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GREEN SYNTHESIS OF SILVER NANOPARTICLES AND ITS OPTICAL PROPERTIES

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Here we report for the first time, to the best of our knowledge, the synthesis of silver nanoparticles of varying sizes using *parthenium* leaf extract at a higher temperature of 100°C as well as at room temperature. The synthesized nanoparticles are characterized using Scanning electron microscope (SEM), X-ray diffractometer (XRD) and UV-visible spectrophotometer. The effect of the reaction time on the particle size has been reported. Also visible photoluminescence (PL) emissions from the synthesized silver nanoparticles have been recorded. Plant extract is very cost effective and eco friendly and thus can be economic and effective alternative for the large scale synthesis of silver nanoparticles.

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1. Introduction

Colloidal silver nanoparticles are widely used for its unique properties in catalysis [1], chemical sensing [2], biosensing [3], photonics [4], electronics [5], and pharmaceuticals [6]. The diversity and importance of these applications has generated a great deal of interest in developing versatile methods to synthesize silver nanoparticles with well defined and controlled properties. Several approaches used to date includes reduction in solutions; chemical and photochemical reaction in reverse micelles; thermal decomposition of silver compounds; radiation assisted, electrochemical; and recently, biosynthesis using living plant system [1-15]. Some well known examples of biosynthesis of metal nanoparticles are gold nano-triangles using Lemmon grass [7] and tamarind leaf extract [8]. Synthesis of silver nanoparticles using geranium leaf [9], fungus [10], synthesis of bimetallic Au core-Ag shell nanoparticles using Neem (*Azadirachta Indica*) leaf broth [11] of well defined composition and shape had been reported. Recently synthesis of silver nanoparticles at room temperature from the extract of *parthenium hysterophorous* L leaves has been reported [13] but not studied in detailed the photoluminescence property as well as the variation of particle size with the reaction temperature and time of reaction.

However, here we report the synthesis of silver nanoparticles using *parthenium* leaf extract in the aqueous solution by introducing solution of silver nitrate and the morphological characterizations are performed using scanning electron microscope (SEM) and X-ray diffractometer (XRD). The optical absorption properties are measured using UV-visible spectrophotometer and observed the absorption peaks in 450-462 nm regions, which are close to the characteristics surface plasmon resonance (SPR) wavelength of metallic silver. In addition, the effect of the reaction time on the particle size has been studied; also the photoluminescence (PL) spectra from the synthesized silver nanoparticles have been recorded.

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2. Experimental details

2.1 Preparation of the parthenium leaf extract

Parthenium leaf extract have been prepared by bringing the fresh leaves of *parthenium hysterophorous* L from our Institute campus to the Nanoscience Laboratory. Green leaves weighing 15 gm are at first thoroughly washed several times in distilled water, cut into fine pieces and then boiled in a 500ml beaker with 150ml of distilled water up to 10 min and then filtered to separate out the broth.

2.2 Synthesis of Silver nanoparticles

Aqueous solution of silver nitrate ($AgNO_3$, Merck, India) of 0.5mM is prepared in a 250 ml beaker and the solution is added to the leaf extract solution at room temperature as well as at the temperature of 100^0C. The color change in the colloidal solutions occurred indicating the formation of silver nanoparticles. Then three sets of sample are collected, one at room temperature and other two samples after 2, and 6 minutes of reduction time at 100°C temperature. Three samples; synthesized at room temperature, synthesized after 2 minutes of reaction at 100°C temperature, and synthesized after 6 minutes of reaction at 100°C temperature will henceforth be called as S1, S2, and S3, unless otherwise specified.

2.3 Scanning Electron Microscope analysis of silver nanoparticles

For the analysis of the nanostructures of the samples, thin films are prepared in glass slides and then observed in Scanning Electron Microscopic (SEM, Hitachi, S-3000N). Thin films of the sample are prepared by using spin coater (Delta spin) and the films are dried by putting it under the IR lamp (Philips) for 5 min.

2.4 UV-Visible spectra analysis

UV-Visible spectral analysis has been done by using a double-beam spectrophotometer (Hitachi, U-3010) and the samples are dispersed in distilled water and kept in quartz cuvette of path length 10mm.

2.5 Photoluminescence (PL) spectra analysis

The photoluminescence (PL) emissions spectra of from the samples are recorded by a spectrofluorimeter (LS 55, Perkin Elmer) at room temperature using a four side polished quartz cuvette of path length 10 mm. For PL measurement also samples are dispersed in distilled water.

