Spectroscopic Study of MgO Nanoparticles Prepared by Pulse Laser Ablation in SDS solution

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ABSTRACT

MgONPs were synthesized by pulsed (Q-switched, 1064-Nd: YAG, E=100mJ) laser ablation of Mg metal plates immersed in SDS solution with concentration (0.01)M and analysis by X-ray diffraction (XRD), scanning electron microscopy (SEM) and atomic force microscopy (AFM)techniques. Absorbance and Fluorescence spectra of the produced nanoparticles solution was measured by uv-vis and Fluorescence spectrophotometer.

Keywords: Pulsed laser ablation, Nanoparticles, MgO , Liquid, Nd: YAG, SDS solution

INTRODUCTION

Nanoscience defines a set of technologies and developments that are based on physical, chemical, and biological phenomena occurring at the nanoscale ranging of approximately 1 to 100 nanometer [1].The properties and behavior of materials at the nanoscale vary greatly when compared to the others at the micro, macro or bulk levels[2].

The transition from micron range particles to nanoparticles leads to a number of changes in their properties; the major change is the increase in the surface area to volume. Thus large fractions of surface atoms together with ultra-fine size and shape effects make nanoparticles exhibit distinctly different properties from the bulk [3].

In general there are two approaches to fabricate nanomaterials: top-down and bottom-up. In the top-down approach the nanoparticles are etching of smaller structures from larger ones. On the other hand, bottom-up approach refers to the build-up of a material from the bottom: atom-by atom, molecule-by-molecule, or cluster-by-cluster [4].

The most efficient physical methods for nanofabrication is laser ablation, it is a typical example of top-down approach in fabrication of nanoparticles, laser ablation is the process of removing material from a solid surface by irradiating it with laser beam[5].

The laser ablation of material from target leads to form nanoclusters either in vacuum by deposition on substrate yielding to the formation of nanostructure film or in liquid when the nanoclusters can be released into the liquid forming a colloidal nanoparticles solution, also the difference occurs between these processes when plasma begins to expand ,which occurs freely in vacuum but is confined by liquid layer, the liquid delays the expansions of the plasma leading to high plasma pressure and temperature, which allows to formation of novel materials [6].

The more effective collection of synthesized particles can be achieved by laser ablation in liquid environment. The liquid not only confines the ablated species at the liquid-solid interface, but also it acts as a mediator for chemical reaction at the liquid-solid interfaces,

ISSN: 2223-9944, eISSN: 2223-9553

therefore the liquid media surrounding the target plays an important role on affecting the shape, mean size, size distribution and composition of the particles [7].

Pulsed laser ablation in liquid media (PLAL) is a promising technique for controlling the fabrication of nanomaterials via rapid reactive quenching of ablated species at the interface between plasma and liquid. Also this technique is a versatile technique for preparing various kinds of nanoparticles materials such as noble metals, alloys, oxides and semiconductors [8].

The mechanism of the laser-induced plasma and ablation of particles from the target using a pulsed laser starts when the laser beam irradiates at the interface between the solid and the liquid through the liquid, a plasma plume is formed at the interface, and confined by the surrounding liquid during each pulse.

The confined plasma expands adiabatically at a supersonic velocity, creating a shock front that in turn induces an elevated pressure and increase of plasma temperature. Such transient pressure in front of the plasma plume impinges the ablation species of metallic ions, atoms and clusters into the confined liquid, and chemical reactions between the ablated species and the liquid occur, forming nuclei of oxides and/or hydroxides, or other compounds depending on the type of liquid. It is believed that in the case of PLAL the shock wave plays a self-limiting role for the generation of NPs and alters the efficiency of the process [9, 10].

PLAL has been demonstrated that size of synthesized material can be controlled by changing different laser parameters such as: laser fluences, wavelength, and pulse laser duration or by changing the type of surfactant solution. The parameters of laser and the type of surfactant effect on the stability and size of produced NPs.

Ablation process which use ultra-short laser makes it possible to produce very gentle material removal converting a bulk material into nanoparticles in gases and liquids media without changing its stoichiometry [11].

