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GREEN SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES USING *CORIANDRUM SATIVUM* LEAF EXTRACT

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Abstract

Development of biologically inspired experimental processes for the synthesis of nanoparticles is evolving into an important branch of nanotechnology. To meet the increasing demands for commercial nanoparticles new eco-friendly "green" methods of synthesis are being discovered. In this study, synthesis of stable silver nanoparticles (AgNPs) was done using *Coriandrum sativum* leaf extract. UV-Vis spectrometer uses to monitor the reduction of Ag ions and formation of AgNPs in medium. XRD and SEM have been used to investigate the morphology of prepared AgNPs. The peaks in XRD pattern are associated with that of face-centered-cubic (FCC) form of metallic silver. The average grain size of silver nanoparticles is found to be 6.45 nm. TGA/DTA result associated with weight loss and exothermic reaction due to desorption of chemisorbed water. FTIR was performed to identify the functional groups of carbonyl, hydroxyl, amine and protein molecule which form a layer covering AgNPs and stabilize the AgNPs in medium.

Keywords: Silver nanoparticles, Coriandrum sativum, Face-centered-cubic structure, Thermal analysis.

1. Introduction

Research based on advanced nanomaterials of noble metals like silver has conquered a lot of interest among scientists during the past decades for its physiochemical properties such as size, distribution and morphology, they have been studied for catalytic activity, optical properties, electronic properties, antibacterial properties and magnetic properties [1-5] and its application in various

Abbreviations

AgNPs	Silver nanoparticles
DTA	Differential thermal analysis
FTIR	Fourier transform infrared
FWHM	Full width half maxima
SEM	Scanning electronic microscope
TGA	Thermo gravimetric analysis
UV-vis	Ultraviolet visible spectrometer
XRD	X-ray diffraction

field such as biomaterial production, biochemistry, medical and pharmaceutical products, toothpastes, optical receptors, biosensing, etc. [6-9].

Chemical, physical, and biological methods have been developed to synthesis nanoparticles but chemical and physical methods are involved in the production of toxic byproducts which are hazardous moreover the methods are very expensive [10, 11]. To synthesis stable metal nanoparticles with controlled size and shape, there has been search for inexpensive, safe, and reliable and "green" approach. The novel methods so called green/biosynthesis have been recently developed by a variety of plant extract such as *Ocimum Sanctum* [12], *Petroselinum crispum* [13], *Murraya koenigii* [14], *Coriandrum Sativum* [15] for the synthesis of metal nanoparticles.

Nature has devised various processes for the synthesis of nano and micro length scaled inorganic materials which have contributed in the development of relatively new and largely unexplored area of research based on the biosynthesis of the nanomaterials. Synthesis using bio-organisms is compatible with the green chemistry principles. "Green synthesis" of nanoparticles makes use of environmental friendly, non-toxic and safe reagents. Nanoparticles synthesized using biological techniques or green technology have diverse natures, with greater stability and appropriate dimensions since they are synthesized using a one-step procedure.

Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as well as contain natural capping agents [12]. Among various plants, we have chosen *Coriandrum sativum* leaves extract for the present study since it has several pharmacological effects such as anti-fertility, anti-diabetic, antihyperlipidemic, antioxidant, and hypotensive activities [16, 17]. Phytochemical screening indicated the presence of chemicals such as quercetin 3-glucoronide, linalool, camphor, geranyl acetate, geraniol and coumarins. The major fatty acid was petroselinicacid followed by linoleic acid [18]. Sathyavathi et al. [15] also reported biosynthesis of silver nanoparticles using *Coriandrum Sativum* leaf extract and their application in nonlinear optics.

For instance, the antibacterial activity of different metal nanoparticles such as silver colloids is closely related to their size; that is, the smaller the silver nuclei, the higher the antibacterial activity. Moreover, the catalytic activity of these nanoparticles is also dependent on their size as well as their structure, shape, size distribution, and chemical–physical environment. Thus, control over the size and size distribution is an important task. Generally, specific control of shape, size, and size distribution is often achieved by varying the synthesis methods, reducing agents and stabilizers.

In this manuscript, we attempted to corroborate the reduction of water soluble silver ion using *Coriandrum sativum* leaf extract to silver nanoparticles by green synthesis method.