3. Results and discussions

The SEM images of the three samples are shown in Figs. 1-3 and XRD pattern is shown

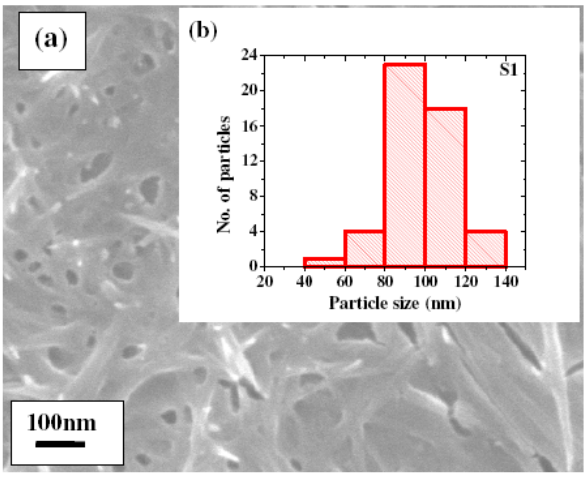

Fig. 1. Scanning Electron Microscope (SEM) image of the sample S1 is shown in (a) and the corresponding particle size distribution is shown in (b).

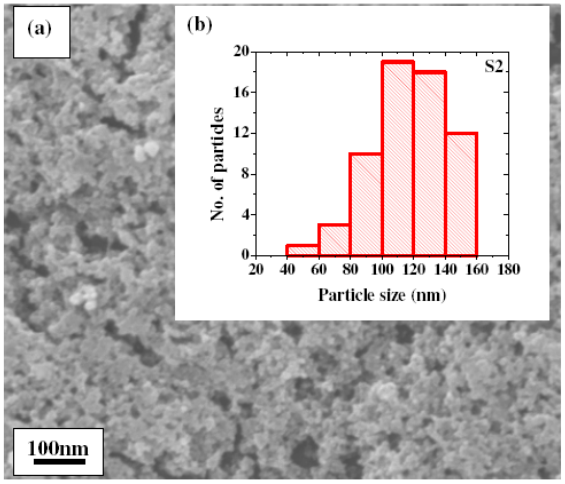

Fig. 2. Scanning Electron Microscope (SEM) image of the sample S2 is shown in (a) and the corresponding particle size distribution is shown in (b).

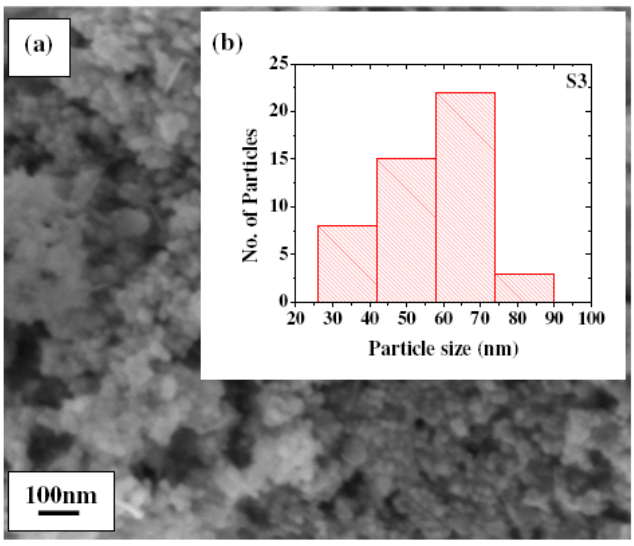

Fig. 3. Scanning Electron Microscope (SEM) image of the sample S3 is shown in (a) and the corresponding particle size distribution is shown in (b).

in Fig. 4. From Figs. 1a and 1b it is clearly seen that in the room temperature synthesized S1 sample, the size (diameter) of the nanoparticles lie within 40-140 nm region and the average size of the nanoparticles is ~ 90 nm. Figures 2a and 2b shows that the size of the silver nanoparticles synthesized after 2 minutes of chemical reaction at a higher temperature of 100°C lie within 40-160 nm and the average size of the nanoparticles is ~ 110 nm. Whereas the size of the nanoparticles synthesized after 6 minutes of chemical reaction at 100°C lie within 25-90 nm and the average size of the nanoparticles is ~ 60 nm which is smaller than that of S1 and S2 samples.

