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Full Length Research Paper

Tapping the unexploited plant resources for the synthesis of silver nanoparticles

Arangasamy Leela[1]* and Munusamy Vivekanandan[2]

[1]Department of Biotechnology, Bharathidasan University, Tiruchirappalli-620024. TN. India.
[2]Biosciences and Research, Vivekananda Institutions, Elayampalayam, Thiruchengode-637 205. TN, India.

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Development of biologically inspired experimental processes for the synthesis of nanoparticles is evolving into an important branch of nanotechnology. The bioreduction behaviour of various plant leaf extracts such as *Helianthus annus* (*Asteraceae*), *Basella alba* (*Basellaceae*), *Oryza sativa*, *Saccharum officinarum*, *Sorghum bicolour* and *Zea mays* (*Poaceae*) in the synthesis of silver nanoparticles was investigated employing UV/Visible spectrophotometry, XRD (X-ray diffraction) and SEM (Scanning Electron Microscopy). *H. annus* was found to exhibit strong potential for rapid reduction of silver ions. It was observed that there is no correlation always between the colour development and the increase in absorbance exhibited by the nanometal synthesised. The work adds to the confirmation of previous reports on biosynthesis of nanometals using plant leaf extracts.

Key words: Nanoparticles bioreduction, nanometals, *Helianthus annus*, X-ray diffraction.

INTRODUCTION

Nanoparticles are being viewed as fundamental building blocks of nanotechnology. The most important and distinct property of nanoparticles is that they exhibit larger surface area to volume ratio. The most effectively studied nanoparticles today are those made from noble metals, in particular Ag, Pt, Au and Pd. Metal nanoparticles have tremendous applications in the area of catalysis, opto-electronics, diagnostic biological probes and display devices. Among the above four, silver nanoparticles play a significant role in the field of biology and medicine.

The aforesaid metal nanoparticles have been synthesized using a variety of methods, including hard-template (Zhou et al., 1999), bio-reduction (Canizal et al., 2001; Mouxing et al., 2006) and solution phase syntheses (Sun et al., 2003; Yu et al., 1997). In the synthesis and assembly strategies of nanoparticles and nanomaterials, precursors from liquids, solids or gas phase are used employing chemical and physical deposition approach. The manufacturing techniques fall under two categories: 'bottom-up' and 'top-down' approach. The bottom-up approach promises a better chance to obtain nanostructures with less defects, more homogenous chemical composition and better short and long range ordering, because this approach is mainly driven by the reduction of Gibb's free energy. Among the various methods like sol-process, micelle, sol-gel process, chemical precipitation, hydrothermal method, pyrolysis, chemical vapour deposition, bio-based protocol etc., bio-based protocol is the most important and eco-friendly production method.

Biosynthesis of nanoparticles by plant extracts is currently under exploitation. The use of *Azadirachta indica* (Neem) (Shankar et al., 2004), *Medicago sativa* (Alfalfa) (Gardea – Torresday et al., 2003), *Aloe vera* (Chandran et al., 2006), *Emblica officinalis* (amla, Indian Gooseberry) (Amkamwar et al., 2005), and micro-organisms (Duran et al., 2005; Vigneshwaran et al., 2006; Bhainsa and D'souza, 2006) has already been reported. According to previous reports, the polyol components and the water-soluble heterocyclic components are mainly responsible for the reduction of silver ions and the stabilization of the nanoparticles, respectively. There

*Corresponding author. E-mail: tomsleela@gmail.com.