2. Materials and Methods

2.1. Synthesis of silver nanoparticles

The fresh and mature leaves of *Coriandrum sativum* were collected from Jessore district in Bangladesh. About 20 gm of leaves were thoroughly washed four times with de-ionized water to remove dust particles and air dried at room temperature. Then the leaves were finely chopped into small pieces and added to 100 ml of de-ionized water, stirred for 20 min at 60°C. After boiling, the leaf extract was cooled at room temperature and filtered conferring75ml of transparent yellow color leaf broth which was stored at 4°C. In green synthesis of AgNPs, 0.01M of aqueous solution of $AgNO_3$ (99.99%) was used. 5mL of leaf broth was added to 45 ml of 0.01M $AgNO_3$ aqueous solution and allowed at ambient condition to react. After different time intervals, the color change of reaction mixture is observed from transparent yellow to dark brown indicates that the formation of AgNPs. The AgNPs solution was collected and UV-vis spectral analysis was used to investigate the reduction mechanism of silver ion in to nanoparticles in solution. The AgNPs solution was allowed to centrifuge and the excess liquid was removed by evaporation in a dryer yielding black colored silver nanopowder.

2.2. Characterization

Bio-reduced AgNPs solution samples were used periodically to observe the optical absorbance between 190 and 800 nm with a UV-vis spectrometer (Shimadzu UV-1800, Japan) at room temperature operated at a resolution of 1 nm. Fourier transform infrared spectra study was used to identify the presence of potential biomolecule and fountional groups. FT-IR spectra were measured by Perkin Elmer spectrometer having a resulation of 1 cm^{-1} in the weavelangth range 500-4000 cm^{-1}. X-ray defracttion mesurment was done with Cu-Kα radiation of 0.154187 nm wavelength to investigate the formation, crystalline behavior and the quality of synthesized AgNPs powder. The scanning was done in the ragion of 2θ from 30° to 80° at 0.02/min and the time constant was 2s. The size of AgNPs was calculated by the Debye-Scherer equation. The surface morphology and particle size of synthesized AgNPs was investigated by scanning electronic microscope. The weight loss and reaction type of synthesized AgNPs was examined by TGA/DTA in temperature region of room temperature to 1000°C where Al_2O_3 was used to heating measurement which carried out in air atmosphere at 20°C/min heating rate.

3. Results and Discussion

3.1. Ultraviolet visible spectroscopy

The reacted mixture of *Coriandrum sativum* leaf extract and silver nitrate solution are shown in Fig. 1 as a function of time using water as a solvent. A visible color change from transparent to light brown within 20 min indicates the more formation of AgNPs, which was confirmed by UV-vis spectrometer and FT-IR analysis. After 70 min there was significant color change to dark brown due to increase reaction time which enhances the growth of silver nanoparticles. It is well-known that silver nanoparticles exhibit yellowish brown color in water due to surface Plasmon vibration [19, 20]. Figure 2 shows the absorbance peak of synthesized AgNPs at various time intervals which was done by UV-vis spectrometer. The peak centered at 316 nm, which is associated with absorbance of AgNPs. The intensity of absorption peak at 316 nm was increases with increasing time period of aqueous component.

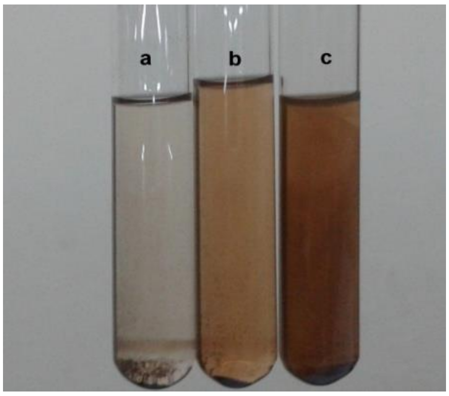

Fig. 1. Photograph of synthesized AgNPs solution over several reaction time (a) 10 min (b) 20 min (c) 70 min.

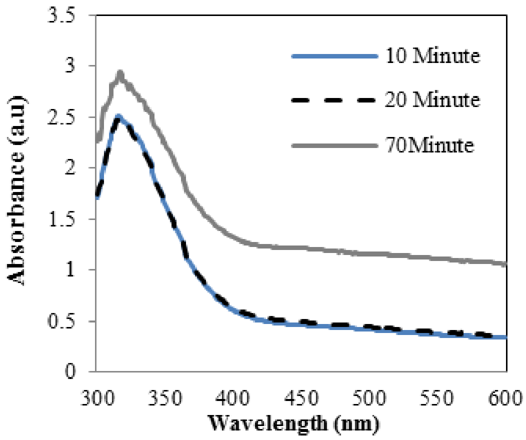

Fig. 2. Optical absorption spectrum of synthesized AgNPs taken at different time intervals.

