Proceeding of ICNM - 2009

1st International Conference on Nanostructured Materials and Nanocomposites (6 – 8 April 2009, Kottayam, India)

Published by : Applied Science Innovations Private Limited, India.
http://www.applied-science-innovations.com

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OPTICAL PROPERTIES OF LASER ABLATED SILVER NANOCOLLOID

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Abstract :

Silver nanocolloid is produced by laser ablation of a silver target in ethylene glycol (EG) medium, with Q-switched 1064 nm Nd:YAG laser radiation. In this work, we present a fast and easy production of stable silver nanocolloid with at relatively low energy at 40mJ/pulse of 1064 nm infrared wavelength and with 10 ns pulse duration at 10Hz. The crystalline nature has been determined by X-ray Diffraction (XRD) measurement. Scanning-Electron Microscopy (SEM) and Transmission-Electron Microscopy (TEM) have been used for the determination of the nanostructure of the prepared silver nanocolloid and from TEM image analysis it has been found that the average size of the prepared nanoparticles are in 10-50 nm region. Linear absorption characteristics of the prepared nanocolloid have been measured using a UV-vis spectrophotometer which shows the presence of Surface Plasmon Resonance (SPR) at 414 nm. Photoluminescence (PL) emission spectrum of the prepared nanocolloid has also been measured and PL emission in the visible region is observed.

Keywords : Laser ablation, Nanocolloid, Plasmon resonance

Introduction :

Laser ablation is a promising technique for producing nanoparticles of solid in liquids for analytical and bioanalytical application [1]. In recent years the development of electronic devices at the atomic level shows the need to develop silver nanocolloids capable of widespread implementation as interconnects in microelectronic, optical and magnetic devices. Silver nanocolloid has also been widely exploited for the use in photography, catalysis, biological labeling and information storage [2]. For analytical application and for the study of physical properties of the particles, such as size and the composition, laser ablation plays an important role as the surface of particles are free of impurities. Surface contamination during the laser ablation is greatly reduced compared to the standard

chemical synthesis method because the particles are formed directly from ablation of a pure target in a pure solvent.
Previously, T. Tsuji *et. al* studied particles size 29nm to 12nm under the incidence of laser light at a high influence of 36J/cm^2 [3]. The relation between particle size and the laser wave length is also studied by Jeon and Yeh [4]. Semerok *et. al* [5] reported the wavelength dependence of ablation efficiency of various metals in the atmospheric circumstances using laser light at 1064, 532, and 266 nm. Here we present a fast and easy production of stable silver nanocolloid with at relatively low energy at 40mJ/pulse at infrared (1064 nm) wavelength and with 10 ns pulse duration at 10Hz in EG. The nanostructures of the prepared nanoparticles have been analyzed using X-ray diffraction (XRD PANLYTICAL), Scanning electron Microscope (SEM Hitachi, S-3000N), Transmission Electron Microscope (TEM - JEOL JEM 2100), Selected Area Electron Diffraction (SAED), UV-vis spectrophotometer (Hitachi U-3010) and a Spectrofluorimeter (F-2500 FL spectrophotometer, Hitachi)

Experimental procedure :

The fundamental (1064 nm) of an Nd: YAG laser were used as an irradiating source. The laser was operated at the power 150W. The central part of the laser beam was selected with an aperture to control the spot size of nonfocused laser light. Laser was conducted onto the target through the opening of the beaker. A lens (f=10cm) was placed above the beaker when laser light was focused onto the target. To change the focusing condition of laser light, the relative position of the lens to the target was varied. Solid sliver target (99.99%) was washed with distilled water and acetone and placed in the beaker containing 10 ml EG. A yellowish colloidal solution of silver nanoparticles was obtained.

Result and discussion :

The fundamental output of Nd:YAG laser (Thunder Series, Quanta System) with wavelength of 1064 nm, 40mJ/pulse energy and with rep. rate of 10 Hz is focused onto a solid silver (99.99% pure, confirmed through EDXA analysis before laser ablation) target with a lens of 10 cm focal length for a duration of 30 min in EG. The color change of the solvent was indicative of the formation of nanocolloid.

