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Optical Properties of Copper Oxide Nanoparticles, Prepared by Pulse Laser Ablation

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Abstract

Copper oxide nanoparticles (CuO NPs) were prepared by pulse laser ablation (PLA) in different aqueous solution (liquid chromatography / mass spectrometry (LC/MS) water, and polyvinyl alcohol (PVA) solution), for different energy pulses (100,200,300) mJ and found surface Plasmon resonance (SPR) at 300mj (631,590) nm, and at energy 200 mJ the (SPR) peak is (625,584) nm in LC/MS water and PVA solution respectively. Investigation of structural and optical properties of CuO NPs thin films by using different technique.

Keywords: CuO NPs, PLA, LC/MS water, SPR.

Introduction

The attention of researchers has increased in recent years on nanoparticles because of their unique characteristics, different from than bulk material by two factors: high surface area to volume ratio and quantum confinement effects. These factors affect the chemical reactivity of materials, as well as their mechanical, optical, electric, and magnetic properties. [1]

The manufacture of nanomaterial is divided by two basic methods: the first is the Collapse method from top to bottom by applied external force on solid lead to the dismantling of material into small particles, which start from a large size to expire Nano, such as pulse laser ablation (PLA), pulse wire discharge (PWD), mechanical (grinding), mechano chemical synthesis, solvo thermal decomposition, And the second size of the Nano such as pulse laser deposition (PLD), Sol-gel process, Electrochemical, physical vapor deposition (PVD). [2-4]. Copper oxide (CuO) is p-type semiconductor with a monoclinic crystal structure and have Narrow band-gap between 1.2 and 1.5 eV, and use in many application, lithium ion batteries, magnetic storage media, gas sensors, super capacitors, Nano fluids, and antimicrobial agents. [5]

Pulse laser ablation in liquids technology is developed method for the manufacture of nanomaterials through the shape and size control to change several variables as energy lasers and high liquid and others. It considers easy and cleaner manner compared to many other synthesis methods [6]. The aim of this work synthesis nanoparticles by PLA method with LC/MS water, (PVA) solutions. The study of the optical properties was determined by (SPR) position and determined the shape of nanoparticles at different energy pulses.

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Experimental Methods

The target of copper high purity it shap cylindrical (dimeter 10mm and height 7mm). and solution (PVA) prepared by dissolve 1g of PVA [(CH2CHOH)n, Barcelona Espana, MW~15000] in 50ml of LC/MS water with stirring at 82°c for 2.5h. laser Q-switched Nd- YAG (DIAMOND-288 patrren EPLS), with wavelength (λ = 1064 nm) operating at 6 Hz, it uses to irradiated Cu target immersed at 4mm depth in the 4mol solution PVA and LC/MS water, with spot of beam 2mm for energy's laser pulses (100-200-300) mJ and constant number of pulse (100 pulses). The distance 14cm between target and laser source.

The colloidal nanoparticle characteristics by ultra violet and visible(UV–vis) absorption spectrophotometer (UV-1800 SHIMADZU), Agilent Technologies Cary Eclipse Fluorescence Spectrophotometer. and drop cast this colloidal on clean glass, after dry under heat for 45minite at 70°c to examine Fourier Transform Infrared Spectrophotometer (FTIR-8400S SHIMADZU) and scanning probe microscope (SPM) [AA3000] to study morphology.

Results and Discussion

Fig.1 shows the UV-Vis absorption spectrum for colloidal nanoparticle prepared by pulse laser ablation of a copper plate immersed in LC/MS water and PVA solution at 100 pulses constant with energies (100,200,300) mJ. The first higher peak in UV reign around (270) nm is attribute to interband transition of copper electron from deep level of valence bandand second low peak in visible reign (590-640) nm is attribute to interband transition of copper electron from upper level of valence band. [7]We can see surface Plasmon resonance (SPR) peak at energy 300 mJ is (631,590) nm, and at energy 200 mJ the (SPR) peak is (625,584) nm in LC/MS water and PVA solution respectively. But at energy 100mJ the (SPR) peak did not clearly, show in LC/MS water and we did not get spectrum absorption in order to number of pulses and energy is few. When increase energy laser pulses the absorption spectrum increase and shifted (SPR) peak to red region wavelength because concentration and particle size increases with increasing laser pulses energy. This results are confirmed with researcher (K. S. Khashan et al)[8] but the deferent he uses DI water and energy of pulses and time ablation, and we got UV-Vis absorption clearly in to peaks.

