International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 7; Issue 2(C); March 2018; Page No. 10623-10625
DOI: http://dx.doi.org/10.24327/ijcar.2018.10625.1807

Research Article

BIO-MEDIATED GREEN SYNTHESIS OF SILVER NANOPARTICLES AND THEIR CATALYTIC ACTIVITY

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A R T I C L E I N F O

Article History:

Received 6th December, 2017
Received in revised form 21st January, 2018 Accepted 05th February, 2018
Published online 28th March, 2018

Key words:

Green synthesis, Coriander sativum leaf extract, Silver nanoparticles

A B S T R A C T

The present study was to investigate the catalytic activity of synthesized silver nanoparticles (AgNPs) using aqueous leaf extract of Coriander sativumthe aqueous leaf extracts. Appearance, crystalline nature, size and shape of nanoparticles are recorded from UV–vis (UV–vis spectroscopy), FTIR (Fourier transform infrared spectroscopy), XRD (X-ray diffraction), SEM (scanning electron microscopy) and TEM (transmission electron microscopy) techniques.

INTRODUCTION

Metal and semiconductor nanoparticles are of significance due to their size-dependent material properties and the potential applications in various promising areas of nanoscience and technology. In recent years, metal-semiconductor composite nanostructures have become an attractive topic because of their potential applications in various fields, such as charge-transfer process [1], optoelectronics [2], catalysis [3], and medicine [4]. Particularly, silver (Ag) nanoparticles are outstanding with their exclusive size and shape-dependent optical, electrical, thermal, catalytic and electromagnetic properties of these nanomaterials [5-7]. The most common method employed for the synthesis of metal nanoparticles involves the reduction of metal ions in solution, usually in the presence of a stabilizing material known as a capping agent [8]. Typically, strong reducing agents such as sodium borohydride or hydrazine are employed. For example, we synthesized silver nanoparticles using plant leaves as the agent with as a stabilizer. However, because of its extremely reactive properties, borohydride or hydrazine poses enormous dangers to the environment and human health and may pollute the final products that sometime, may not be suitable for biological applications. To overcome these problems, an alternative approach plant-mediated green synthesis of Ag nanoparticles has been found to be efficient, cost-effective, and environmental friendly [9]. exploits biological methods of synthesis and utilizes microorganisms or plant extracts. Hence researchers were moved to incorporate "green chemistry" approaches for designing environmentally benign materials. Among the green sources, plants appear to be the best candidates for large-scale production of nanoparticles with various shapes and sizes. The green synthesis and classification of highly developed metal nanomaterials by using natural plants, seeds, flowers, and leaves (Azadirachta indica [10], Ocimum sanctum [11], Mentha [12], Jatropha curcas [13], Tanacetum vulgare [14], Klebsiella pneumoniae [15], and lemongrass [16] have been successfully used as reducing and capping agents for the green synthesis of metal nanoparticles. The biomolecules present in plants can be used to reduce and stabilize metal ions in metal nanoparticles in a single-step green synthesis process. Here we report the green synthesis of AgNPs by using an aqueous extract of Coriander sativum as reducing and capping agent without adding surfactants and polymers. Coriander sativum (C.sativum) is most important oil-bearing species as well as medicinal plants. Belong to the family umbelliferae /apiaceae. It is an extremely reputed ayurvedic medicinal plant commonly known as "Dhanya" in India. The various part of this plant, such as seeds, leaves; flower and fruit possess antioxidant activity, anti-diuretic activity, anti-mutagenic, antimicrobial activity, anthelemintic activity [17-19]. Coriander sativumcontains cardiac glycosides, terpenoids, steroids, saponin, tannin, flavonoids, and alkaloids. These biomolecules may be used to reduce and stabilize metal ions in metal nanoparticles. The synthesized AgNPs were characterized by UV-vis spectroscopy, XRD, FTIR, and TEM.

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MATERIALS AND METHODS

Biosynthesis of Silver Nanoparticles

Fresh matured leaves of medicine plant Coriander sativum, free from diseases were collected from Chidambaram region, Tamilnadu, India. The leaves were washed separately using tap water were washed 2–3 times with de-ionized water. 30 g of fresh leaves was finely sliced and added to 100mL of distilled water and stirred at 50 °C for 2 h. After boiling, the mixture was allowed to cool and filtered with Whatman paper number 1. Filtrate was collected and stored approximately at 5 ˚C in the refrigerator for further use. 0.2M of aqueous solution of silver nitrate ($AgNO_3$) was prepared and used for the synthesis of silver nanoparticles. 10m L of leaf extract of Solanumnigrum was added to 90mL of 0.2M $AgNO_3$ solution for bioreduction process at room temperature.

