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RESEARCH ARTICLE

Green synthesis of silver nanoparticles and their structural and optical properties

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ABSTRACT

Green synthesis of silver nanoparticles (AgNPs) by *Coccinia indica* leaf extract was extent the biogenic synthesis of metal nanomaterials offers an environmentally benign alternative to the conventional chemical synthesis. Upon contact, rapid reduction of Ag+ ions was observed in <1 min with Ag nanoparticle formation reaching 90% completion in <20 min. Effect of leaves extract concentration on the particle size and shape were investigated from UV–vis spectrum, X-ray Diffraction (XRD), and Energy Dispersive X-ray (EDX). The biosynthesis of silver nanoparticles is in the size range of 10-20 nm and is crystallized in face centred cubic symmetry. The possible biochemical mechanism leading to the formation of silver nanoparticles was studied using FT-IR. The synthesized silver nanoparticles may be extremely useful in making biosensor devices as well as for other applications.

INTRODUCTION

The biological synthesis of nanoparticles (NPs) has the remarkable application then the chemical and physical methods derived nanoparticles. There is a required the development in NPs synthesis processes by environmental friendly methods that do not have the toxic chemicals in the synthesis protocol (Ahmad *et al.,* 2003; Song and Kim 2009). In addition, synthesis of silver nanoparticles using chemical methods could still lead to the presence of some toxic chemicals being adsorbed onto the surface of nanoparticles. The chemicals used for these syntheses are often toxic, costly and non-ecofriendly. Nowadays bioreduction methods based on fungi, microorganisms, plant extracts are being attempted due to the ease of synthesis, environmentally benign nature and greater stability of nanoparticles (Pugazhenthiran *et al.,* 2008; Fayaz *et al.*, 2009; Xie *et al.,* 2007). Generally, plant extracts, like Magnolia kobus, Diopyros kaki, Ficus benghalensis and Citrus limon extracts, have ability to produce nanoparticles with high stability (6-8) because the plants materials have the reducing agents and phytoconstituents such as alkaloids, polyphenols and flavonoids. Among the noble metals, silver nanoparticles (AgNPs) have become the focus of intensive research, because of low cost of production and emerging applications. AgNPs biosynthesized by leaf extract of *Coccinia indica*, AgNPs was characterized by visible observation, UV-Vis Spectrophotometer, FT-IR, XRD and EDX measurements.

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EXPERIMENTAL

Silver nitrate and methylene blue were purchased from Sigma-Aldrich Chemicals. All glassware's were sterilized with HNO_3 and distilled water and dried in oven. *Coccinia indica* leaves were collected from Chidambaram rural area, Cuddalore, Tamilnadu, India.

Preparation of leaf extract

Fresh plant leaves were washed several times with running tap water, followed by distilled water. 20g of leaves was boiled for 15 minutes in 100 ml Milli-Q water. The extracts were filtered through Whatman filter paper No. 1. the final volume of the filtrate was stored in refrigerator at 4° C. This extracts were used as reducing and stabilizing agent for the nanoparticles synthesis.

Synthesis of Silver nanoparticles

30 ml of 0.01 M aqueous solution of silver nitrate was taken in Erlenmeyer flask; and 2.0, 2.5, 3.0 and 3.5ml of *Coccinia indica* leaf extract was added and incubated for 30 min at room temperature. The solution turned yellow to yellow-red dark brown indicating the formation of silver nanoparticles.

Characterization of silver nanoparticles

The UV–vis spectroscopy measurements were recorded on a JASCO dual beam spectrophotometer (Model SHIMADZU UV -1650) operated at a resolution of 2 nm. Photoluminescence (PL) spectra were recorded using Perkin Elmer LS 55 fluorescence spectrometer. Fourier Transform Infrared Spectrometer spectra were recorded under identical conditions in the 4000-400 cm^{-1} region using Fourier Transform Infrared Spectrometer (spectrum RX-I, FT-IR system, Perkineliner Model). The phytoreduced silver colloidal solution was drop-coated onto a glass substrate; and the XRD measurements were carried out using a powder diffractometer (PANalytical X'per PRO model X- Ray diffractometer), on the instrument operating at a voltage of 50 kV and a current of 30 mA.