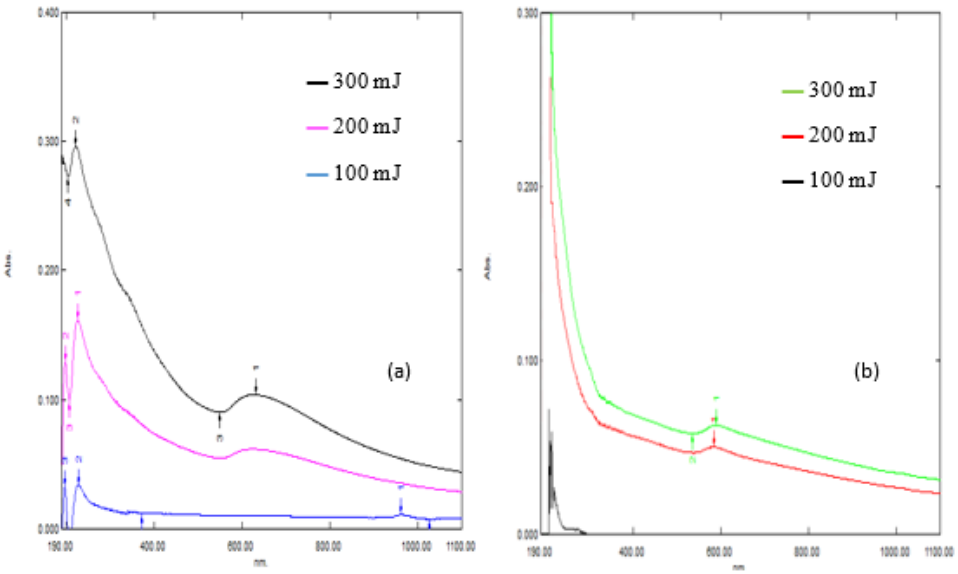


Fig. 1 UV–Vis absorbance spectra of colloidal CuO NPs prepared by laser ablation at different laser energies for 100 pulses (a) LC/MS water. (b) PVA solution.

Fig.2 shows two peak of fluorescence spectrum for colloidal CuO NPs in PVA solution and LC/MS water at 200mJ for 100 pulses with light scours excitation 350 nm after but this colloidal in ultrasonic about 1 hour, the first small peak 1.77 eV (wavelength 699 nm) is located near infrared region and second large peak 3.54 eV (wavelength 350 nm) is located in the UV region near. From this figure the effect PVA solution is greater than the LC/MS water in the same preparation and measurement conditions. These results its agree with the (S.Dagher et al) to [9].

