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FABRICATION OF METAL NANOPARTICLES BY LASER ABLATION

Nguyen Thanh Dinh, Nguyen Quang Dong, Trinh Thi Hue, Vu Thi Khanh Thu,
Pham Thi Thanh Van, Duong Thi Nguyet, Nguyen The Binh
University of Natural Science, VNU Hanoi. Email address: thebinh@vnu.edu.vn

ABSTRACT

We study to produce metal nanoparticles by laser ablation, using Nd:YAG laser (Quanta Ray Pro 230-USA) in Q-switch mode. The Ag, Au, Cu nanoparticles were prepared successfully by laser ablation from metal plate in several surfactant solutions. The average size, the size distribution and the plasmon resonance absorption spectrum of the metal nanoparticles were observed in different laser ablation procedures such as different laser intensities and different laser irradiation times. We also studied laser induced particle size control by plasmon resonance. Using the second harmonic wavelength (532nm) of Nd:YAG laser which is near the plasmon resonance absorption of gold nanoparticles (520nm) we can control average size of gold nanoparticles and produce gold nanoparticles with average size from 3 to 7nm.
Key words: nanoparticle, laser ablation, surface plasmon resonance

EXPERIMENTAL

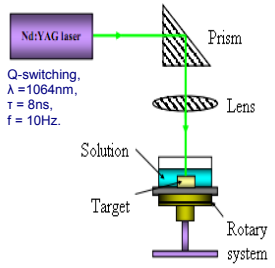

Fig.1. *Experimental layout*

Laser beam was focused on the target by the optical system. To change ablation position and attenuated aggregation effect the target is rotated during the laser ablation. Diffrerent solutions were used such as H_2O, ethanol, isopropanol…

RESULTS AND DISCUSIONS

1. Copper nanoparticles prepared by laser ablation

1.1. Copper nanoparticles prepared in Isopropanol

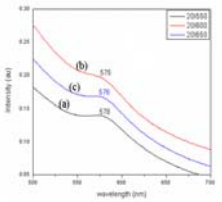

Fig.2. *Absorption spectra of copper nanoparticles in Isopropanol with the different average laser powers 550 mW(a), 600 mW(b) and 650 mW(c)*

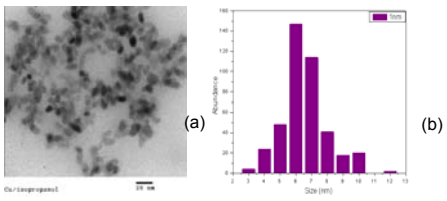

Fig.3. *The electron micrograph (a) and size distribution (b) of copper nanopracticles produced by laser ablation in Isopropanol with the average laser power of 600mW*

The average particle diameter of copper nanoparticles produced in Isopropanol is about 6 nm.

1.2. Copper nanoparticles prepared in solution of Isopropanol and PVP

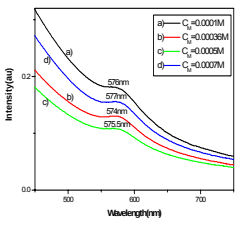

Fig.4. *Absorption spectra of copper nanoparticles in 0.0001M (a), 0.00036M (b),0.0005M (c) and 0.0007M (d) solution of PVP*

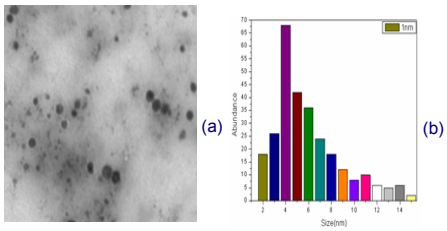

Fig.5. *TEM image (a) and size distribution (b) of PVP protected copper nanoparticles produced in the 0.0036M solution of PVP*