The production of NPs by femtosecond laser has been getting more common due to its efficiency in ablation of materials and effective controls of particle size compared with nanosecond laser ablation and minimize the laser–plume interaction then reduce the heat affected zones. Moreover the limited heating effect results from the interaction of ultra-short pulses with the matter benefit a faster cooling of ablated particles and prevent them from aggregating [12]. But in nanosecond (ns) laser pulses ablation process occurs from both the melted and the vapor phases, leading to emission of particulate and liquid micro-droplets. Moreover, the long lasting material emission and the longer pulse duration lead to laser-vapor interaction, limiting the control on the properties of the ablated particles. For all the above reasons, the ultra-short laser pulses especially femtosecond laser processing of nanoparticles has been getting more popular because of its efficiency in ablation of materials and effective control of particle size [13].

Laser pulses can be applied not only for the generation nanoparticles, but also to produce smaller and mono disperse particles, the process which be responsible on reducing the size of NPs is called fragmentation process , this process caused by the interaction between pulsed laser light and the produced nanoparticles, when these nanoparticles possess as strong absorption band whose energy coincides with the energy of the laser**,** this process is also called ‘‘two-step laser-assisted method’’[14-15].

PULSED LASER ABLATION IN LIQUID MEDIUM (PLAL)

Laser ablation of materials from a solid target occurs either in vacuum or in liquid environment in laser-based materials processing to produce nanoclusters. In the former method the nanoclusters can be deposited on a solid substrate resulting formation of a

ISSN: 2223-9944, eISSN: 2223-9553

nanostructured film [16]. This method has some disadvantages such as the difficulty of controlling the production of NPs. In the latter method the nanoclusters can be released into the liquid forming a colloidal nanoparticle solution leading for a more effective collection of synthesized particles. The solvent can provide positive physical and chemical effects such as plasma confinement, cooling actions, oxidation or reduction leading to enhancement of ablation efficiency [17]. PLAL is a one-step top–down procedure (dispersion method) strategy of nanoparticles preparation[18, 19].This technique can also be applied for the preparation of oxides base nanostructures such as oxide nanoparticles and nanocomposites, because ablated species with high energy can be easily reacted with water and oxidized, and the formed nuclei can react with the organic molecules in aqueous solution[14, 19].

EXPERIMENTAL

Laser ablation of magnesium plate (Mg) in aqueous media was carried out with a nanosecond Q-Switch Nd-YAG pulsed laser. The laser wavelength λ operates at: 1064nm, 6Hz repetition rate with a number of pulse (200)p and with energy of (100) mJ. Metal plate placed on the bottom of glass vessel containing 3ml SDS solution with concentration (0.01)M.

The structural measurements such as, morphological features by X-ray diffraction atomic force microscope (AFM), scanning electron microscope (SEM) and atomic force microscope (AFM) as well as optical properties by using UV-visible and Fluorescence measurements.

RESULT AND DISCUSSION

x-ray Diffraction

XRD peaks of MgO NPs, number of pulses (200)p and concentration of the solution SDS (0.01)M are shown in fig.(1.a). Peaks at 2θ values of 42.78 and 62.07 deg corresponding to (200) and (220) planes of MgO have been observed and compared with the JCPDS, powder diffraction card MgO file No. 43–1022. But this result different when MgO is non-NPs shown in figure (1b) because different in intensity due to the different in the density of the material MgO whether nanoscale material or non-nanoscale material. Increase the broadening of the FWHM of MgO NPs in the XRD spectrum because decrease grain size of MgO.

