Special Issue Published in International Journal of Trend in Research and Development (IJTRD), ISSN: 2394-9333, www.ijtrd.com

Biosynthesis of Silver Nano Particles Using Indian Nettle Leaves

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Abstract-- Currently, there is a growing need to develop environmentally benign nanoparticle synthesis processes that do not use toxic chemicals in the synthesis. In the present work eco friendly approach is employed to synthesize silver nanoparticles using Indian nettle leaves by bio-chemical method. The biomolecules found in plants induce the reduction of Ag+ ions from silver nitrate to silver nanoparticles. The process of reduction is fast which may lead to the development of easy biosynthesis of silver nanoparticles. X-ray diffraction (XRD) spectrum of the silver nanoparticles exhibited 2θ values corresponding to the silver nanocrystal. The average crystallite size is found to be 23nm. The FTIR study confirmed the functional groups present. UV-visible spectrum demonstrated the peak corresponding to the absorbance of silver nanoparticles. The silver nanoparticles are expected to have diagnostic, antibacterial and optical applications.

Keywords-- *Ag nano particles, Indian nettle leaf, biochemical method, XRD, FTIR, UV.*

I. INTRODUCTION

Nano particles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. The interesting and sometimes unexpected properties of nano particles are therefore largely due to the surface area of the material, which dominates the contribution made by small bulk of the material. Nanoparticles with controlled size and composition are of fundamental and technological interest as they provide solutions to technological and environmental challenges in the areas of solar energy conversion, catalysis, medicine and water treatment. Thus, production and application of nanomaterials from 1 to 100 nanometers (nm) is an emerging field of research [1, 2]. Global warming and climate change have induced a worldwide awareness and effort to reduce generated hazardous wastes. Thus, "Green" chemistry and chemical processes are progressively being integrated in science and industry for sustainable development [3]. Nanomaterials due to their sheer size show unique and considerably changed physical, chemical, and biological properties compared to their macro scale counterparts [4]. Gold, silver, and copper have been used mostly for the synthesis of stable dispersions of nanoparticles, which are useful in areas of photography, catalysis, biological labeling, photonics, optoelectronics, and surface-enhanced Raman scattering (SERS) detection [5–7].

Biological methods are considered safe and ecologically sound for the nanomaterial fabrication as an alternative to conventional physical and chemical methods. Biological routes to the synthesis of these particles have been proposed by exploiting microorganisms [8–12] and by vascular plants [13–22]. The functions of these materials depend on their composition and structure. Plants have been reported to be used for synthesis of metal nanoparticles of gold and silver and of a gold-silver-copper alloy [13–22]. Colloidal silver is of particular interest because of its distinctive properties such as good conductivity, chemical stability, and catalytic and antibacterial activity [23–25].

II. EXPERIMENTAL SECTION

The research has been focussed on the preparation and characterization of silver nanoparticles synthesized by the bio–chemical method .Fresh leaves from indian nettle were collected from our college (Sadakathullah Appa College) campus and washed several times with water to remove dust particle and then sun dried to remove the residual moisture and grinded to form powder. Then plant extract was prepared by mixing with deionized water. 0.1M of Silver Nitrate salt was mixed with the (20ml) plant extract. Then the solution was stirred vigorously and the PH was set in the range of 10. Distilled water was subsequently added as a precipitant agent while vigorous stirring of solution continued until green precipitate formed. The resulting precipitate was filtered and washed twice with deionized water. The green precipitate is dried at 100^0c for 1 ½ hours at hot air oven.

III. RESULT AND DISCUSSION

A. X-Ray Diffraction

There are number of analytical techniques used to characterize the materials. One of the methods, X-ray powder diffraction (XRD), is an instrumental technique that is used to identify the minerals, as well as other crystalline materials.

The XRD measurements were carried out at room temperature using Analytical XPERT-PRO with monochromatic beam of Cu Kα radiation (1.5406 A). An accelerating voltage of Kv and a current of 30 mA with a scan rate of 0.01° s-1 were used. Fig. 1 shows that the XRD pattern of silver(Ag) nanoparticles. The XRD patterns were recorded in the 2θ range of 10 - 70° versus intensity. The values of 2θ, d- spacing, relative intensity and FWHM obtained from the XRD pattern are given in table 1. Identification of phases was carried out by comparing the diffraction pattern obtained from XRD with standard JCPDS database. The lattice parameters and cell volume were calculated using UNIT CELL software.

