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Preparation ZnO nanoparticles with Different Concentration by Laser Ablation in Liquid

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K E Y W O R D S

Pulse Laser ablation in liquid (PLAL),
Zinc oxide (ZnO),
Nano-particles,
Nd:YAG laser.

A B S T R A C T

The effects of varying laser pulse numbers on the fabricated of ZnONPs by pulsed laser ablation in deionized water of Zn-metal are investigated. The Nd: YAG laser at energy 600mJ prepared three samples by change the laser pulse number (100, 150, and 200). The results were collected and examined using an electron scanning microscope, XRD – diffraction, and transmission electron microscope. The result revealed the colloidal spherical shape and the homogeneous composition of the ZnO NPs. The nanoparticles resulted in different concentrations and sized distributions by changing the pulse number of a laser. The average particle size and the mass concentration of particle size increase with an increasing number of laser pulses by fixed the laser energy.

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1. Introduction

The style and properties of materials at the nano-technique widely changing compared with micro-levels. The attitude of nanoparticles varies in electrical, optical, magnetic and chemical properties compared to macrostate of the same materials. Zinc oxide is a wide bandgap semiconductor of about 3.37 eV, use in different fields such as industrial and medical. Because of the strong UV absorption properties of ZnO, they are increasingly used in personal care products, such as cosmetics and sunscreen. In addition, ZnO NPs have superior antibacterial, antimicrobial, and excellent UV-blocking properties. Therefore, in the textile industry, the finished fabrics by adding ZnO NPs exhibited the attractive functions of ultraviolet and visible light resistance, antibacterial and deodorant [1-5]. Many techniques are used to fabricate nanoparticles for example, vapor deposition, sol-gel, and flame synthesis [6-11]. These techniques were complex setup and need special parameters such as temperature and pressure to get the desired composition and size distribution. Nowadays, laser ablation of materials was a nearly new technique first invented in 1993 by Fo- jtik et al has proven merits as the common efficient procedure for getting nanoparticles [12-14]. This is the chosen method is characterized by its ease, efficiency, and does not require complicated situations or specific conditions to obtain a nanoscale solution [13]. This promising method can control the size and concentration of fabricated nanometers via changing the laser parameters, therefore, it processes as much attention as a novel NPs manufacture way [15]. In this manuscript, we have studied the effect of the laser pulse on the concentration of NPs prepared by laser ablation for a zinc-bulk in distilled water. The effect of changing the laser pulse at fixed energy on the concentration and size distribution studied experimentally and the morphology of nanoparticles is investigated.

2. Materials and methods

Prepared ZnO nanoparticles by PLAL, the zinc-target (99.9%) immersed in 3ml of double distilled water (DDW) at room temperature. The Nd: YAG laser work at (1064 nm, 1Hz) energy up to 600 μJ/pulse was used to get ZnONPs (figure 1). Laser beam focused (focal length =20cm) of the lens at a distance (5cm) about the zinc bulk. The vessel was rotated for producing homogenous nanoparticles. The three samples of ZnONPs (100,150 and 200) pulses and fixed the laser energy was prepared. Nanoparticle solution with an increased pulse number will lead to variation in the color of the ZnONPs solution in liquid [16, 17]. The characterization of ZnO nanoparticles was investigated using X-ray diffract meter XRD of Cu-kα (1.5 A°), Scanning electron microscopy SEM equipped with energy dispersive x-ray EDX spectrometer, and transmission electron microscopy TEM at Khashan University.

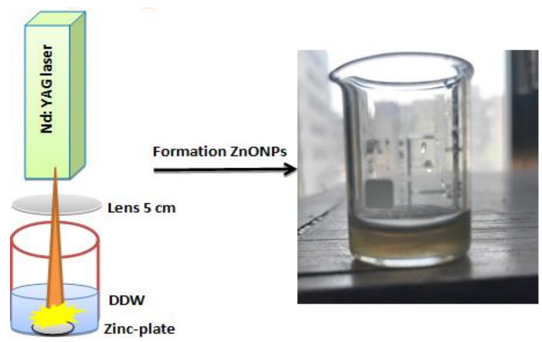

Figure 1: The PLAL-techniques of formation ZnO colloidal.