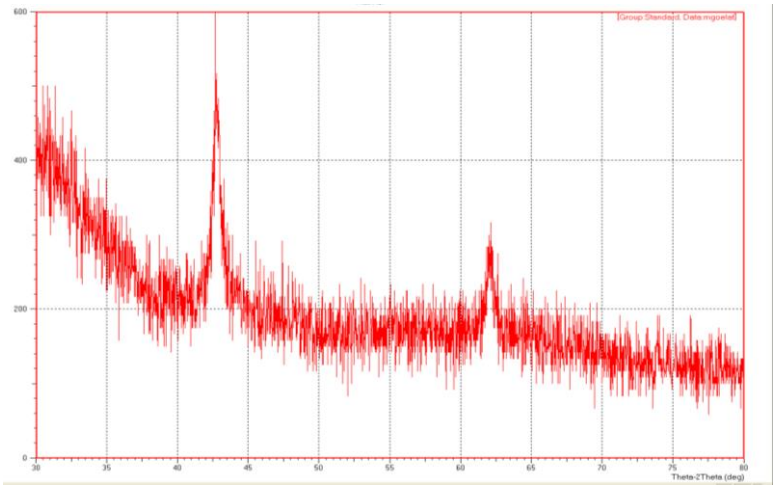


Figure 1a. XRD of MgO NPs

ISSN: 2223-9944, eISSN: 2223-9553

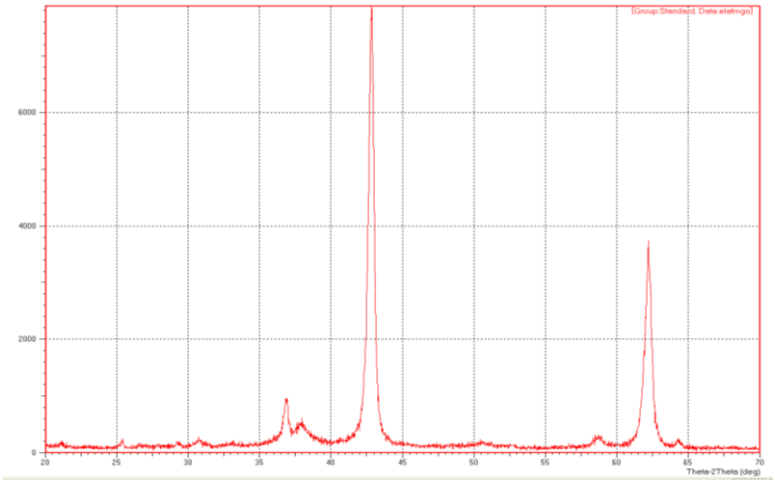


Figure 1b. XRD of MgOnon-NPs

Scanning Electron Microscopy (SEM)

Figure (2a) shows SEM image for MgO NPs after the deposition on glass substrate, number of pulses(200)p and concentration of the solution SDS (0.01)M . Nanoparticles resulting in Fig.2 close to the form tube. While the SEM image of the MgO non-NPs in the form of powder show uniform in shape shown figure (2b)

