OPTOELECTRONICS AND ADVANCED MATERIALS – RAPID COMMUNICATIONS Vol. 6, No. 11-12, Nov. – Dec. 2012, p. 1168 - 1169

Silver nanoparticles for different applications

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The photo-sensitization synthetic technique of making silver nanoparticles using BP is studied using either a laser or a mercury lamp as a light source. In the laser synthesis, as either the laser power or the irradiation time increases, the intensity of the surface plasmon resonance absorption at 400 nm is found to increase linearly first, followed by a reduction of the red edge of the plasmon resonance absorption band. The above results are discussed in terms of a mechanism in which, the excited benzophenone forms the ketal radical, which reduces Ag+ in solution and on the Ag nanoparticle surface.

(Received September 25, 2012; accepted October 30, 2012)

Keywords: Silver nanoparticles, Plasmon resonance absorption, TEM, UV-VIS spectra

1. Introduction

Noble metal nanoparticles show brilliant colors due to the surface plasmon resonance absorption. The examination of the surface plasmon resonance absorption is part of a large on going research field to investigate properties on the nanometer scale.

With the rising importance of nanoparticles, different synthetic methods are being explored to create nanoparticles in solution [1,4], polymer films [5], and glasses.

The plasmon resonance allows size and shape transitions to be monitored simply by following UV/visible absorbance. Silver nanospheres are well known to have a plasmon resonance at 400nm, with the wavelength depending on the size and shape of the nanoparticles.

The paper presents the study of physical properties of silver nanoparticles obtained by chemical method and varying the AgNp concentration [6, 7].

2. Experimental procedures

The silver nanoparticles used in this study were synthesized by chemical reduction method.

The solution used for irradiation contained benzophenone, stabilizer and metal salt. The femtosecond laser irradiation experiments used solution A1 with 3.3×10-5M benzophenone (BP) (stock solution of benzophenone is dissolved in isopropyl alcohol), 0.3M isopropyl alcohol (IPA) (total in solution), and 6.0×10-4M hexadecyltrimethylammonium bromide (CTAB) acting as the stabilizer in water [8].

The solution for mercury lamp irradiation experiments used solution A2 with 3.0×10-3M benzophenone, 0.3M isopropyl alcohol, and 1mL per 100mL solution of Ludox (Aldrich AS-30) dissolved in water. Both systems used the same solution B containing 0.0043M $AgNO_3$ in water [9]. The final solution contained 2.1mL of A and 0.9mL of B.

The sample was placed in a quartz 2mm cylindrical cuvette, and the sample was spun during irradiation. At higher laser powers a ring of silver metal was observed on the inside surface of the cuvette after irradiation, which could be removed with aqua regia.

For the obtained solutions were performed optical characterizations using an UV-VIS Perkin Elmer spectrofotometer, in the range 200-650 nm. The chemical composition was analyzed by atomic absorption spectroscopy (AAS). The particle’s size were determined and theirs distribution was analyzed.

3. Results and discussion

Initially, upon irradiation with UV laser light the solution with benzophenone and silver salt develops a faint yellow color, indicating the appearance of silver nanoparticles.

As irradiation continues, the solution continues to darken in color indicating the formation of more nanoparticles as the irradiation is continued.

Fig. 1 shows the absorbance of the silver/BP solution after various irradiation times with a UV femtosecond laser. This shows an increase in intensity of the plasmon resonance for silver spheres at 400 nm with increasing laser irradiation.

The plasmon resonance absorption red shifts with increasing size and dielectric constant around the particles.

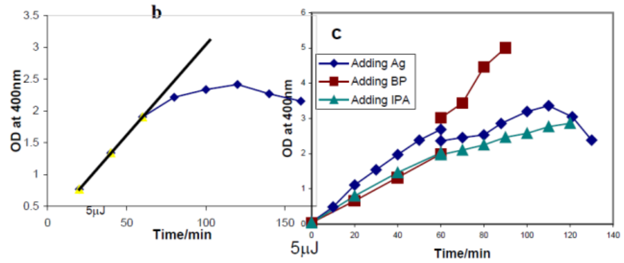

Fig. 1.(a) UV-VIS absorbance spectra of silver/benzophenone solution irradiated with 5μJ. (b) UV-VIS Absorbance of sample at 400 nm plotted as a function of the time of irradiation.

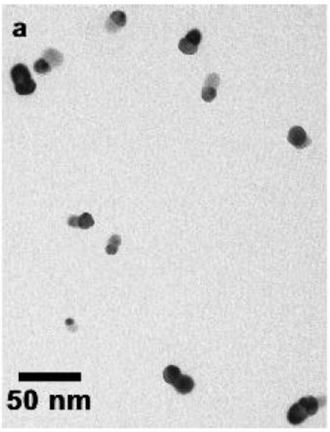

Fig. 2(a). TEM image of 0.5μJ, 60 min femtosecond aser irradiation.

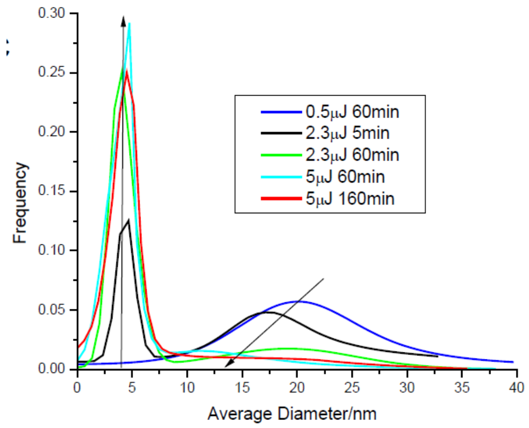

Fig. 2(b). Gaussian fits to size distribution data for samples from Fig. 2, femtosecond laser, CTAB stabilizer, at various powers. The size of the nanoparticles remains relatively constant for the smaller nanoparticles at ~5nm in diameter.

The dominating process at the time of formation determines the sizes generated. The larger nanoparticles are formed first by growth mechanisms, with the size determined by the local concentrations of benzophenone, Ag+ and the stabilizer process.

4. Conclusions

The TEM results presented here demonstrate the growth mechanism is followed by ablation for photosensitized metal nanoparticles using benzophenone. Changes are observed in the optical spectra which can be used to follow the generation of nanoparticles, but TEM is required to show the increasing importance of the ablation mechanism in the laser synthesis as the energy or time of irradiation increases.

Nanoparticle growth was observed with mercury lamp and femtosecond laser irradiation with Ludox and CTAB as stabilizers determining the size of nanoparticles generated, respectively. At longer times or high power, the benzophenone concentration decreases causing a decrease in the rate of formation of the large particles while the rate of ablation is at its maximum.

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