3. Results and discussion

The mass concentration of different colloidal ZnO nanoparticles prepared at 600μJ with different pulse numbers (100,150.200) is shown in Figure 2. The amount of ablated material in the colloidal was calculated by weighted the target before and after the laser ablation process. The results display by increasing laser pulse increases the production of nanoparticles in DDW.

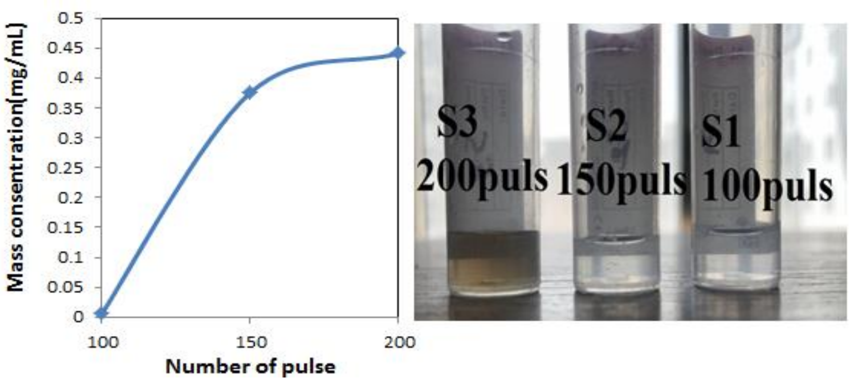

Figure 2: Mass concentration by change laser pulses (100,150 and 200) pulse and Change in ZnO suspension color due to pulse energy variation

UV-visible absorption spectra of the ZnONPs prepared by PLAL were determined over the wavelength range of 200–1200 nm. Optical absorption of colloidal ZnONPs samples prepared at different laser energy is shown in figure 3. The Right image shows the change colors in the different samples where ZnO colloidal with 200 pulses the color much darker compared with (100 and 150) number of the laser pulse. The color changes give an indication of the nanoparticles suspended in the liquid [18]. The absorption spectra have peaks centered at (250, 230, and 210) nm for the laser pulses (100, 150, and 260) respectively

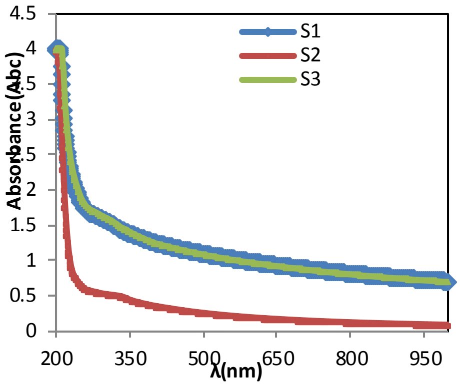

Figure 3: Absorption spectrum of ZnONPs

The XRD- pattern of the three samples is donated in Figure 4, the peaks that have resulted can be seen at 2θ (10-80) data were measured by using Cu Kα radiation (1.5406 A). The diffraction peaks as display in the pattern at 37.39° and 44.51° correspond to the reflection from the (100) and (101). The dominant peaks of XRD for ZnO NPs by DDW conformity reveals are crystalline in a hexagonal structure [13]. An average size 'd' of the ZnONPs resulted from laser ablation was calculated by using the Scherer formula in the Xpert High Score program all data are listed in the table.1 [19-21].

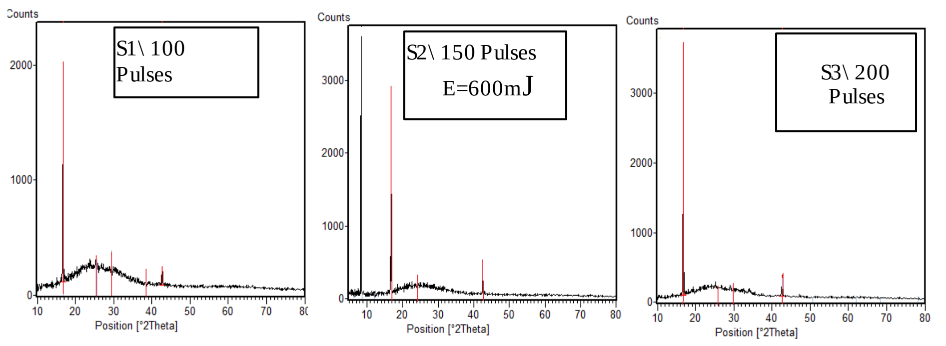

Figure 4: XRD pattern for ZnO-samples with a different laser pulse and same laser energy.