Fig.1. shows the XRD spectra exhibited peaks at around 39^0, 44^0, and 51^0 corresponds to reflection from (111), (200), and (104) planes, respectively. First two peaks correspond to cubic and last peak corresponds to the hexagonal phases of crystalline silver. From XRD peak broadening, the size of the nanoparticles has been estimated to be around 30 nm. Synthesized samples were characterized by HRTEM as shown in Fig.2a. HRTEM observation demonstrate that the the SEM image particle in the range of 10-50 nm. Inset shows the SAED pattern of the prepared samples. Fig.2b shows of the silver nanocolloid prepared in EG.

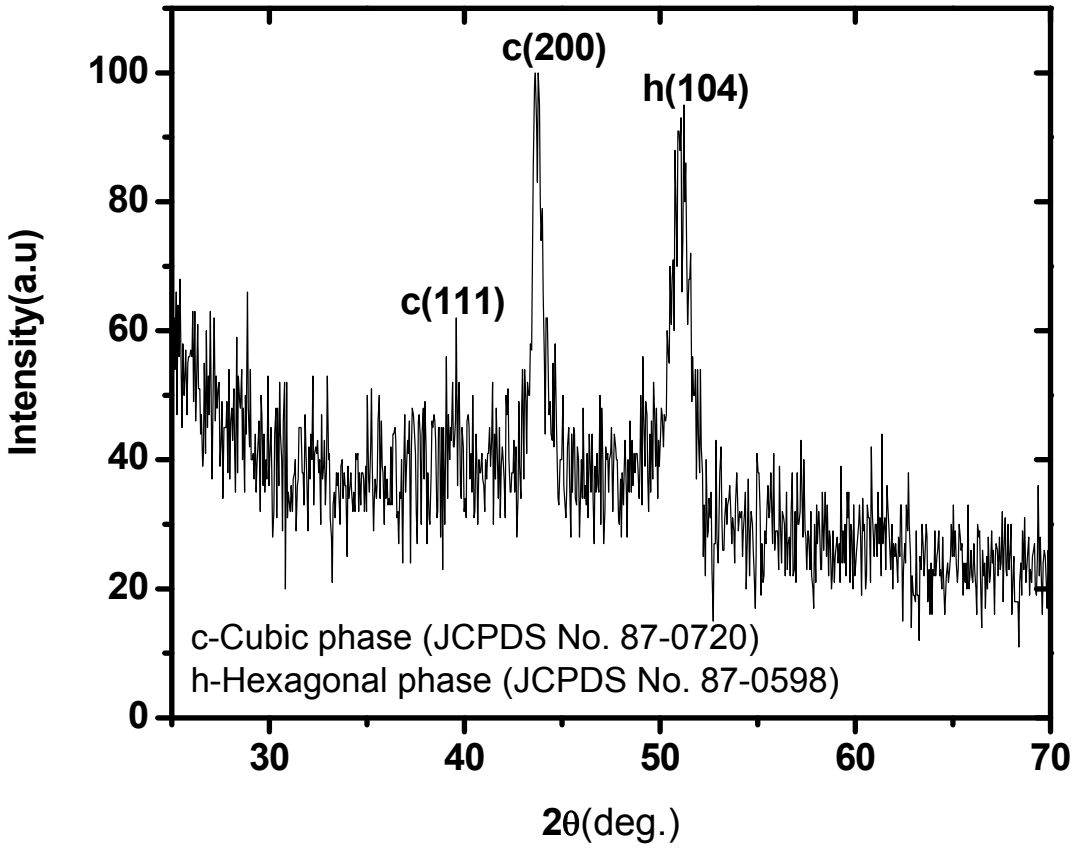

Figure (1) : XRD spectra of the silver nanoparticles prepared at 1064 nm in EG.