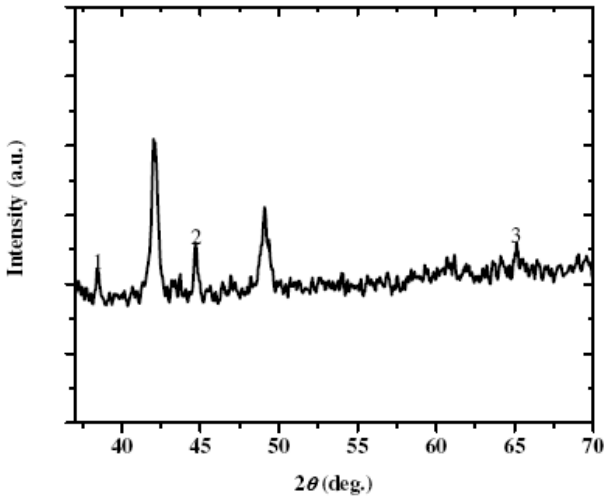

Fig. 4. Typical X-ray diffraction (XRD) pattern of the as-prepared silver nanoparticles, viz. for S2 sample. XRD peaks 1, 2, and 3 appear at 38.1°, 44.6°, and 64.8° due to reflections from (111), (200), and (220) planes of silver (JCPDF: 03-0931), respectively.

Structural characterization has also been performed using XRD analysis and the typical XRD pattern for, S2 sample; viz. is shown in Fig. 4. From the Fig. 4 it is seen that three XRD peaks 1, 2, and 3 appear at 38.1°, 44.6°, and 64.8° due to reflections from (111), (200), and (220) planes of silver (JCPDF:03-0931), respectively. In addition to these three peaks there are two unidentified peaks appeared in the XRD pattern.

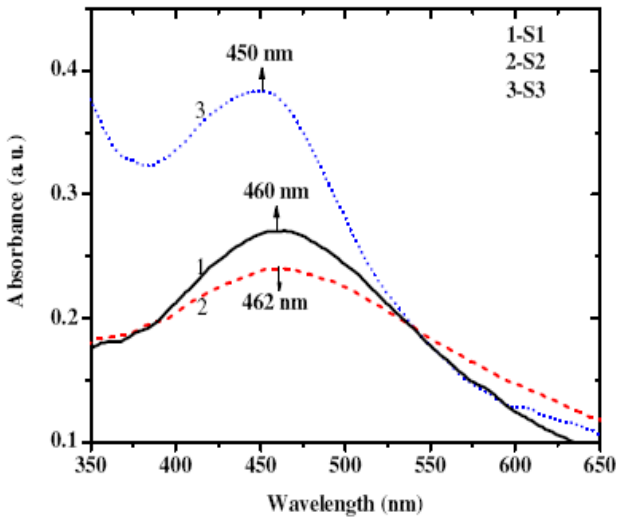

Fig. 5. UV-Visible absorption spectra of the aqueous solutions of all the samples, measured at room temperature. Curves marked as 1, 2, and 3 correspond to S1, S2, and S3 samples, respectively.

Silver nanostructure exhibits interesting optical properties directly related to surface plasmon resonance (SPR), which is highly dependent on the morphology of the samples. UV-visible absorption spectrophotometer is the commonly used to investigate the SPR. We have measured UV-visible absorption characteristics of all the synthesized samples and those are shown in Fig. 5. From Fig. 5 it is seen that the UV-visible absorption peaks appeared for S1, S2, and S3 samples, respectively at 460, 462, and 450 nm, which are close to the usual SPR wavelength of silver. The red-shift of UV-visible absorption peak in S2 sample, confirms the increase in particle size in the high temperature synthesized sample after 2 minutes of reaction. On the other-hand the blue shift of UV-visible absorption peak in S3 sample confirms the decrease in particle size in the high temperature synthesized sample after 6 minutes of reaction. Thus UV-visible absorption analysis provides the same results as found in SEM studies.