TABLE I: The particle size of ZnONPs samples by using Scherer eq.

Sample	Laser pulses	Particles size
S1	100	38
S2	150	29
S3	200	41

The SEM images of ZnONPs fabricated by laser ablation in DDW with different pulses (100,150 and 200) and the same laser energy 600μJ are shown in Figure 5(B). Morphology of ZnONPs be based on energy and also on the laser pulse number. As well as, the concentration of ZnONPs suspension increased by increasing the number of pulses. It clears the ZnONPs suspension in circular shapes increases with increase the pulse number. Figure.5 (A) display the EDX analysis, which measured the element in ZnO colloidal, include the Zn, O, C, Na, and N elements in different amounts. Sample 3 contains Zn amount larger than other samples as shown in the EDX result this approve the increase in laser pulse increasing the particle ablation rate [22]. Figure 6 shows the TEM images for ZnONPs colloidal prepared at energies 600 μJ, size of particles varies with domain a range between a few tens of nanometers. The different images showed changes in the laser energy that's lead to may change in the distribution and particle size. Where (A) 100 pulses are used the particle size tends to lower in numbers in solution compared with B (150) and C (200) these tend to increase in concentration. The ablation attached with light ablates the surface front layer without any melting effects (surface effect). The increase in laser pulses leading penetrates deeply the Zinc target to increase the colloidal concentration. The nanoparticles produced due to the interaction of laser pulse with zinc target are roughly uniform and spherical in the form [23, 9].

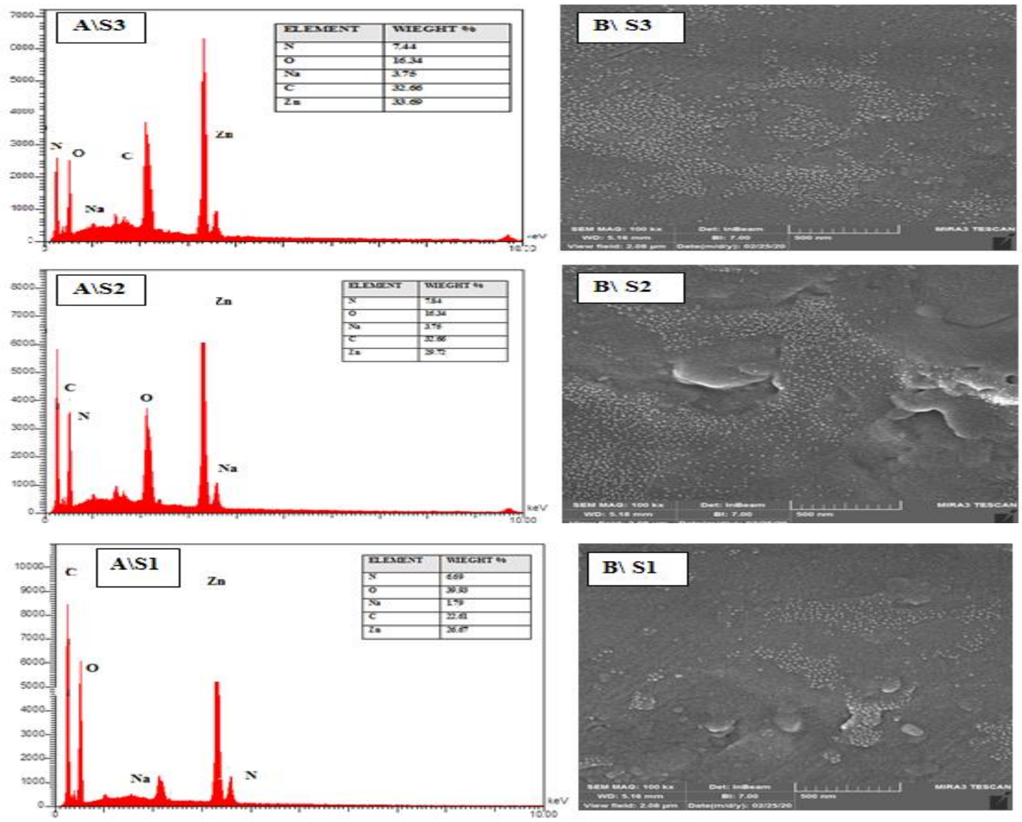

Figure 4: A. EDX spectrum for ZnO colloidal elements and, B the SEM image for the prepared ZnONPs