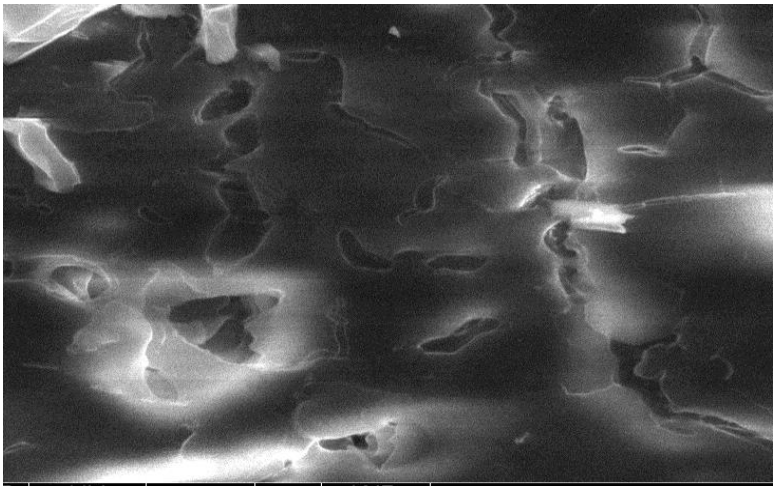


Figure 2a. SEM of MgO NPs

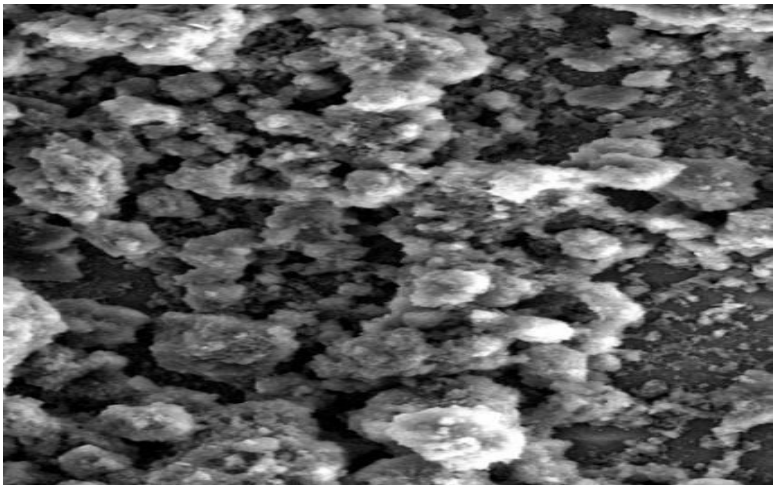


Figure 2b. SEM of MgOnon-NPs

ISSN: 2223-9944, eISSN: 2223-9553

Atomic Force Microscopy (AFM)

Figure 3a shows AFM images of the MgONPs after the deposition on glass substrate, number of pulses(200)p and concentration of the solution SDS (0.01)M. The grain size was (50.52)nm. While the AFM image of the MgO non-NPs is shown in figure 3b.The grain size was (104.04) nm.