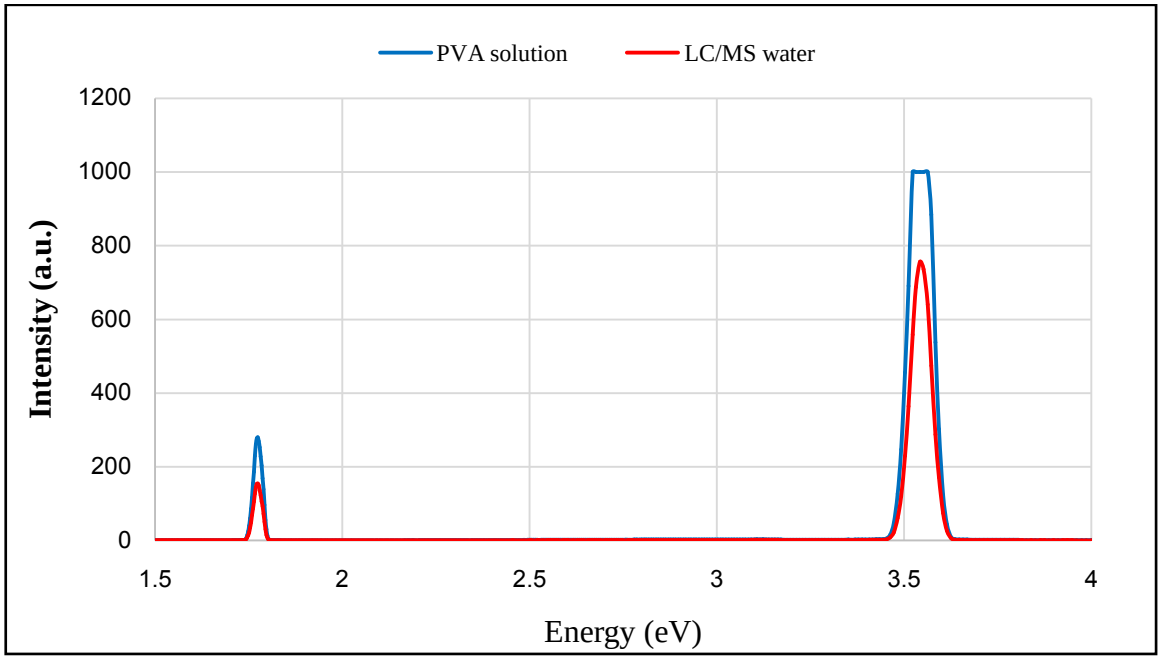


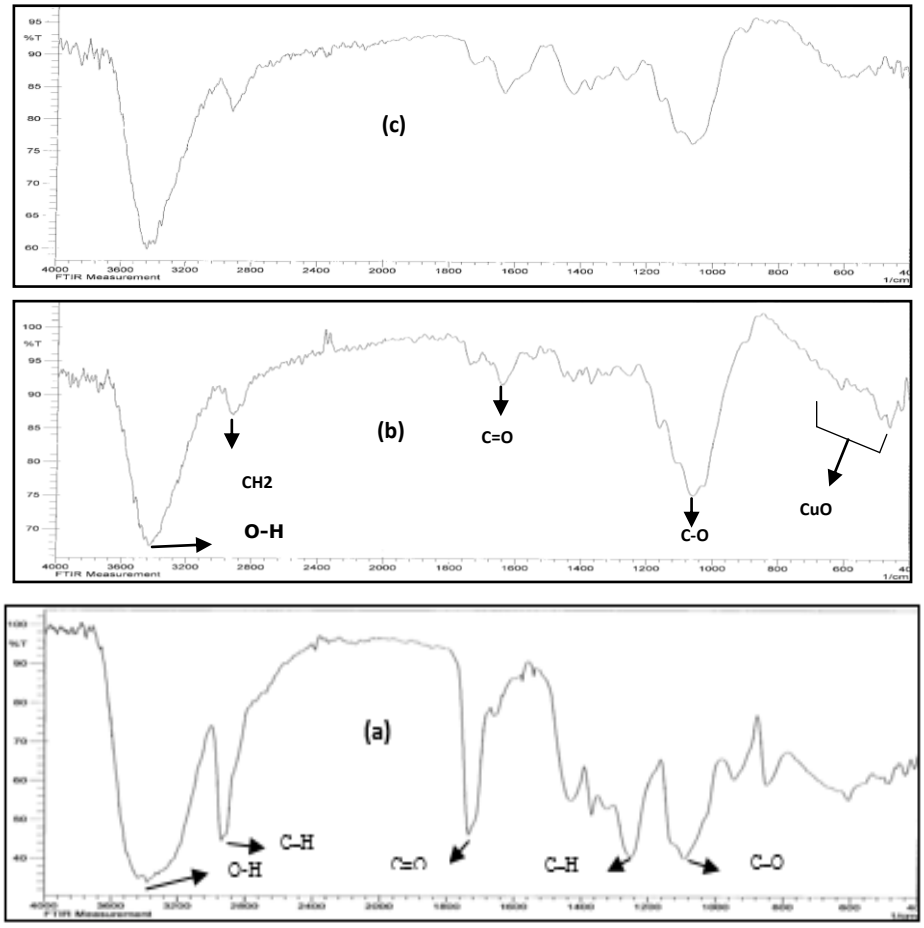
Fig. 2. fluorescence spectrum for colloidal CuO NPs in PVA solution and LC/MS water at 200mJ for 100 pulses, with light scours excitation 350 nm.

IR spectroscopy is an imported technique based on the vibrations of the atoms of a molecule. The molecule shows IR absorptions, when it must have an electric dipole moment change during the vibration. This is the selection rule for infrared spectroscopy. [11]

Fig.3(a) shows FTIR spectrum for pure PVA, the peaks range (3000–3670) cm^{-1}attributed to the O–H stretching vibration, the peak 2937 cm^{-1} is corresponding to C–H asymmetric stretching vibration from alkyl groups, the peak 1735 cm^{-1} from carbonyl group, the peak1249 cm^{-1}attributed to C–H wagging vibration, the peak 1093 cm^{-1}attributed to stretching vibration of C–O.