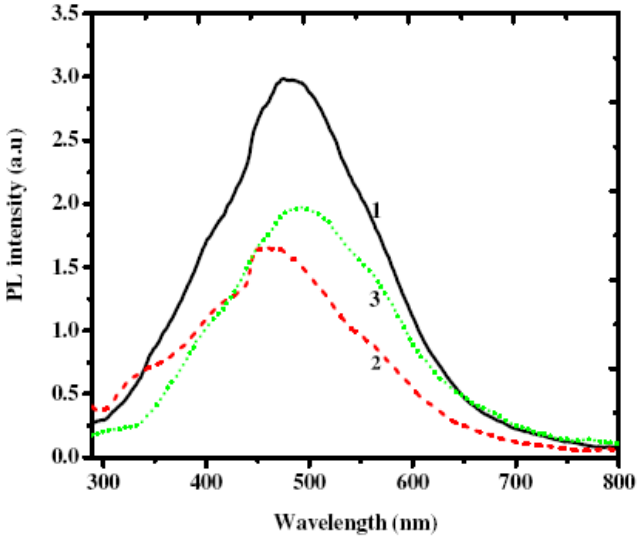

Fig. 6. Photoluminescence emission spectra of the aqueous solutions of all the samples, measured at room temperature. Curves marked as 1, 2, and 3 correspond to S1, S2, and S3 samples, respectively.

The synthesized colloidal silver nanoparticles are found to be photoluminescent. Photoluminescence (PL) spectra obtained from the synthesized silver nanoparticles at room temperature are shown in Fig. 6. From Fig. 6 it is seen that PL peaks appeared in S1, S2 and S3 samples are at 480, 462, and 490 nm, respectively. In the S2 sample, PL emission peak and UV-visible peak appeared at the same wavelength. For the S1 and S3 samples, PL emission peaks are red shifted by ~ 20 nm and 40 nm, respectively from their corresponding UV-visible peaks. The visible luminescence from silver nanoparticles had been reported earlier and attributed to the excitation of electrons from occupied d bands into states above the Fermi level [12, 16].

4. Conclusions

Here we have reported for the first time, the synthesis of silver nanoparticles of varying sizes using *parthenium* leaf extract in the aqueous solution at a higher temperature of 100°C as well as at room temperature. The variation of particle size with the reaction temperature and reaction time has been reported. The structural characterizations of the samples are performed using SEM and XRD analysis. The UV-visible optical absorption properties are measured and found the shift of SPR wavelengths with the average particle size of the synthesized samples. In addition visible photoluminescence emissions are observed from the synthesized silver

nanoparticles. This green chemistry approach towards the synthesis of silver nanoparticles has many advantages. Plant extract is being eco friendly and very cost effective; the presented method can be economic and effective alternative for the large scale synthesis of silver nanoparticles in nanotechnology processing industries.

Acknowledgement

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References

[1] N. R. Jana, T. K. Sau, T. Pal, J. Phys. Chem. B. **103,** 115 (1999).
[2] F. Frederix *et al.* Anal.Chem. **75**, 6894 (2003).
[3] W. Songping, Shuyuan, Mat. Chem. Phys. **89**, 423 (2005).
[4] K.P. Velicov, G.E. Zegers, A. VonBlaaderen, Langmuir **19**, 1384 (2003).
[5] U. Kreibig, J. Phys. F: Met. Phys. **4**, 999 (1974).
[6] P. Galletto, P. F. Brevet, H. H. Girault, R. Antoine, M. Broyer, J. Phys. Chem. B. **103,** 8706 (1999).
[7] S. S. Shankar, A. Rai, B. Ankamwar, A. Singh, A. Ahmed, S. Murli, Nature Materials. **3,** 482 (2004).
[8] B. Ankamwar, M. Chaudhary, M. Sastry, Metal- Organic and Nano-Metal Chem. **35,** 19 (2005).
[9] S. S. Shankar, A. Ahmad, M. Sastry, Biotechnol. Prog. **19**, 1627 (2003).
[10] P. Mukherjee *et al.* Nano Lett. **1,** 515 (2001).
[11] S. S. Shankar, A. Rai, A. Ahmad, M. Sastry, Journal of Colloid and Inter. Science. **275**, 496 (2004).
[12] M. Fayaza, C.S. Tiwary, P.T. Kalaichelvan, R. Venkatesan, Colloids and Surfaces B: Biointerfaces **75**, 175 (2010).
[13] V. Parasar, R. Parasar, B. Sharma, A. C. Pandey, Digest J. Nanomat. and Biostruct. **4**, 45 (2009).
[15] R. Sarkar, P. Kumbhakar, A. K. Mitra, Current Appl. Phys. **10**, 853 (2010).
[16] S. L. Smitha, K. M. Nissamudeen, Daizy Philip, K.G. Gopchandran, Spectrochimica Acta Part A **71**, 186 (2008).