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Research Article

Study the Influence of Laser Energy on the Surface Morphology of Copper Nanoparticles Prepared by Pulsed Laser Extirpation Method in Liquid

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Abstract

A study reports a novel synthesis of pure copper and the effect of laser energy on optical properties and the particle size of colloidal copper nanoparticles prepared by pulsed laser ablation in liquid (PLAL). Different laser energies (600,700,800 mJ) of pulsed laser (Nd: YaG) were used to prepare colloidal copper nanoparticles size of about (40.4 nm - 91.3 nm) which were measured using Field Emission Scanning Electron Microscopy (FESEM). The presence of Copper NPs in distilled water, respectively, with nanostructure in the shape of a spherical construction and size of about 50 nm were measured using Transmission Electron Microscopy (TEM). The absorption spectrum and Surface Plasmon Resonance (SPR) were measured to study the optical properties of the prepared copper nucleus, and the results showed that the SPR and high optical density were found in the 320 wavelengths at the laser energy of (600 mJ), present at wavelength 333 to the laser energy (700 mJ) and shifted to a lower wavelength (blue shift) with a higher optical density, a wavelength of 341 at the laser energy of (800 mJ).

More Information

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Keywords: PLAL; Cu NPs; Colloidal nanoparticles; FESEM; Optical absorbance

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Introduction

In the past years, nanomaterials have moved abroad, and the development activity and importance of research. Nanomaterials are interesting because of their scale, they have unique optical, magnetic, electrical, and other properties. These properties have the potential to produce favorable effects in medicine, electronics, and others [1,2]. The nano-materials can be defined as a group of substances (amorphous or crystalline) of inorganic or organic substances having sizes ranging from 1 nm - 100 nm. Nanomaterials are categorized as nano-materials, nanostructured materials, and nano-particles [3,4]. Copper is compared to silver and gold, so it is preferable to install this particle within an aqueous medium. Pulsed laser ablation in aqueous media provided an alternative technique for the preparation of a size control metal nano-particles [5]. A laser ablation method can synthesize substances within a very clean environment such as de-ionized water that is efficiently- controlled, resulting in the assembly of high-purity nano-materials. The properties of nanoparticles such as their size and shape are often controlled by laser pulse parameters such as wavelength, pulse duration, laser energy, and the liquid medium [6]. Due to the internalization of optical and magnetic properties, nano-particles have attracted great interest regarding metal grains within the nano-scale [7,8]. Nanoparticles can be produced by short-pulse laser ablation of a solid target in a liquid medium. This method provides an opportunity. Laser ablation is unique for resolving the reported cytotoxic effects of nanoparticles resulting from chemical synthesis [9]. The process of removing a substance from a substance by irradiating it with a laser beam is heated. The material by the laser energy absorbed by the target causes vaporization or sublimation due to the high temperature. When the laser energy drops, high per unit time on the target, the substance turns into plasma. Ablation is used to remove material using a pulsed laser. The rate of ablation (the amount of material removed by a single laser pulse) depends on laser power, penetration depth, and optical properties of the material laser wavelength and pulse duration [10]. A high-energy laser directed at the target sample increases the temperature of the sample material by the energy absorbed from the laser and reaches temperatures of 20,000 K. During this time, plasma forms. The electric field accompanying a pulse acts, and electromagnetic lasers accelerate free electrons to standard energy to ionize the atoms they collide with, which produces other electrons that contribute to ionization [11]. At the end of the laser pulse, the cooling process begins with the expansion of the plasma with a shock wave in front. During the cooling of the plasma, the emission is observed as radiation at a wavelength characteristic of the sample due to the return of the excited atoms and ions to the ground state [12]. The duration of the laser pulses can vary from milliseconds to femtoseconds, making laser ablation extremely valuable for both research and industrial applications [13]. Laser ablation, which is a special type of physical vapor deposition for the preparation of nanoparticles, has many applications [14]. And can create nanoparticles from materials that cannot be easily evaporated by other methods. Laser ablation is used to manufacture some types of connectors high-melting-point materials and laser crystals [15]. CuNP copper nanoparticles possess unique optical properties in the visible region due to the surface plasmon oscillation of electrons. Free when light falls on it [16,17] noble ones such as silver, gold, and copper, and this property is responsible for changing the colors of these elements when they reach nanoscale size and depends on the size. The particle, its shape, and the medium in which it is located, this property cause the temperature of the medium surrounding the nanoparticle to rise when light falls on it and has several properties and applications, including [18,19], in the field of biotechnology and biomedicine [20]. Nanoparticles of copper metal will have promising applications in the production of electronic devices that rely on precious and expensive metals. It also has another important advantage in that it is suitable for manufacturing electronic components using 3D printing techniques, as it is one of the best environmentally friendly manufacturing methods. Copper nanoparticles are copper particles ranging in size from 1 to 100 nanometers. Like many other forms of nanoparticles, copper nanoparticles can be prepared by natural processes or through chemical synthesis. These nanoparticles are of particular interest due to their historical application as coloring agents, and biomedical and antimicrobial agents [3]. In this paper, the effect of pulsed laser energy on the optical properties and grain size of copper nanoparticles was studied.