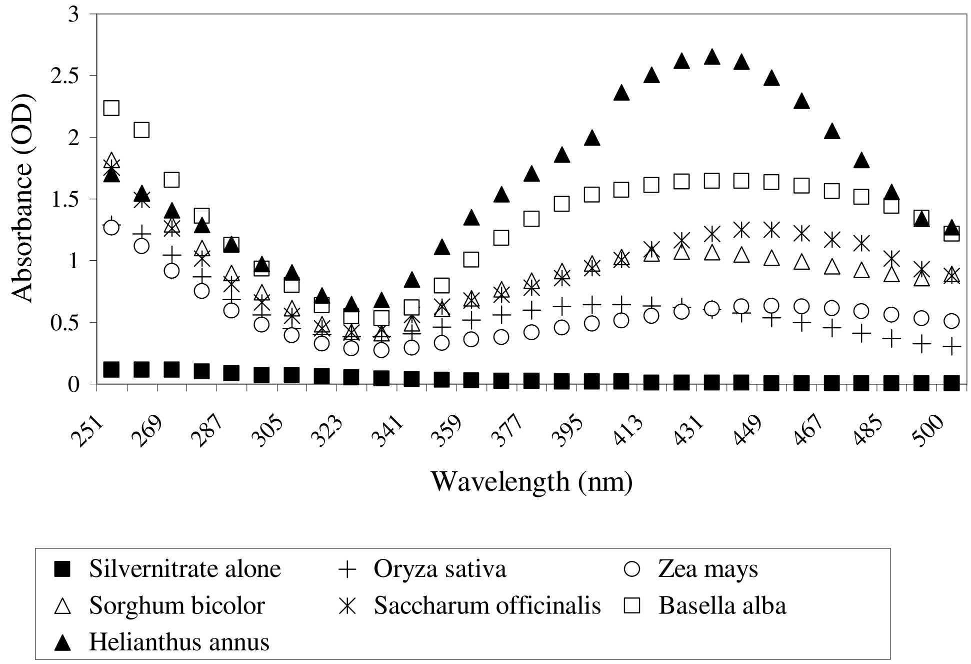


Figure 1. UV visible absorption spectra recorded as a function of time of reaction at 10^{-3} M aqueous solution of silver nitrate with different leaf extracts. The silver nanoparticle formation was monitored through UV-Visible absorption spectroscopy (excitation band near 430 nm for silver) at regular intervals as a function of time of reaction on a Genesys 10-UV Thermo Spectrophotometer operated at a resolution of 3 nm.

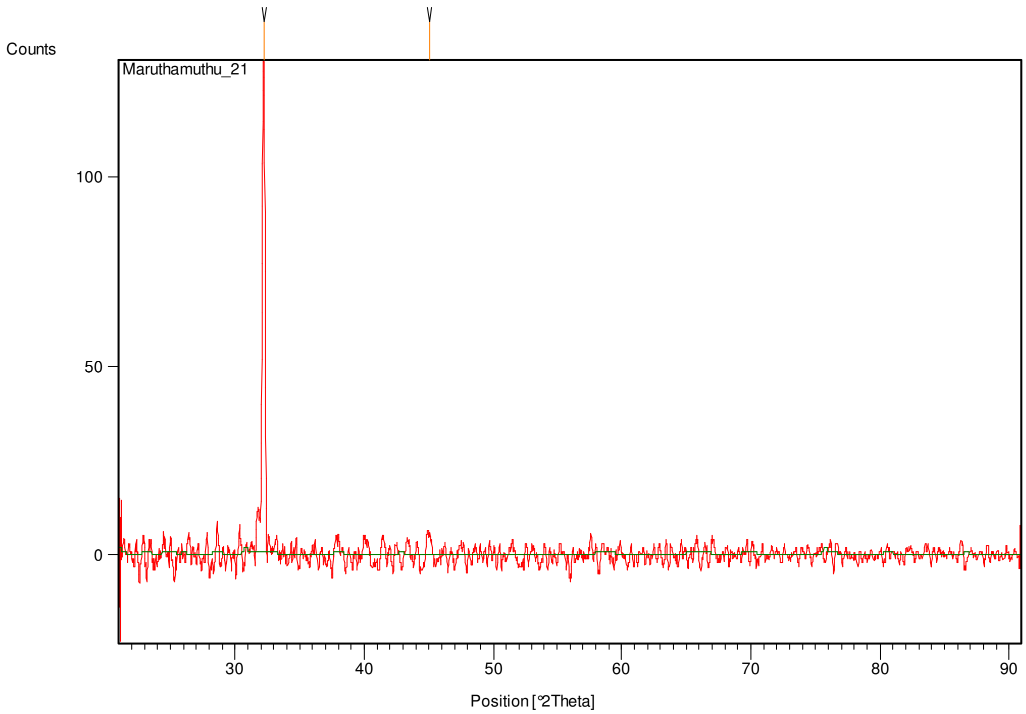
are also reports on reductases (Anil Kumar et al., 2007) and polysaccharides (Huang and Yang, 2004) as factors involved in biosynthesis and stabilization of the nano-particles, respectively. Our hypothesis is that several factors together determines the nanoparticle synthesis, including the plant source, the organic compounds in the crude leaf extract, the concentration of silver nitrate, the temperature and other than these, even the pigments in the leaf extract. The longtime aim is to identify those compounds and the mechanism in detail. As a prelimi-nary work we screened the following plants: *Basella alba* (*Basellaceae*), *Helianthus annus*, (*Asteraceae*), *Oryza sativa*, *Saccharum officinarum*, *Sorghum bicolour* and *Zea mays* (*Poaceae*) and systematic comparative study was carried out to investigate their efficiency to reduce silver ions as well as the formation of silver nanoparticles.