Fig.3 (b and c) The interaction between PVA and copper oxide through O–H bonds, that appear clearly in the range (3000–3670) cm^{-1} [10] this may be due to the electrostatic interaction between the surface charge of the Cu-NPs and OH electric dipoles in the polymer chain. And around 1634cm^{-1} may be for the Cu-O symmetrical stretching, the range (500–700) cm^{-1} peaks shows the vibrational modes of CuO NPs. This results are confirmed by two researches (S. Mahendia and I. Z. Luna) [12,13]

Fig. 3. CuO NPs in PVA solution at 200mJ CuO NPs in PVA solution at 300mJ



The Figures (4-7) which represents of the morphology of the surface shape and size distribution of particles of different energies (200 and 300) mJ at 100 pulse, which are summarized in the following table I.

Table I. The value of roughness average and grain diameter in LC/MS water and PVA solution at 100 pulses constant varying laser power

Type of the solution	Laser power (mJ/pulse)	Grain diameter (nm)	Roughness Average (nm)
LC/MS water	200	73.01	1.17
	300	88.97	0.455
PVA solution	200	105.54	0.366
	300	127.90	0.216

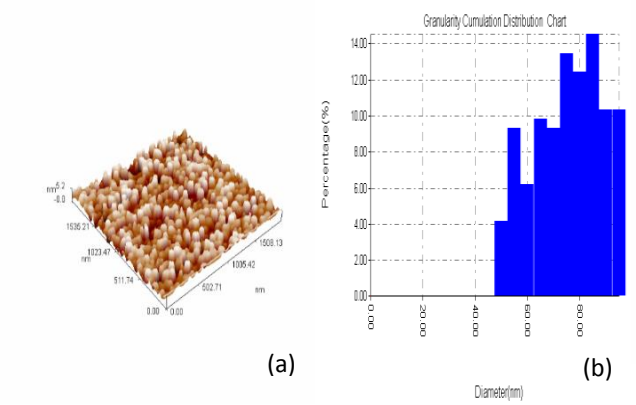


Fig. 4colloidal CuO NPs in LC/MS water at 200mj for 100 pulses (a) 3D image (b) granularity cumulation distribution chart.

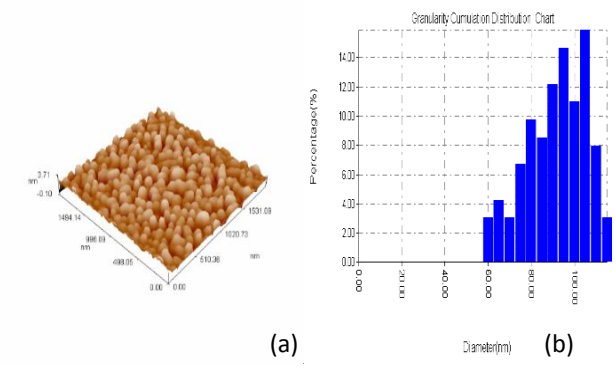


Fig. 5 colloidal CuO NPs in LC/MS water at 300mj for 100 pulses (a) 3D image (b) granularity cumulation distribution chart.

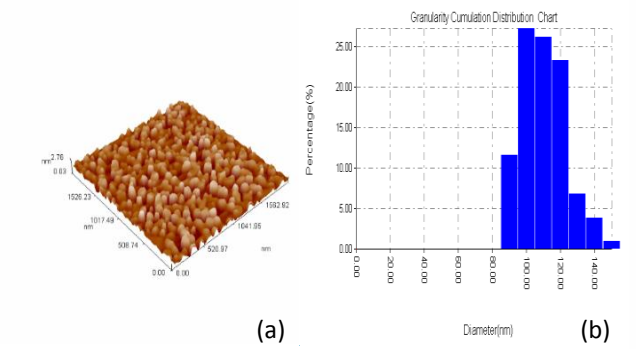


Fig.6 colloidal CuO NPs in PVA solution at 200mj for 100 pulses (a) 3D image (b) granularity cumulation distribution chart.