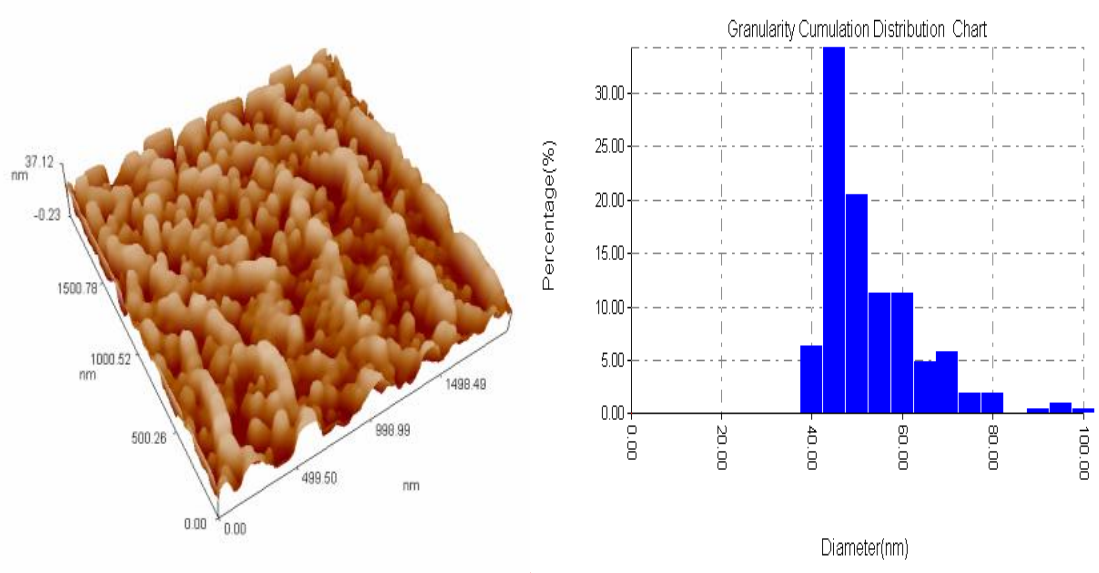


Figure 3a. AFM of MgO NPs

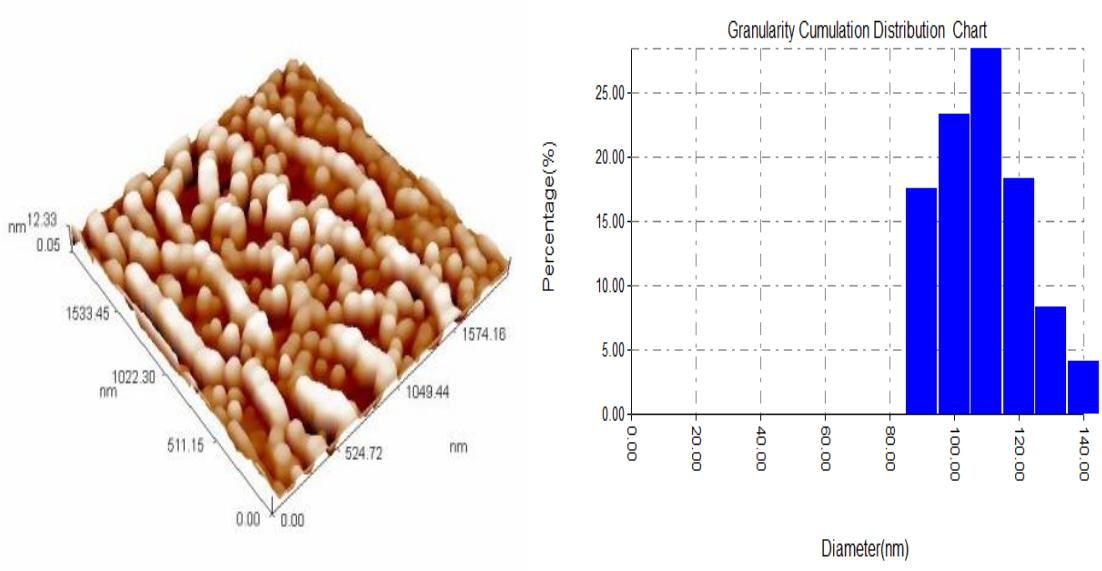


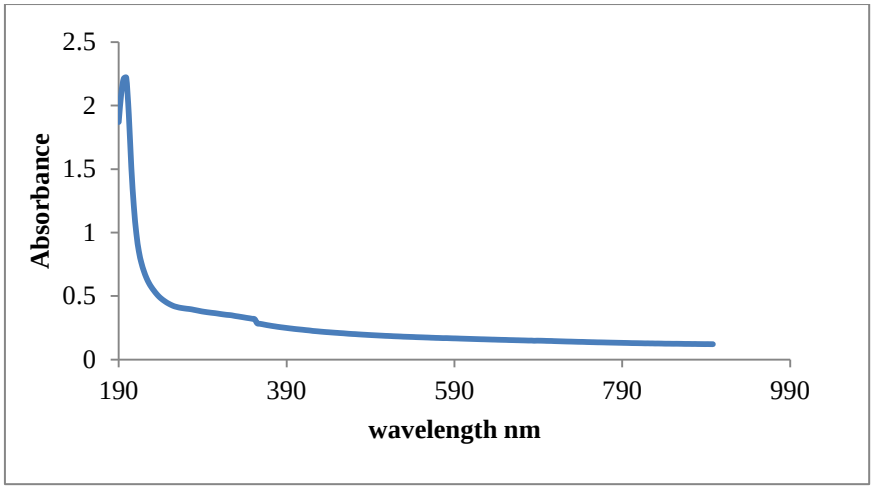
Figure 3b. AFM of MgOnon-NPs

UV-visible and Fluorescence spectra

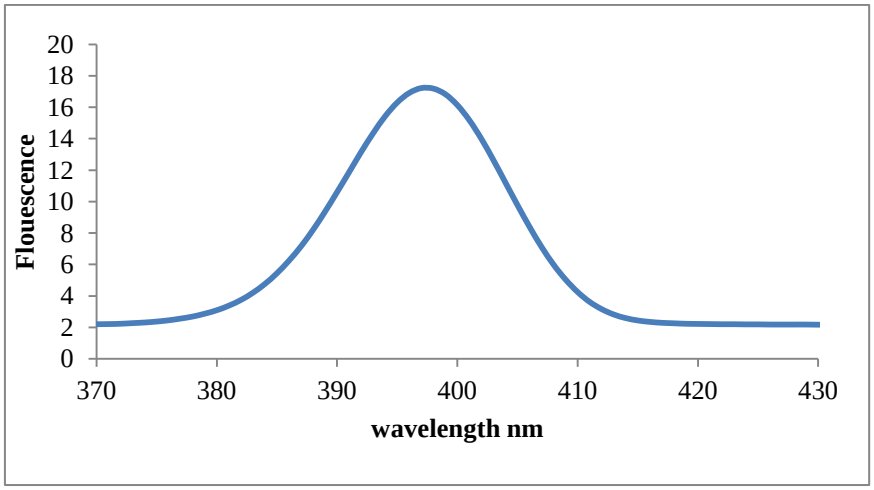
Figure 4 shows the study of the absorption (uv-vis) and fluorescence spectra of MgO NPs at number of pulse 200 p and concentration of solution SDS 0.01M.Where the absorption peak at (199)nm and the fluorescence peak at the wavelength (397)nm.