Experiment setup

CuNPs were prepared by pulsed laser ablation in liquid PLAP of a piece of high purity copper 99.99% and circular in shape, diameter (1.8 mm), and thickness (0.05 mm), its dimensions were measured using vernier, in distilled water solution (DW). It was carried out using a YAG: Nd laser with a wavelength of 1064 nm, a pulse time of 9 ns, a repetition frequency of 6 Hz, and a number of pulses of 150 pulses. The sample was at the bottom of a container of water, and the laser beam was focused on the surface of the sample using a quartz lens with a focal length of (9cm) placed in front of the sample for the purpose of obtaining the energy density required for scraping. The height of the water above the objective was 10 mm and the diameter of the laser beam was 10 mm before the lens. The volume of water in the ablation container was 3 ml and the target underwent ablation at different laser energies (600, 700, 800 mJ). The YAG:Nd (Yttrium Aluminum Garnet Doped Neodymium Aluminum Garnet) pulsed laser is used in many applications as a power source Figure 1.

Results and discussions

Ultraviolet visible spectrophotometer

Optical measurements involving the absorbance spectrum of Cu NPs were performed by (UV-visible Spectrophotometer / 2700) two-beam supplied by the English company (CECIL). The absorption of metallic nanoparticles [2] showed the absorption spectra of Cu NPs, by 600mJ laser energy and 150 pulses used. Individual colloids were shown, (SPR) corresponding to monometallic counterparts and SPR Peak position at (320 nm) for Copper NPs respectively Figure 2.

Figure 3 shows the absorption spectra of the metallic nanoparticles for Cu NPs, by the laser power used 700mJ and 150 pulses. Individual colloids were shown, (SPR) corresponding to monometallic counterparts and the SPR peak position at (333 nm) for Copper NPs respectively.

Figure 4 shows the absorption spectra of metallic nanoparticles for Cu NPs, using 800 mJ laser power and 150 pulses. Individual colloids were shown, (SPR) corresponding to monometallic counterparts. The position of the SPR peak is

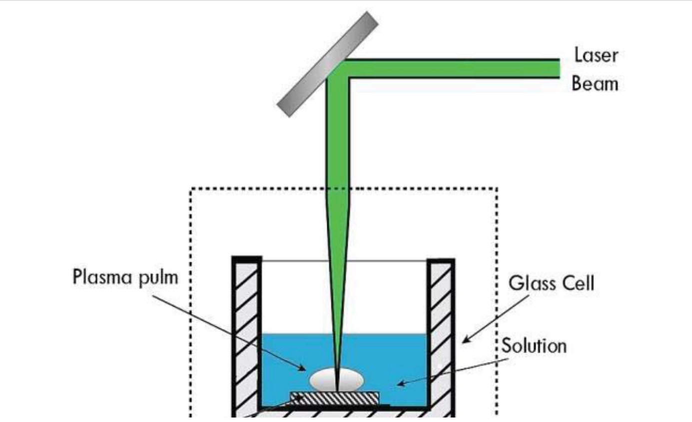

Figure 1: Pulsed laser ablation in liquid method.

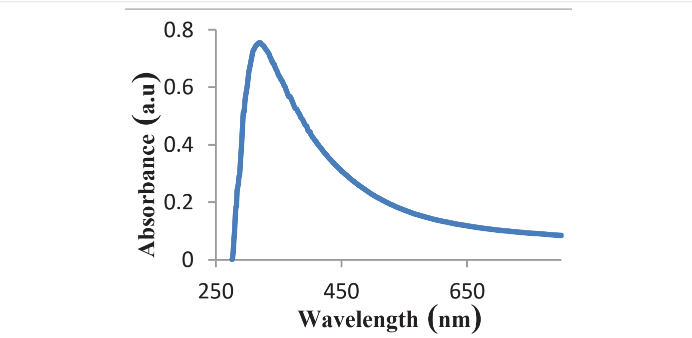

Figure 2: Absorption spectra of Copper NPs, in laser energy 600 mJ and 150 pulses.