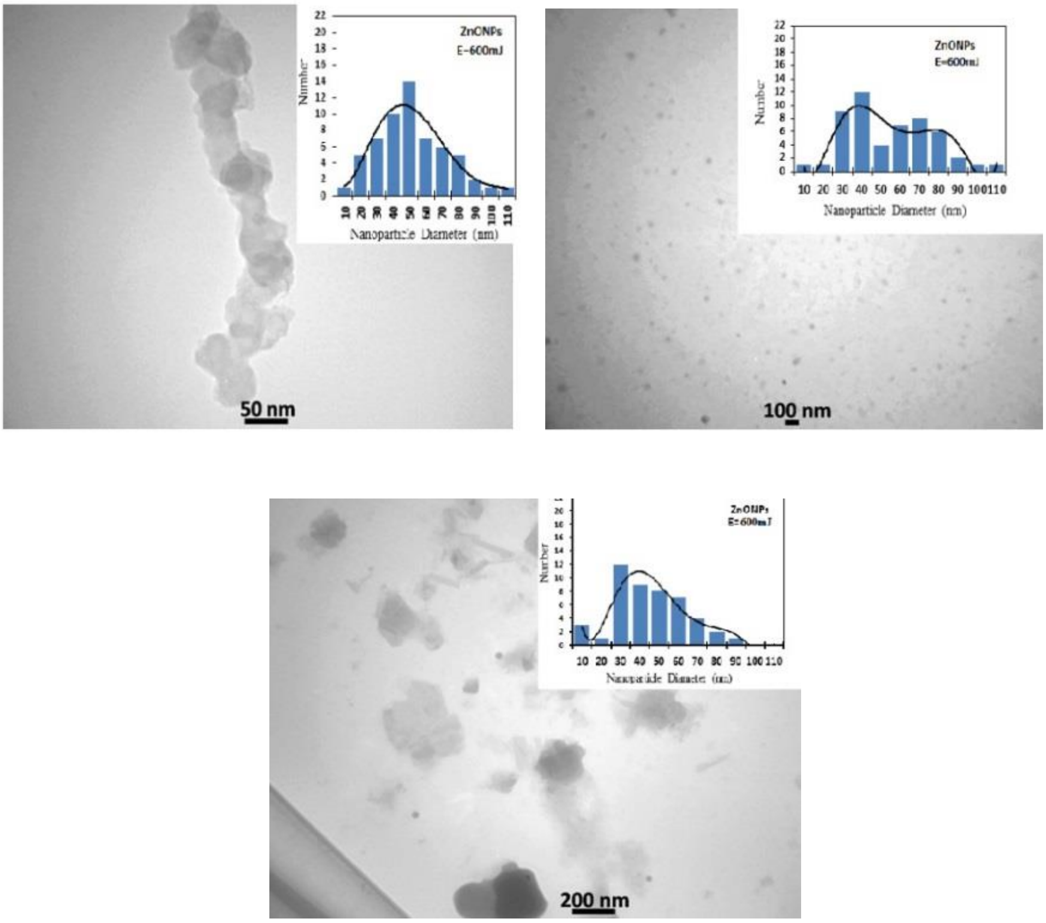

Figure 5: TEM image for ZnO suspension with different magnifications (50,100 and 200) nm and size distribution for NPs.

4. Conclusion

ZnO suspension has prepared via PLAL- technique. The samples prepared by changing the laser pulses and fixed the energy. The result proved the ZnO with hexagonal structure with an orientation of (100). The crystalline size was increased with the increasing number of laser pulses. In all cases, where the ZnONPs were homogenous and size distribution concentrated at a few tens of nanometer and free of defects and contaminations, the mass concentration increases with the increasing the pulse number.

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