3.2. Fourier transform infrared

Figure 3 shows the sharp FT-IR spectrum of synthesized AgNPs located at about 663.52 cm^{-1}, 1401.31 cm^{-1}, 1642.41 cm^{-1} and 3361.02cm^{-1}. Absorption peaks at 663.52 cm^{-1} assigned to C-Cl stretching for halogen compounds, 1401.31 cm^{-1}

assigned to C-O stretching for alcohol and phenols,1642.41 cm^{-1} assigned to C=O stretching for tertiary amides 3361.02 cm^{-1} assigned to O-H stretching for alcohols and phenols. IR spectroscopic study confirmed that carbonyl group form amino acid residues and proteins has the stronger ability to bind metal, could possibly form a layer covering the metal nanoparticles (i.e., capping of silver nanoparticles) to prevent agglomeration and thereby stabilize the medium [21, 22]. These results suggest that the biological molecules perform dual functions of formation and stabilization of silver nanoparticles in the aqueous medium.

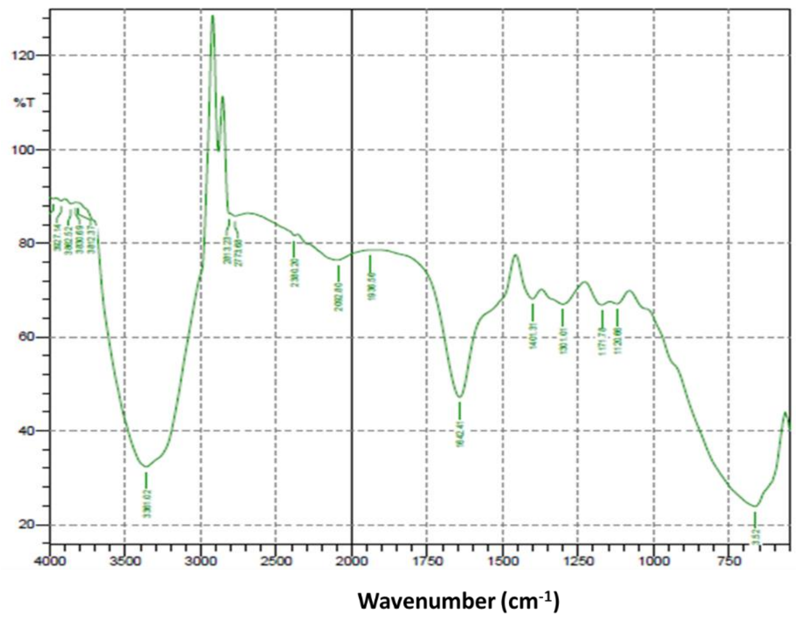

Fig. 3. FT-IR spectrum of synthesized AgNPs using *Coriandrum sativum* leaf extract.

3.3. X-ray diffraction

The XRD pattern of synthesized AgNPs using *Coriandrum sativum* leaf extract was shown in Fig. 4. The XRD was done to determine the crystalline nature of AgNPs and the resulted peaks were found at 37.90°, 44.05°, 64.25° and 77.20° representing (111), (200), (220) and (311) face centered cubic structure of silver which were compared with the standard powder diffraction card of Joint Committee on Powder Diffraction Standards (JCPDS), silver file No. 04–0783. A few intense unassigned peaks were also noticed which was raised at 32^0, 45.95^0, 54.6^0 and 57.2^0. These Bragg peaks might have resulted from some bioorganic compounds/proteins present in the *Coriandrum sativum* leaf extract [14, 23]. The average particle size was calculated by Debye-Scherer equation where full width at half maximum (FWHM) data were used [12]. The average particle size estimated was approximately 6.43 nm. Debye-Scherer equation is

$$\tau = \frac{K\lambda}{\beta\cos\theta}$$

where, τ is the particle size; K is a dimensionless shape factor; λ is the X-ray wavelength; β is the line broadening at half the maximum intensity (FWHM); θ is the Bragg angle (in degrees).

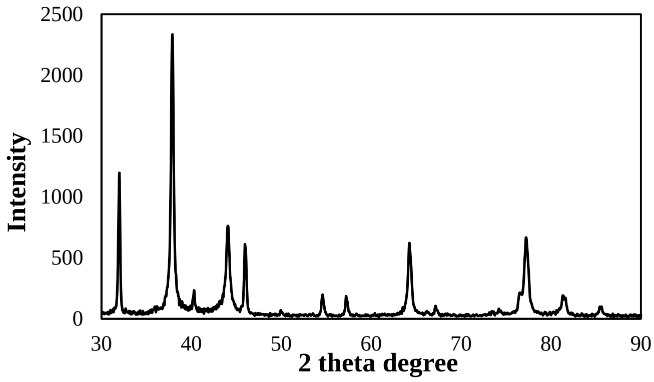

Fig. 4. XRD pattern of synthesized AgNPs using *Coriandrum sativum* leaf extract.