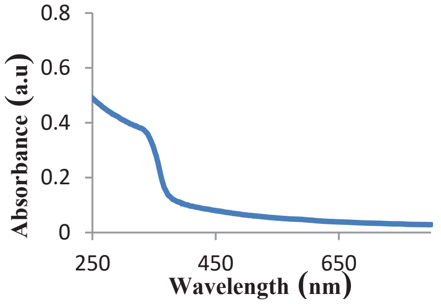

Figure 3: Absorption spectra of Copper NPs, in laser energy 700 mJ and 150 pulses.

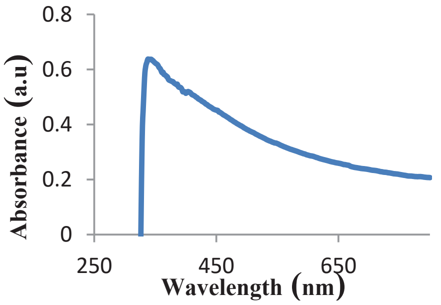

Figure 4: Absorption spectra of Copper NPs, in laser energy 800 mJ and 150 pulses.

also at (341 nm) for Copper NPs respectively. The appearance of the surface plasmon resonance (SPR) peak with increasing laser power was towards the shorter wavelength (blue shift). This is due to scattering Mie, which occurs when an electromagnetic wave falls on quasi-spherical nanoparticles, whose, radii are equal to the wavelength of the incident light.

Morphological investigation

The purpose of this assay is to analyze the structural and morphological characteristics of the surface membranes of samples of nanoparticles prepared after they were deposited on glass slides and imaged using a field-emitting scanning electron microscope (FESEM) (type 7600F-JSM) from Japan company production JEOL Ltd. FESEM scanning of the prepared copper particles as shown in Figure 5. It was observed that they have a nearly spherical shape, that the particles are lumpy and regular in shape and the average particle size is nanometers (91.3 nanometers) and their particle size ranges in the nanometer range (55.5-91.3 nanometers) by the laser power used 600 mJ and 150 pulses.

FESEM scanning of copper particles prepared is shown in Figure 6. It showed that they have a quasi-spherical shape and that the particles are lumpy and regular in shape, the average particle size is nanometers (77.5 nanometers) and their particle size ranges in the nanometer range (51.03-77.57 nanometers) at a laser power of 700 mJ and 150 pulses.

FESEM scanning of the prepared copper particles is shown in Figure 7. It showed that they have a nearly spherical shape and that the particles are lumpy and regular shaped, the

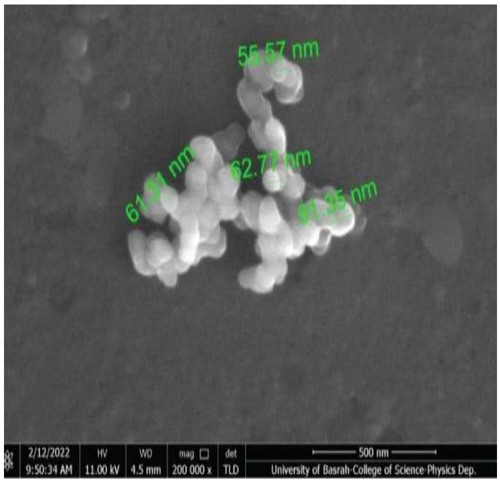

Figure 5: The FESEM of the nanoparticle in laser energy 600 mJ and 150 pulses in 500 nm.

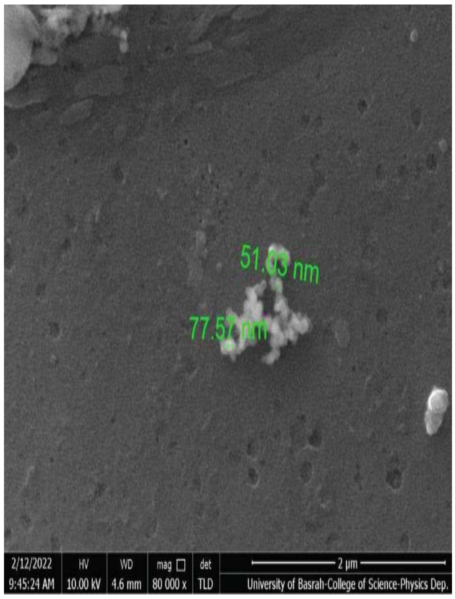

Figure 6: The FESEM of the nanoparticle in laser energy 700 mJ and 150 pulses in 2 µm.