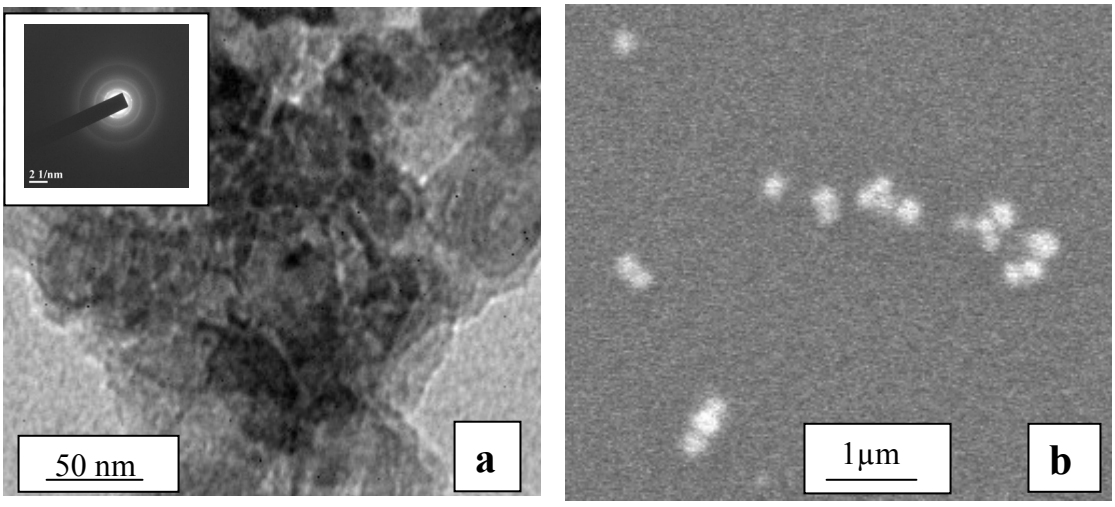

Figure (2) : (a) shows the HRTEM images of the silver nanocolloid. Inset SAED pattern. (b) Shows the TEM images of the silver nanocolloid.

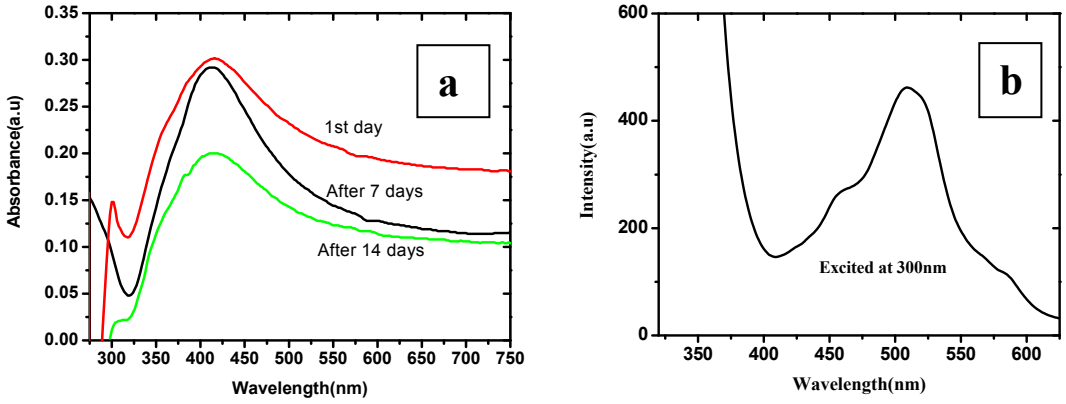

Figure (3) : (a) Optical absorption spectra variation with time and (b) shows the PL emission spectra of the samples with excitation wavelength 300 nm

Optical absorption spectra and PL emissions are recorded using a UV-vis spectrophotometer (Hitachi U-3010) and a spectrofluorimeter (F-2500 FL spectrophotometer, Hitachi) with quartz cuvette of path length 10mm. To study the variation of the absorption with time, the absorption characteristics of the freshly prepared samples along-with those after one and two weeks have been measured as shown in Fig. 3a. It is found that the nanocolloid is stable fairly well. Figure 3a shows the PL emission spectra of the samples with excitation wavelength 300 nm. The absorption spectra consist of a strong absorption due to plasmon band around 414 nm. A blue green emission with the peaks at 460 and 500 nm was observed which could be attributed to Ag+ as shown in Fig. 3b

Conclusion :

It is possible to produce the stable silver nanoparticles in a simple and easy way with at relatively low energy at 40mJ/pulse at infrared (1064 nm) using laser ablation technique with out using a capping agent. XRD data confirmed the crystalline nature of the sample. SEM, TEM data have been obtained to confirm nano size of these materials. UV-visible absorption spectrum shows the presence of surface plasmon resonance at 414 nm. Absorption characteristics of the prepared samples after two weeks have been found that the nanocolloid is stable fairly well with out using any capping agent. Photoluminescence emission in the visible region is observed with blue green emission peaks at 460 and 500 nm.

Acknowledgement :

Authors are grateful to TEQIP, faculty research grant, NIT, Durgapur, India, for the financial support.

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