3.4. Scanning electronic microscope

Figure 5 shows the SEM images of the same synthesized silver nanoparticles sample. SEM images showed that most of the silver nanoparticles are predominately spherical in shape having smooth surface and well dispersed with close compact arrangement. The average particle size was found around 6.45 nm using an advanced software named "IMAGEJ' and the obtained particle size is almost similar to XRD.

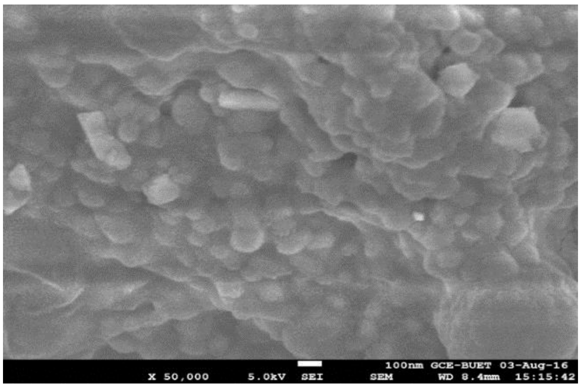

Fig. 5. SEM image of synthesized AgNPs using*Coriandrum sativum* leaf extract.

3.5. Thermo gravimetric and differential thermal analysis

TGA and DTA spectrums of AgNPs powder are given in Fig. 6. The prevalent weight loss of AgNPs sample observed from TGA spectrum which rises up in temperature region of 200 to 500^{0}C and a slight weight below 200^{0}C and above

800ºC. There is almost no weight loss in temperature region between 550ºC and 800ºC. It can be generally ascribed due to evaporation of water and organic compounds. DTA spectrums displays two exothermic peaks ascend between 200ºC and 300ºC and between 400ºC and 500ºC.

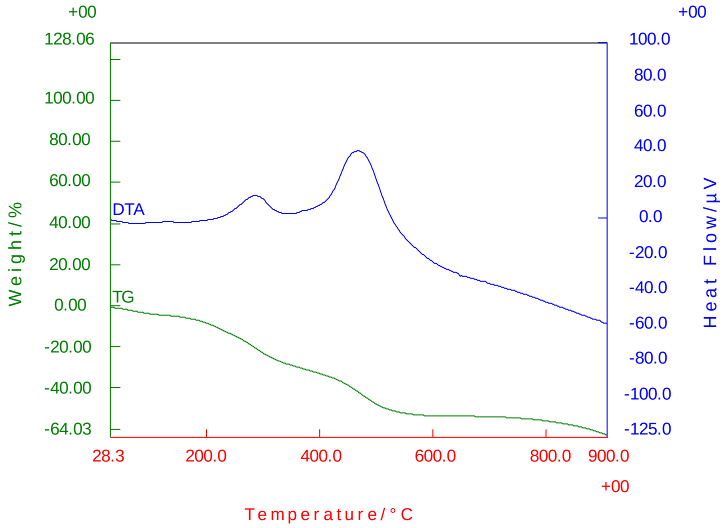

Fig. 6. TGA/DTA curve of synthesized AgNPs using *Coriandrum sativum* leaf extract.

4. Conclusions

The green synthesis of AgNPs using *Coriandrum sativum* leaf extract was shown to be rapid, eco-friendly and produced nanoparticles are fairly uniform in size and shape. AgNPs began to form within 10min and higher formation yield at 70min after addition of leaf extract to silver nitrate as shown by the UV-vis spectrum at 316 nm. It was found that the formation of AgNPs was increased with time. The XRD peaks ascribed with FCC structure of silver. The synthesized AgNPs were spherical in shape and particle size found about 6.45 nm from XRD results in addition justified further by the SEM analysis. TGA/DTA prevalent weight loss occurs in temperature region of 200 to 500°C and a slight weight below 200°C and above 800°C and reaction type was exothermic. The FT-IR spectrum ascribed the biological molecules which perform dual functions of formation and stabilization of silver nanoparticles in the aqueous medium. So, it can be summarized that, green synthesis is an effective and eco-friendly method of producing metal nanoparticles.

Acknowledgments

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