超音波支援液相レーザーアブレーション法を用いた金属ナノ粒子の調製

Ultrasonic Assisted Fabrication of Metal Nanoparticles by Laser Ablation in Liquid

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1. Introduction

Laser ablation of a solid target in a confining liquid provides a highly effective means to synthesize the NPs (nanoparticles). It has demonstrated plenty of advantages, such as chemically clean and no extreme temperature and pressure. These merits allow us to combine selected metal targets and liquid to fabricate compound nanostructures with desired functions. To produce smaller NPs which possess better biological, optical and catalytic properties, the ultrasonic is critical to the process. Here we combine the laser ablation in liquid with the ultrasonic to produce the metal NPs and compare them with the situation which only uses the laser ablation.

2. Experimental method

The metal gold (Au) or silver (Ag) plate was utilized as a target and irradiated by the secondary harmonic Nd: YAG laser (λ=532 nm, Power=500 mW) for 10, 20 and 40 minutes. The NPs colloidal solution was analyzed by UV-Vis spectrophotometer and TEM (Transmission electron microscopy). A method has also been proposed in this work for assessing the crater volume uniquely from the images of the ablated specimens obtained using laser microscope and Matlab.

3. Results and discussion

Figure 1 presents the obtained absorbance of the gold colloidal solution with peak wavelength. One can notice that the peak intensity of ultrasonic assisted laser ablation is higher than the process without ultrasonic, which represents the ultrasonic could enhance the formation rate of NPs in the process of laser ablation. It is known that a plasma plume from the solid target will be generated on the interface between the solid target and the confining liquid. Applying the ultrasonic can result in the growth and collapse of the bubbles created during the laser pulse

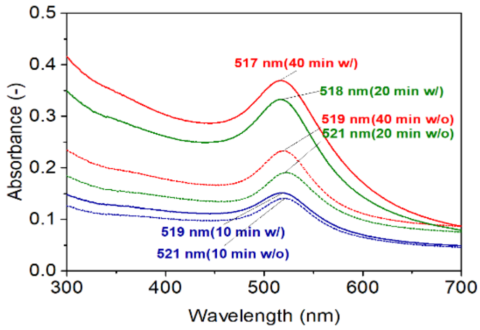

Fig.1. UV-Vis spectra of gold nanoparticles produced by the 532 nm laser in the distilled water ('w/' means with ultrasonic while 'w/o' means without ultrasonic)

strike leading to the increase in the plume temperature. The plasma with the increased temperature can play the role of another heat source on the target surface beside the laser beam. This could result in more evaporation from the target and consequently the enhancement of the formation of NPs.

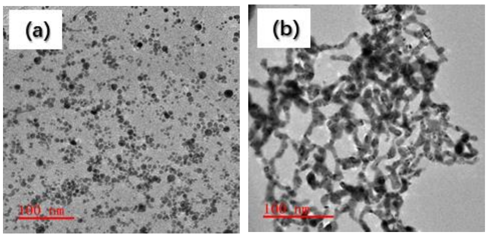

Fig.2. TEM images of the synthesized gold nanoparticles fabricated by laser ablation for 20 minutes with ultrasonic (a) and without ultrasonic (b)

Figure 2 shows the TEM images of the synthesized gold NPs. Clearly, one can see that ultrasonic-assisted-fabrication NPs are smaller and more dispersive than the without ultrasonic process. It can be explained that when the plasma plume is formed by the laser, the ultrasonic may break the aggregates, intensify the irregular motion of NPs and increase the collisions with each other, which could help to fabricate novel NPs.