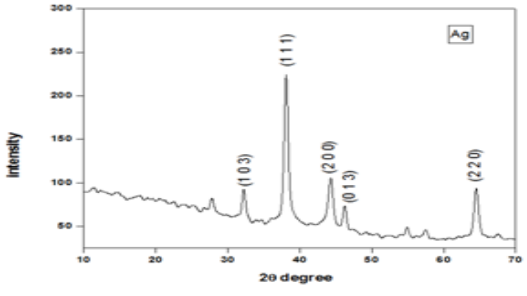

Figure 1: XRD graph for the Ag specimen

In this pattern the peaks occur at 2θ = 32.2379, 38.1295, 44.3078, 46.2331, and 64.451 with corresponding to the hkl

values (1 0 3),(1 1 1) (2 0 0), (0 1 3), and (2 2 0) respectively, it resembles the presence of cubic structure of Ag nanoparticles with the lattice parameter a=b=c= 4.085.The obtained values were well coincidence with the JCPDS File No:893722. All the diffraction lines observed have been found to be in good agreement with standard lines as given in the above file. Thus, the comparison confirms the presence of Ag phases in the present specimens with cubic crystal structures.

Table 1: XRD Parameter of Ag Nanoparticles

Sr. no	2θ	Measured d-spacing (A˚)	Standard d-spacing (A˚)	FWHM (degree)	(h k l)	Relative Intensity %
1	32.2379	2.7745	2.3587	0.2676	(1 0 3)	22.02
2	38.1295	2.3582	2.0423	0.2676	(1 1 1)	100
3	44.3078	2.0427	1.4444	0.5353	(2 0 0)	23.98
4	46.2331	1.9620	1.2318	0.4015	(0 1 3)	13.43
5	64.4518	1.4445	1.1793	0.2676	(2 2 0)	29.53

The grain size is estimated by the Debye formula [13,14] and summarized in table 2.

$$D_{hkl} = \frac{K\lambda}{\beta \cos\theta}$$

Where, ,D_{hkl} is the mean grain size,

K is a dimensionless shape factor (0.94),

λ is the wavelength of the X-ray,

β is the line broadening at half the maximum intensity (FWHM),

θ is the Bragg's angle.

The micro structural parameters such as Dislocation density (δ) and Micro strain (ε) have been calculated using the following relations [14] and their values are summarized in table 2.

$$\text{Dislocation density } (\delta) = 1/ D^2$$

$$\text{Micro Strain } (\varepsilon) = \frac{(\beta \cos\theta)}{4}$$

The macro strain can be calculated using the equation,

$$\text{Macro strain} = d_{obs} - d_{std} / d_{std}$$

where, d_{obs} & d_{std} are the observed and standard interplanar spacing for different crystal planes with different miller indices(hkl).

Table 2: Crystalline Size, Micro strain, Macro strain and Dislocation density

S.No.	(h k l)	Crystalline Size (nm) (x10-9)	Micro strain (m4)(x103)	Macro strain	Dislocation density (m-2)1015
1	(1 0 3)	33.0466	1.1208	0.1772	0.9156
2	(1 1 1)	31.0039	1.1027	0.1554	1.0403
3	(2 0 0)	14.2982	2.1616	0.4154	4.8913
4	(0 1 3)	19.0211	1.6095	0.5941	2.7637
5	(2 2 0)	26.2501	0.9870	0.1936	1.1688

The average value of crystalline size is **23nm**.
The average value of micro strain is **$1.39x10^{-3}$ (m^{-4})**

The average value of macrostrain is **0.30718**

The average value of dislocation density is**$2.4363x10^{15}$(m-2)**

The 'd' values for all the lines have been calculated and the patterns have been indexed. Consequently, the cell parameters and the cell volumes of the compounds have been computed by using the software referred as "unit cell". A comparison of all the parameters is presented in table 3. The table shows that the computed values of all the parameters in close agreement with those in the standard JCPDS files.

Table 3: Unit cell parameter for Ag

Parameter	Ag NO_3(cubic face centered)	
	Observed	Standard(JCPDS Fill No: 89-3722)
a(A˚)	4.7181	4.085
V(A^3)	105.6980	68.19

B. Fourier Transform Infrared (FTIR) Spectrometer

This technique is one of the most important and widely used spectroscopic techniques of analyzing quantitatively the structural units of the unknown compounds. It helps to identify the functional units, internal structure of the molecules and nature of the chemical bonds of a compound. Figure 2 shows the FTIR spectra for Silver specimen.