RESULTS AND DISCUSSION

Nanotechnology is a fast emerging discipline not only in physics and chemistry but also in the field of biology. In view of the tremendous applications of nanotechnology, there is a fillip among scientists to carry out research in this most vital discipline. Chemists are highly interested in synthesizing nanoparticles of different dimensions employing many of the precious metals. Already scientists have started exploiting the bio-based synthesis of nano-metals using leaf extracts and microorganisms (bacteria and fungi). The present study was conducted to screen the un-exploited plant sources in the development of silver nanoparticles. The plants belonging to the following families such as *Basellaceae*, *Asteraceae*, and *Poaceae* were selected and their rates of reduction of silver nitrate was investigated. The silver nanoparticle formation was confirmed by X-ray diffraction (XRD) and electron micro-scopy. The qualitative analysis for nitrate reduction and the antimicrobial activity of the silver the synthesized nanoparticle was also performed.

The absorption spectrum of aqueous silver nitrate only solution exhibited λ max at about 220 nm. There was a gradual increase in color development in the reaction mixture (silver nitrate solution + plant leaf extract). Of all the plants studied, the intensity of color development in the reaction mixture was significantly higher in *H. annus* (sunflower), *B. alba* (spinach) and *S. officinarum* (sugarcane).

In the spectrophotometric analysis (Figure 1), though the reaction mixture of each plant studied exhibited a strong absorption between 400 and 500 nm, sunflower was found to exhibit very strong absorption. Also it was observed that there is no correlation always between the



Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]
32.3068	95.08	0.3178	2.77106	100.00
5.0227	5.87	0.4896	2.01193	6.18

Figure 2. The XRD Image of silver nanoparticles synthesised using Sunflower leaf extract. The diffraction patterns were obtained by measurement of angles at which X-ray beam is diffracted by the crystalline phases in the specimen. X-ray diffraction (XRD) measurement of the bio-reduced silver nitrate solution drop-coated on glass substrate bio-film was carried out on a Philips PW 1830 instrument operating at 40 kV and a current of 30 mA with Cu K_a radiation.

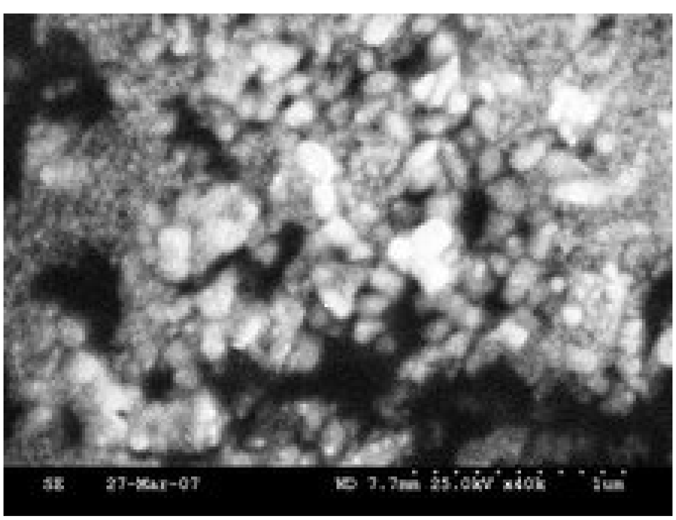


Figure 3. The SEM image (WD 7.7 mm 25.0 kV x 40 k) of silver nanoparticles synthesised using sunflower leaf extract. Dried suspension of silver nanoparticles synthesized by reduction of silver ions in water was subjected to electron microscopy (SEM) using Hitachi made Scanning Electron Microscope of Model No.S3000H at central electro chemical research institute

colour development and the increase in absorbance exhibited by the nanometal synthesised. The difference in the morphology of the nanoparticle synthesised may be the possible reason for the difference in optical properties (Xu and Kall, 2002).

The biosynthesised silver nanostructure by employing sunflower leaf extract was further demonstrated and confirmed by the characteristic peaks observed in the XRD image (Figure 2) and the structural view under the scanning electron microscope (Figure 3).

Thus the sunflower leaf extract was found to be promising in the development of silver nanoparticles. The SEM image showing the high density silver nanoparticles synthesized by the sunflower leaf extract further confirmed the development of silver nanostructures by the plant extract.

Isolation and testing of individual fractions for metal ion reduction and binding with the nanoparticles is necessary. By altering the pH, strength of elements, plant sources, and incubation temperature of the nanoparticle synthesis reaction mixture, the synthesis methods, it is possible to create a wide range of different nanoparticles.

Nanoparticles of various sizes and properties may be obtained by further tapping the plant bioresources of different kind in wild environment.

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