Fabrication of Zinc Oxide Nanoparticles by pulsed laser ablation in liquid –PLAL and Study their physical Properties

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Abstract. ZnO NPs are manufactured using pulsed laser ablation in double distilled water (DDW). Nd:Yag laser used as a source of energy for this research by immersing the zinc-target in DDW water. The glass container with laser pulses was rotated to prevent etching effect and getting homogenous distribution particles. By changing the parameters (laser energy and number of pulses), the results were collected and examined using an ultra violet-visible spectrum and electron scanning microscope. The calculations revealed the colloidal spherical shape and the homogeneous structure for the ZnO NPs. The band gap plot display varies in the band gap proportional with particle size, this result agree with effective mass model.

Keywords: PLAL- pulse laser ablation, metal oxides NPs, Colloidal Structure.

1. Introduction
The nanometer dimensions equal ten times the diameter of a hydrogen atom and the diameter of one hair is equivalent to 80,000 nanometers. On such scales, the normal rules of physics and chemistry not apply. For example, material properties with nanoparticles dimensions different completely, such as color, hardness, resistivity, wide volume ratio and high purity. Carbon nanotubes more hardness and strongest than bulk about one hundred this good example for enhanced the properties of material compared with NPs [1]. The nanotechnology contributed with clean energy to help the environment, and improved to solve complicated medical problems. Nanotechnology aims to enhance manufacturing production and reduced costs by increased the materials with high efficiency [2]. The Zinc (Zn, Z=30) and its bluish white in color is one of essential trace elements for humans [3]. Achievements made over the last decades in nanotechnology are promising and important results at many fields such as physics, chemistry, biology, engineering and medicine [4-7]. There are many techniques used to produce (ZnO) particles in Nano-scale such as, chemical method [8] ,PLAL Method [9],  Microemulsion Method [10], spray pyrdsis Method[11], hydrothermal Method [12].those methods have some drawback such as, complex fabrication, need more devices and some techniques low purity because chemical additive[13]. In this study, we used the PLAL Method because it’s simple
and quick steps and easily control to particles shape by change laser properties, this makes the method easy and low cost[14]. Zinc Oxide NPs called also (Zincite) has 80.3% Zn, used in widely dimensions paints, ointments, cement because of the promising physical and chemical parameters [3].

2. Materials and methods

The ZnONPs synthesize by pulse laser ablation in liquid, first weighted the zinc-plate then immersed in 1ml of deionized water. The Q-switched pulsed Nd:YAG laser (1064nm) at energy (500 and 600)mJ per 100 pulse was used to prepare 2-samples of ZnONPs. The convex lens 25 cm, distance between lens and target was 4 cm with this parameters the ZnONPs prepared. The glass container with laser pulses was rotated to prevent etching effect and getting homogenous distribution particles. The result ZnO colloidal with different laser energy and fixed pulse number was varied in the color of ZnO-solution in DDW as shown in figure 1.

![Formation ZnONPs](image.png)

**Figure 1.** The pulse laser ablation techniques of formation ZnO-colloidal.

3. Results and discussion

The absorbance spectrum for ZnO(NPs) prepered By PLAL as shown in UV-visible absorption peak. The absorption peak at (230 and 255) nm as display in figure (2 -B) were peaks consist due the travelling of inner-electron into outer. The resulted peak aproved with (Lee et al 2005) were showed the ZnONPs peak at 255 nm [15]. The shift in peaks for S2(230) nm is because the varies in particles size which effect on surface plasmon resonance [16]. Figure( 2-A) display the mass concentration for ZnO-colloidal prepared by PLAL method. Were the ZnO-target weighted before and after the prepartion of NPs.
Figure 2. (A) the amount of ablated nanoparticles versus the laser energy, (B) absorption peak for ZnO colloidal fabricated by PLAL.

The bandgap for ZnO(NPs) in the Figure 3 appear the increasing band gap with the decrease in particle size as showed in the spectrum shifted towards high concentration. The bandgap of synthesis ZnONPs from plot by using the general equation of standard mass (αhν) n = B (E − Eg), where B is a constant, Eg the band gap energy, E= hν the photon energy, and n = ½ or 2, if the transitions are indirect or direct [17].

Table 1. The absorption peak values versus laser energy, and band gap calculation

| Sample | Laser Energy (mJ) | Absorption peak (nm) | Band gap (eV) | Particle size (nm) |
|--------|-------------------|----------------------|---------------|--------------------|
| S1     | 600               | 250                  | 2.1           | 37.3               |
| S2     | 500               | 230                  | 3.8           | 28.6               |

Figure 3. The curve of band gaps for ZnO NPs suspension at different laser energy.
XRD patterns of the ZnO-products synthesis in DDW different laser energy is presented in Figure 4. X-ray diffraction was measured for the ZnONPs concentrated suspension was dried on a glass substrate. The peaks was resulted can be seen at 2θ (10-80) data were measured. The diffraction peaks as shown in Figure 4(a) the pattern at 18.39° and 40.51° correspond to the reflection from the (100) and (101). The peak was shifted in (b) to 19.31° and 43.45° this shifting is due the change in particle size. The diffraction peaks of XRD pattern for ZnONPs are crystalline and possess the hexagonal quartzite structure [18]. The size of particles change at few tens of nanometers, particles are almost spherical in shape and homogeneous as shown in figure 5. The size distribution of ZnONPs is nearly Gaussian type shows agglomerates [19] of small grain ZnO NPs. The SEM images appear varies of the particle size due the change in laser energy (A) 600 mj is used the particle size tends higher numbers in solution compared with (B) 500mj these tend to increase in concentration.
Figure 5. SEM magrograph and size-distribution for ZnONPs fabricated by PLAL at different laser energy (A) 600mJ and (B) 500mJ.

4. Conclusions
- Change energy of laser source changing the size of Nano particles of the ZnO.
- The bandgap of ZnO(NPs) varies with the particle size decreasing the absorption peak shifted to high concentration-side because decrease particle size.
- The absorbance-peak for ZnO(NPs) prepared by PLAL-route lying at position 230 and 255 nm for different laser energy.
- The SEM images appear varies of the particle size due the change in laser energy.
- The diffraction peaks of XRD pattern for ZnO(NPs) are crystalline and possess the hexagonal quartzite structure.
5. References

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