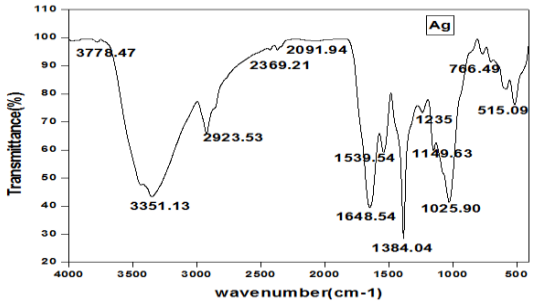

Figure 2: FTIR spectrum for the Silver specimen

The spectrum has four profiles 515 cm^{-1},1539 cm^{-1},1384 cm^{-1},2923 cm^{-1}. The main vibration frequency at 515 cm^{-1} is the characteristic of stretching for Ag NPs. Tamasa panigrahi have reported that the vibrational band around 500-550 cm^{-1} corresponds to the characteristics of stretching for Ag NPs. Ajitha et al have been reported the peak 1550 cm^{-1} corresponds to the characteristic of C-H band stretching. B.Sundarajan et al have reported that the peak at 1333 cm^{-1} can be attributed to the O-H bond stretchng. Saswathisaha et al have reported that the peak at 2912 cm^{-1} can be attributed to the stretching for C-H bond. Assignments of the observed bands in the spectra are also presented in table 4.

Table 4: FTIR Spectroscopy data for the silver specimen along with the band assignments and a comparisons with literature.

S .no	Transmittance band		Band assignment
	Literature review	Present study	
1	Tamasa panigrahi (2015) 500-550cm^{-1}	515cm^{-1}	Stretching For Ag nanoparticles
2	Ajitha et al (2011) 1550 cm^{-1}	1539cm^{-1}	C-H bond stretching
3	B.Sundarajan et al (2014) 1333cm^{-1}	1384cm^{-1}	O-H bond stretching
4	Saswathisaha Et al (2015) 2912cm^{-1}	2923cm^{-1}	C-H bond stretching

The wavenumber and band assignment values obtained are given in the table 5.

Table 5: FTIR Spectrum of Silver specimen

Wavenumber (cm^{-1})	Band assignment
515 cm^{-1}	C-Br stretching
766 cm^{-1}	C-Cl stretching
1025 cm^{-1}	N-O Assymetric stretching
1648 cm^{-1}	N-H Bending
2923 cm^{-1}	C-H stretching
1235 cm^{-1}	C-N stretching
623 cm^{-1}	C-C stretching
3351 cm^{-1}	O-H Stretching
1384 cm^{-1}	O-H Stretching
1539 cm^{-1}	C-H Stretching

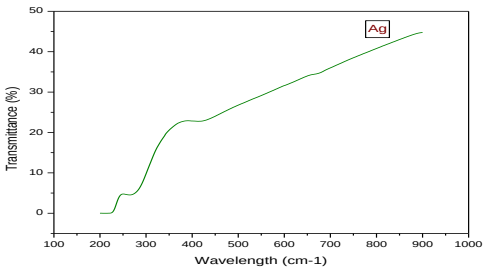

Figure 3: UV Trasmittance plot

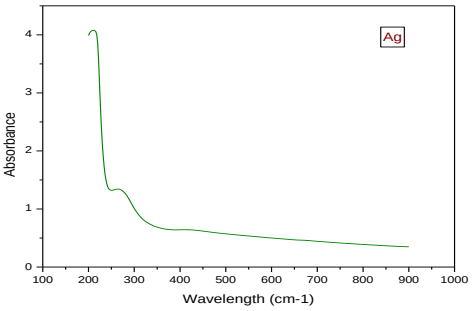

Figure 4: UV absorption plot

C. UV-visible spectroscopy

UV-visible spectroscopy studies have proven to be a powerful tool for the primary characterization of silver nanoparticles. Silver nanoparticles exhibit a strong and broad peak in the UV-visible spectrum for specific ranges of wavelength, depending on the geometry of the particles and their size distribution. Usually, a peak is observed around 450 nm for spherical, around 550 nm for pentagonal, and around 680 nm for triangular silver nanoparticles. Fig 3 the UV visible transmittance plot for the synthesized silver nanoparticles. The cutoff wavelength is found around 430 cm^{-1}. The enery band gap is 2.8MeV. Hence it can be used in optoelectronics applications. Fig 4 shows the UV absorption plot for the synthesized nanoparticles.

CONCLUSION

Development of synthesis of nanomaterials over a range of sizes, shapes and chemical composition is an important aspect of nano technology. The size-development and physical-chemical properties of nanoparticles have fascinated and inspired research activities. In this work the Ag nanoparticles were prepared by using Bio-chemical method.The synthesized nanoparticles were characterized by XRD,FT-IR spectroscopy . The XRD pattern showed that the synthesized Ag nanoparticle were crystallite in nature, they have an average crystallite size of 23 nm. The FT-IR study confirmed the functional group appeared at 515 cm^{-1} in Ag

nanomaterials were due to the Ag bond stretching. The UV visible analysis showed the optical property of the silver nanoparticles. More Studies have to performed in order to shower an insight in deducing further details and discern for a better interpretation of the results obtained. Silver nanoparticles have been used extensively as anti-bacterial agents in the health industry, food storage, textile coatings and a number of environmental applications.

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