The average particle diameter of copper nanoparticles is 4 nm

2. Gold nanoparticles prepared in solution of ethanol and H_2O

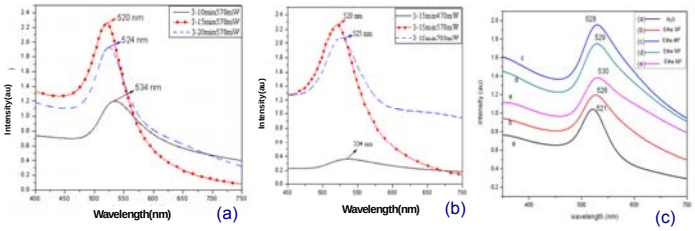

Fig.6. *a) The absorption spectra of gold nanoparticle in water with different time (10,15 and 20min) b) The absorption spectra of gold nanoparticle in water with different average laser powers (470 mW, 570mW and 700mW). c) The absorption spectra of gold nanoparticle in water (a), 30^0 ethanol (b), 40^0 ethanol (c), 50^0 ethanol (d) and 60^0 ethanol (e)*

When laser irradiation times change the absorption peak was shifted also nanoparticles of size varied (according to Mie theory) which is smallest size with the irradiation time of 15 minutes.
When increasing laser power of ablation (from 470mW to 570 mW) the resonance absorption peak of nanoparticles is short – shifted => Size of nanoparticles induced. Continuously icreasing laser power, the number of small particles produced increased lead to increase coagulation of particles => The size of particles is larger.
The nanoparticles of size increases when the concentration of alcohol increases from 0^0 (the absorption spectrum peak of samples obtained long-shifted)

Size control of gold nanoparticles using 532nm wavelength

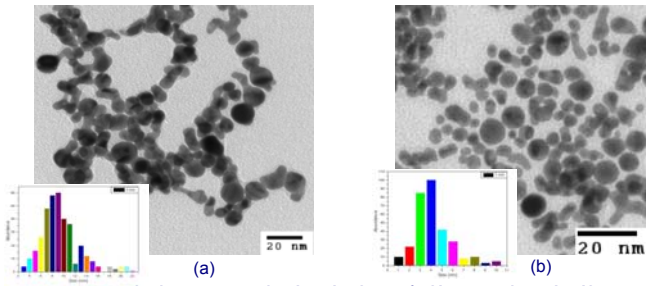

Fig.7. *The electron micrograph and size distribution of gold nanoparticles produced by laser ablation before(a) and after(b) illuminated 532nm wavelength in 60^0 ethanol. .*

TEM micrograph exhibits that the average diameter of before and after irradiation nanoparticles is 3.5nm and 9nm respectively. The samples after irradiation dispersed more evenly in solution.

3. Silver nanoparticles prepared in SCD

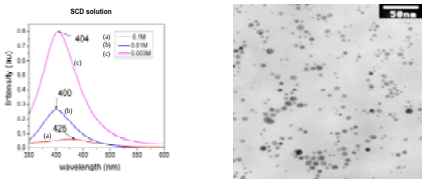

Fig.8. *Absorption spectra of silver nanoparticles in solution of SCD*

Fig.9. *TEM image (a) and size distribution (b) of silver nanopracticles produced by laser ablation in solution of SCD 0.003 M*

Silver nanoparticles were prepared by laser ablation in 0.003M solution of SCD with parameter: 532 nm wavelength, repetition rate of 10 Hz, average laser power 420 mW, laser irradiation time of 40min. The average particle diameter of silver nanoparticles is 8nm with formation rate of 20%. Prepared silver nanoparticle diameter ranges concentratively from 8nm to 10nm.

CONCLUSION

Using the Quanta Ray Pro 230 Nd: YAG laser, we prepared successfully metal nanoparticles such as gold, silver and copper particles. Metal nanoparticles were prepared in different solutions with different concentrations, average laser powers and laser irradiation times to determine suitable process of preparation of metal nanoparticles. Laser ablation in combination with the laser-induced size control provides a versatile full physical preparation method of size-selected gold nanoparticles without contamination by a reducing agent, which is inevitably used in conventional wet-chemical techniques.

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