RESULT AND DISCUSSIONS

UV–vis analysis

UV–vis absorbance spectroscopy is a very useful technique for metal nanoparticle study. The peak positions and shapes are sensitive to particle size. Fig. 1 shows the UV–vis absorption spectra of the Ag nanoparticles with different concentration of leaf extract addition amount of 2.0, 2.5, 3.0 and 3.5 ml. Upon the addition of aqueous extract of *Coccinia indica* to the silver nitrate solution, the solution turned to yellowish brown. This indicated the formation of AgNPs (Mukherjee *et al.,* 2001). The SPR band became narrower at higher concentration of the extract. The broad SPR at lower concentrations of the extract is due to the formation of large particles. It is found that SPR wavelength 436 to 420 nm has a small shift to shorter wavelength and consequently FWHM decreases showing decrease in particle size.

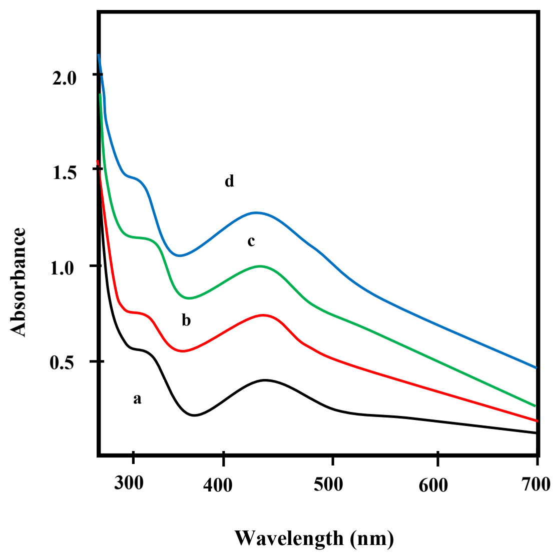

Fig.1. UV-vis spectrum of Ag nanoparticles synthesised by *C. indica* leaf extract under different concentrations of extracts (a) 2.0 ml, (b) 2.5 ml, (c) 3.0 ml, (d) 3.5 ml

The blue shift of maximum absorption wavelength indicates that the size of silver nanoparticles decreases with increased concentration of *Coccinia indica* (Mervat *et al.,* 2012).

PL analysis

The photoluminescence spectrum of synthesized silver nanoparticles was shown in Fig. 2. The obtained PL emission within the visible range, from 400 to 600 nm, with peak positions at 600, 520 and 424 nm for a, b, c, d samples respectively. The PL emission peaks was found to be gradually decreased in higher concentration of leaf extract 3.5 ml (Fig. 2), while the intensity increases sharply with decrease of particle size. In the other words this emission behaviour supports the involvement of *Coccinia indica* extract in stabilizing the silver nanoparticles. Subsequent relaxation by the electron-phonon scattering process leads to an energy loss and, finally, the photoluminescent radiative recombination of an electron from an occupied sp band with the hole takes place.

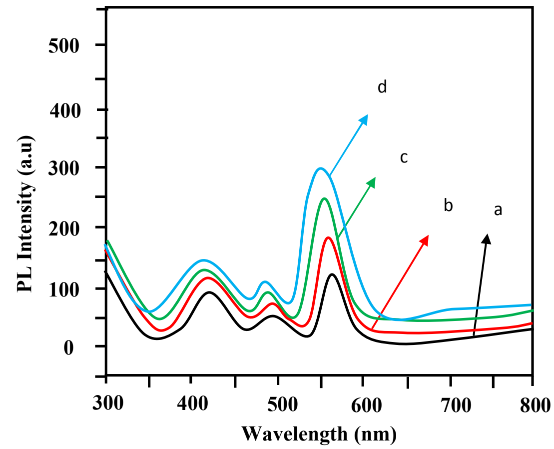

Fig.2. PL spectrum of Ag nanoparticles synthesised by *C. indica* leaf extract under different concentrations (a) 2.0 ml, (b) 2.5 ml, (c) 3.0 ml, (d) 3.5 ml

The optical properties of silver nanoparticles depend on both interband and intraband transitions between electronic states. The PL emission displayed here are consistent with earlier reports (Ramakrishna Vasireddy *et al.,* 2012; Sarkar *et al.,* 2010; Bar *et al.,* 2009).