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,T-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 (PANalyticalX'per PRO model X-Ray diffractometer), on the instrument operating at a voltage of 50 kV and a current of 30 mA. Morphological characterization of the samples was carried out using FE-SEM (JEOL JSM 6701-F). A pinch of dried sample was coated on a carbon tape. It was again coated with gold in an auto fine coater and then the material was subjected to analysis. The films on the grids were allowed to dry prior to TEM measurement in a TECHNAI10-Philphs instrument.

RESULT AND DISCUSSION

XRD Studies

The XRD technique was used to find out and confirm the crystal structure of the AgNPs. Fig. 1 shows the synthesized silver nanoparticles were highly crystalline with diffraction peaks corresponding to the face-centered cubic (fcc) phase of metallic silver. The five diffraction peaks present in the spectra at 2θ values of 38.35, 44.49, 64.68, 77.58, and 81.66were indexed to the (111), (200), (220), (311), and (222) reflections of the fcc structure of metallic silver.

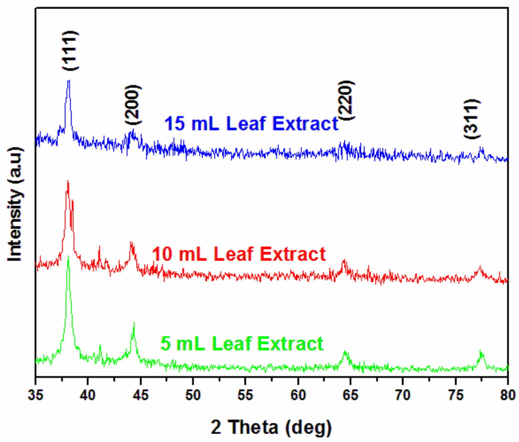

Figure 1 XRD Spectra of synthesized silver nanoparticles using Coriander sativum leaf extract

The obtained data was matched to the database of the Joint Committee on Powder Diffraction Standards (JCPDS) file No. 04-0783. Moreover, two small insignificant impurity peaks were observed at 60° and 70° which may be attributed to other organic substances in the culture supernatant. The mean size of the silver nanoparticles determined using Scherr's formula,

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

Where, D - the crystal size, λ - the wavelength of the X-ray radiation (λ=0.15406 nm) for CuKα, K - usually taken as 0.89, β- the line width at half-maximum height. The Scherrer formula was used to calculate the particle sizes and was found to be in the range of 60-70 nm. This result is in good agreement with a previous result [20].

UV–visible Studies

UV–visible spectroscopy is a suitable instrument for measuring the reduction of metal ions based on optical properties. A variation in the biological material and metal salt concentration is known to influence NP synthesis [21]. Fig. 2 shows the UV–vis spectra of the silver nanoparticles obtained with Coriander sativumof leaf extract. Here the AgNPs is rapidly formed after the addition of Coriander sativum. The color of the solutions changed from yellow to yellowish brown to dark brown clearly indicates the fabrication of silver nanoparticles. The intensity of the color increased with increasing Coriander sativum extract quantity due to excitation of surface plasmon vibrations in the metal nanoparticles [22]. Surface plasmon spectra were obtained for brown–yellow silver solutions in the range of 300–1000 nm.It can be seen that the surface plasmon resonance (SPR) of AgNPs is 448 nm.

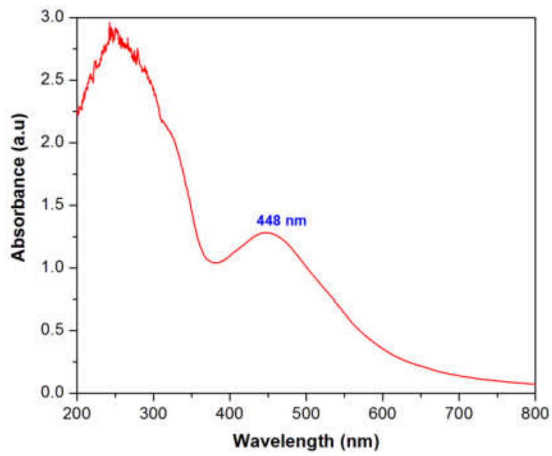

Figure.2 UV-Vis spectrum of synthesized silver nanoparticles using Coriander sativum leaf extract