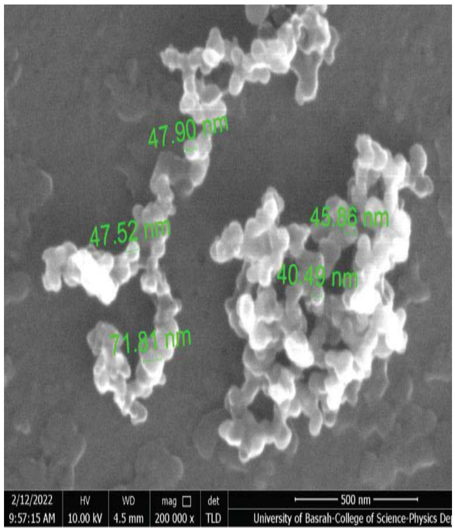

Figure 7: The FESEM of the nanoparticle in laser energy 800 mJ and 150 pulses in 500 nm.

average particle size is in nanometers (71.8 nanometers) and their particle size ranges in the nanometer range (40.4-71.8 nanometer) at a laser power of 800 mJ and 150 pulses.

Transmission electron microscope

The TEM images of the prepared Copper NPs in distilled water were recorded using a (PHILIPS CM10). The TEM images in Figures 8-10 show the presence of Copper NPs in distilled water, respectively, with nanostructure in the shape of a spherical construction and size about 50 nm, that is, the Copper NPs are too small.

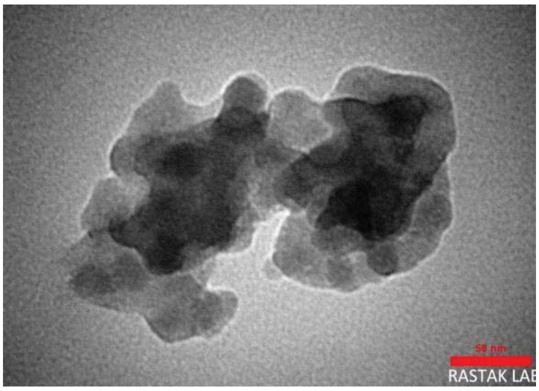

Figure 8: The TEM of the nanoparticle in laser energy 600 mJ and 150 pulses in 50 nm.

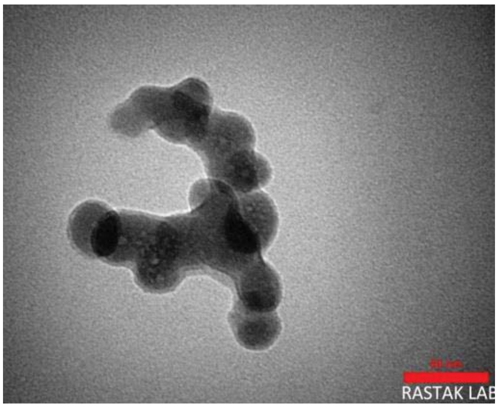

Figure 9: The TEM of the nanoparticle in laser energy 700 mJ and 150 pulses in 50 nm.

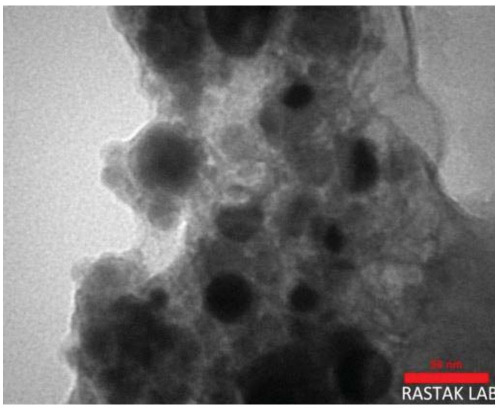

Figure 10: The TEM of the nanoparticle in laser energy 800 mJ and 150 pulses in 50 nm.

Conclusion

Fabrication of copper nanoparticles using a variety of methods, including physical, chemical, and biological. The laser ablation method is an easy-to-prepare method, safe to demonstrate, inexpensive, and does not require much time to produce nanomaterials, in this way, metals can produce metal oxides, and therefore it is a preferred method. For the preparation of copper and other metals. Copper rings can be measured using a spectrophotometer and FESEM. The laser power effect on the size of the nanomaterials is also shown. The results of the study proved that copper nanoparticles are more stable than the rest of the noble metal nanoparticles, and these results are identical to the results of ultraviolet and visible spectroscopy and electron microscopy images.

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