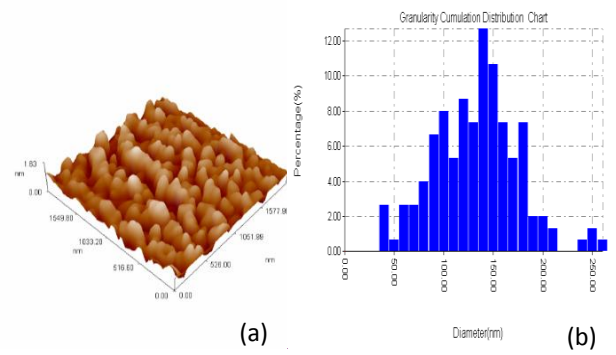


Fig.7colloidal CuO NPs in PVA solution at 300mj for 100 pulses (a) 3D image (b) granularity cumulation distribution chart.

Conclusions

The pulse laser ablation in liquid a good and easy technique to formation nanoparticles and clean method. when the energy pulse laser increases the absorbance increase too because increase in copper nanoparticle concentration and size in the same liquid, and position (SPR) depend on type of solution and energy laser pulses. The intensity absorption SPR in LC/MS water greater than PVA solution in absorption spectrum and conversely in fluorescence spectrum. The fluorescence spectrum depends on energy source excitation and particle size. The change in FTIR spectrum it is due to interaction between O–H bonds and CuO nanoparticle and vibrational CuO-NPS.

Reference

1. C. Buzea, Ivan. I. Pacheco Blandino, and K. Robbie," Nanomaterials and nanoparticles: Sources and toxicity" Biointerphases, Vol.2, No.4,pp.MR17 - MR172,(2007).
2. L.Filipponi and D. Sutherland,"Nanotechnologies: Principles, Applications, Implications and Hands-on Activities", abook Edited by the European Commission (2013).
3. S. A. Yousaf and S. Ali," Why Nanoscience and Nanotechnology? What is there for us?", Journal of Faculty of Engineering & Technology, p.11-20, (2007-2008).
4. Tamilvanan, K. Balamurugan, K. Ponappa and B. Madhan Kumar," Copper Nanoparticles: Synthetic Strategies, Properties and Multifunctional Application", International Journal of Nanoscience Vol.13, No.2,1430001 (22 pages), (2014).
5. R. Sierra-Ávila, M. Pérez-Alvarez," Synthesis of Copper Nanoparticles Using Mixture of Allylamine and Polyallylamine", Hindawi Publishing CorporationJournal of Nanomaterials Vol. (2015), Article ID 367341.(2015).
6. K. D. Malviya, K. Chattopadhyay," High quality oxide-free metallic nanoparticles: a strategy for synthesis through laser ablation in aqueous

medium", J. Mater. Sci. Vol.50, No.2, pp.980–989, (2015).
7. R. K. Swarnkar, S. C. Singh and R. Gopal," Effect of aging on copper nanoparticles synthesized by pulsed laserablation in water: structural and optical characterizations", Bull. Mater. Sci., Vol.34, No.7, pp. 1363–1369, (2011).
8. K. S. Khashan· G. M. Sulaiman and F. A. Abdulameer," Synthesis and Antibacterial Activity of CuO Nanoparticles Suspension Induced by Laser Ablation in Liquid", Arab. J. Sci.Eng.Vol.41, No.1,pp.301-310, (2015).
9. S. Dagher, Y. Haik, A. I. Ayesh and N. Tit," Synthesis and optical properties of colloidal CuO nanoparticles", Journal of Luminescence Vol.151,pp.149–154, (2014).
10. K. K. Dey, P. Kumar, R. R. Yadav, A. Dhar and A. K. Srivastava," CuO nanoellipsoids for superior physicochemical response of biodegradable PVA", RSC Adv., Vol.4, No.20, pp.10123-10132, (2014).
11. B.Stuart, "Infrared Spectroscopy: Fundamental and Applications", AnTs analytical techniques in the sciences. WILEY. 2004.
12. S. Mahendia, A. K. Tomar, P. K. Goyal, and S. Kumar," Tuning of refractive index of poly (vinyl alcohol): Effect of embedding Cu and Ag nanoparticles", J. Appl. Phys. Vol.113, No.7, Article ID 073103, (2013).
13. Z. Luna, S. Chowdhury, M. Abdul Gafur, N. Khan1 and R. A. Khan," Preparation and Characterization of CuO-PVA Nanofluids for Heat Transfer Applications", J. Chem. Eng. Chem. Res. Vol. 2, No. 5,pp. 607-615, (2015).