While the absorption peak at (322)nm and the fluorescence peak at the wavelength (396)nm when MgO non-NPs. Shown figure 5.

ISSN: 2223-9944, eISSN: 2223-9553

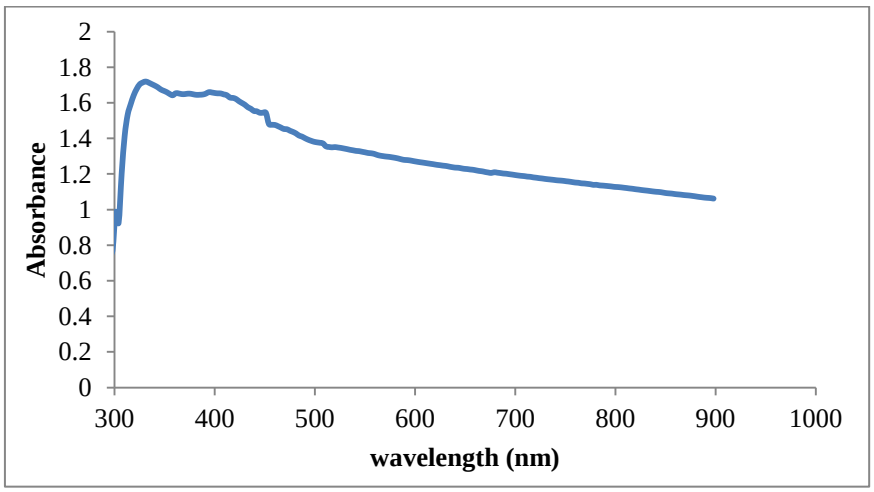


Absorbance Spectrum of MgO NPs



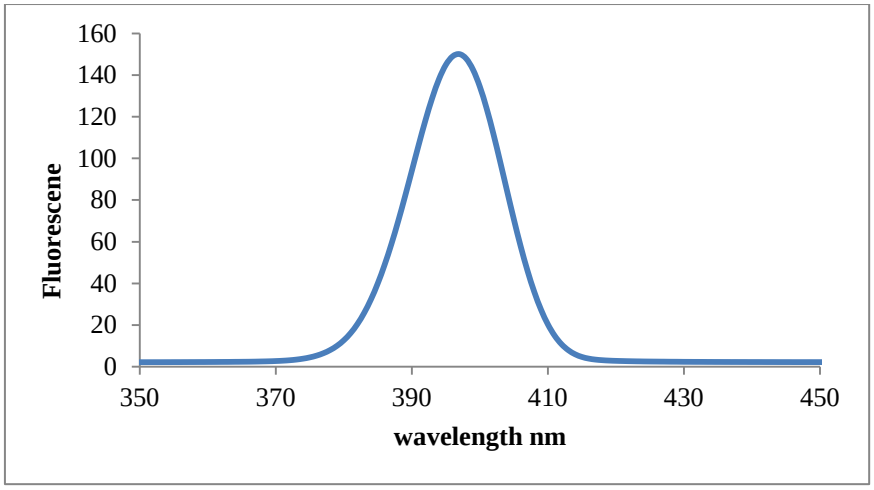
Fluorescence spectrum of MgO NPs

Figure 4. Absorbance and Fluorescence spectra of MgO NPs



Absorbance spectrum of MgOnon-NPs

ISSN: 2223-9944, eISSN: 2223-9553



Fluorescence spectrum of MgO non-NPs

Figure 5. Absorbance and Fluorescence spectra of MgO non-NPs

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