XRD analysis

A XRD profile of biosynthesized silver nanoparticles was shown in Fig.3. The diffraction peaks at 38.26°, 44.38°, 64.72° and 77.50° (assigned to the (111), (200), (220) and (311) planes of a faced centre cubic (fcc) lattice of silver) were obtained. The XRD pattern was consistent with earlier reports (Bar *et al.,* 2009; Satishkumar *et al.,* 2009). The mean particle diameter of silver nanoparticles was calculated from the XRD pattern according to the line width of the plane, refraction peak using the following Scherrer formula,

$$D=K\lambda/\beta \cos\theta$$

Where D is the size of the particles, K is the shape dependent Scherrer's constant, γ is the wavelength of radiation and βs is the full peak width and θ is the diffraction angle. For natural plant extract synthesized silver nanoparticles the calculated average particle size of the silver was found to be 10-20 nm. It can be seen that the size of the Ag nanoparticles could be manipulated by controlling the amount of the *Coccinia indica* extract used in such way that as more extract was used, the smaller nanoparticles were obtained. The slight shift in the peak positions indicated the presence of strain in the crystal structure which is a characteristic of nanocrystallites

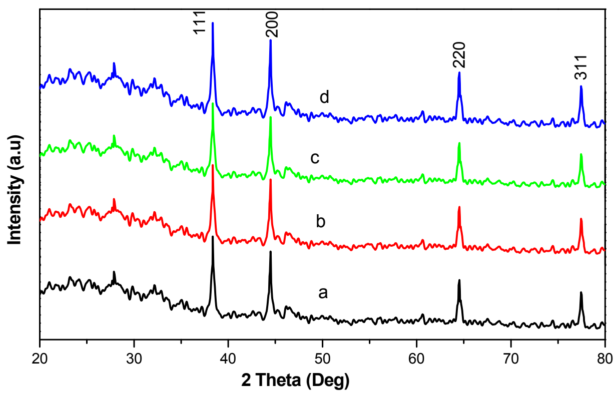

Fig.3. XRD spectrum of Ag nanoparticles synthesised by *C. indica* leaf extract under different concentrations (a) 2.0 ml, (b) 2.5 ml, (c) 3.0 ml, (d) 3.5 ml

FT-IR analysis

FTIR measurements were carried out to identify the potential biomolecules *Coccinia indica l*eaf to responsible for reduction and capping of the bio silver nanoparticles. The IR bands Fig.4 observed the band at 3388 cm^{-1} corresponding to O-H stretching of high concentration of alcohols or phenols. The band at 2854 cm^{-1} assigned to aldehydic C-H stretching this suggest the presence of saturated molecules secondary metabolites, proteins and lipids are present in the plant leaves (Mano Priya *et al.,* 2011). The bands at 1650cm^{-1} are characteristic of amide I band amide II (Caruso *et al.,* 1998). The peak at 1047 cm^{-1} corresponds to C-N stretching vibration of the amine. The band positions from 765 to 895 cm^{-1} are due to C-C and C-H phenyl ring substitution as expected for this plant. These compounds may be responsible for production of Ag NPs from leaves of *Coccinia indica* leaf extract.

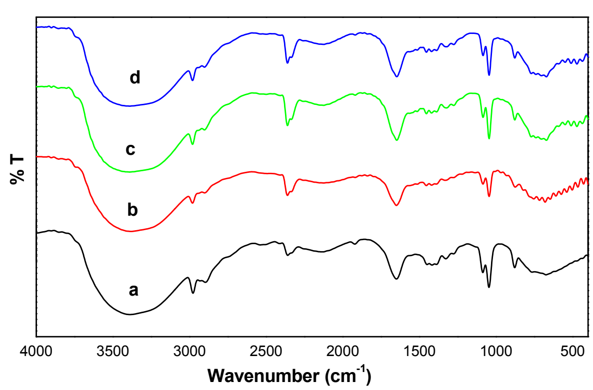

Fig.4. FT-IR spectrum of Ag nanoparticles synthesised by *C. indica* leaf extract under different concentrations (a) 2.0 ml, (b) 2.5 ml, (c) 3.0 ml, (d) 3.5 ml

Conclusion

We succeeded in the biological reduction of silver nanoparticles by *Coccinia indica* leaf extract. The amount of plant material was found to play a critical role in the size disparity of NPs. The synthesized aqueous solution of Ag nnoparticles were found to be stable in room temperature for more than a month due to the presence of natural products, such as flavanones, terpenoids, proteins and reducing sugars. The synthesized silver nanoparticles may be extremely useful in making biosensor devices as well as for other applications. These silver nanoparticles were of high purity, making them potentially useful for biological applications.

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