FTIR studies

FTIR spectrum was carried out to distinguish the presence of possible biomolecules in Coriander sativum leaf responsible for the reduction of silver ions as shown in Fig. 3. In the case of nanoparticles, the broad absorbance peak at 3395 cm1 involving the binding of silver ions with hydroxyl groups of the extract [23]. The peak at 2930 cm-1 corresponds to asymmetric stretching of C–H bonds. The band at 1384 cm-1 corresponds to C–N stretching vibrations of aromatic amines [24]. The bands in the 1500–1200cm−1 regions arise mainly from the C–H bending vibrations of –CH3, –CH2 and –CH functional groups [25]. The adsorption on the surface of metal nanoparticles is a characteristic of flavanones and terpenoids, which may be able possibly by interaction through carbonyl groups in the absence of other strong ligating agents in sufficient concentration [26].

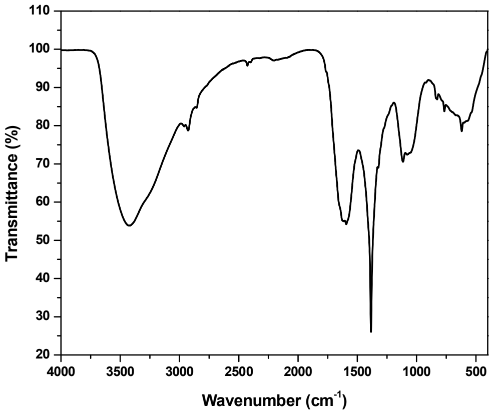

Figure 3 FTIR spectrum of synthesized silver nanoparticles using Coriander sativum leaf extract

The result indicates that the hydroxyl (-OH) and Amine (C-N) groups of leaf extracts are mainly involved in the fabrication of silver nanoparticles. This evidence suggests that the biomolecules may perform the role for the development and stabilization of the silver nanoparticles in an aqueous medium.

TEM Studies

The size, shape, and morphologies of the silver nanoparticles were determined by transmission electron microscopy. Figure (4a-c) shows the TEM image of bio-synthesized silver nanoparticles.

These nanoparticles are polydisperse, aggregated, and the average particle size obtained from these micrographs was about 60-70 nm. The selected-area electron diffraction (SAED) patterns depicted in Figures 4d exhibit concentric rings with irregular bright dots, indicating that these nanoparticles are highly crystalline in nature. These rings can be attributed to the diffraction from the (111), (200), (220), and (311) planes of face-centered cubic (fcc) silver. The crystallinity of the synthesized nanoparticles was also supported XRD results.

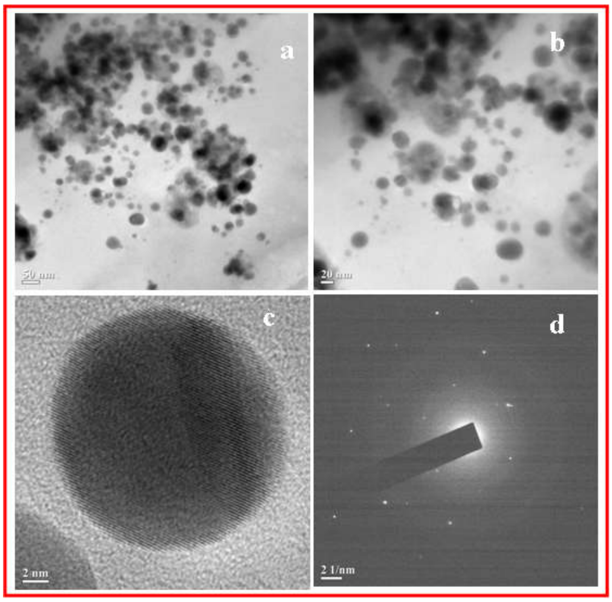

Figure 4 TEM images of synthesized silver nanoparticles using Coriander sativum leaf extract at different magnifications

Further, the analysis of the silver nanoparticles by energy dispersive X-ray (EDX), fig. 5 shows the presence of the signal of elemental silver was confirmed in the metallic silver. The silver nanocrystallites display an optical absorption band peaking at 3 keV, which is typical of the absorption of metallic silver nanocrystallites [27].

CONCLUSIONS

In conclusion, the biosyntheses of silver nanoparticles by Coriander sativum leaf were demonstrated. These nanoparticles were prepared at ambient conditions with Coriander sativum polyphenols acting as both the reducing and stabilizing agents. The nanoparticles were characterized by UV–vis, XRD, TEM, and TEM. TEM images showed that the synthesized AgNPs are mainly in indistinct spherical shape with an average size around 50 nm.

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