Biores., 2 (2011) 52-56.

[12] S. S. Nath, D. Chakdar, G. Gope, Nanotrends- A Journal of Nanotechnology and its Application, 02, 03 (2007) 20-28.