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

Structural Observation of Silver Nanoparticle Using Seed Extract of Caesalpinia Bonducella

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Abstract— Nanotechnology is an escalating field of modern research involving in synthesis, design, characterization, production, and application of structures, devices and systems by controlling shape and size at the nanometer scale. Currently, there is a growing need to develop sustainable preparation of nanoparticles using bio method. Metal nanoparticles, especially silver nanoparticles are of particular interest in the modern research of nanotechnology due to its unique properties and low cost. Hence seed extract of caesalpinia bonducella (C. Bonducella) was added with silver nitrate to synthesis silver nanoparticle. The particle size, dislocation density and micro strain of synthesized sample were determined using X-ray diffraction data.

Keywords—*Biosynthesis; Caesalpinia bonducella seeds; XRD; nanoparticle;*

I. INTRODUCTION

Nanotechnology is a branch of science which deals with matter with at least one of its dimension sized from 1-100 nm. High surface to volume ratio is responsible for the fascinating properties of nanomaterials such as antimicrobial, magnetic, electronic and catalytic activity. Generally properties of nanoparticles depend on size, shape, composition, morphology and crystalline phase. They find applications in areas ranging from photonic, molecular computing, energy storage, fuel cells and tunable resonant devices to nano medicine. Since they exhibit larger surface to volume ratio compared to their macro sized counter parts, they have increased reactivity. Nanoparticles have many functional platforms that can be utilized for imaging and therapeutic functions. Development of reliable biosynthetic and environment friendly approach has added much importance because of its eco-friendly products, biocompatibility and economic viability in the long run and also to avoid adverse effects during their application especially in medical field. Biosynthesis of nanoparticles is a bottom up approach where the main reaction occurring is reduction/oxidation. The plant phytochemicals with antioxidant or reducing properties are usually responsible for the preparation of metal and metal oxide nanoparticles [1]. Among the various biosynthetic approaches, the extract of plant or part of it has advantages such as easily available, safe to handle and possess a broad viability of metabolites. The main phytochemicals responsible for the synthesis of nanoparticles are terpenoids, flavones, ketones, aldehydes, amides [2].

The synthesis of metal nanoparticles has attracted considerable attention in physical, chemical, biological, medical, optical, mechanical and engineering sciences [3]. In the present work, the Caesalpinia bonducella seed extract (CBSE) was added with silver nitrate to synthesis silver nanoparticles (Ag NPs). Caesalpinia bonducella seeds have been used in the folklore medicine since long time and it is reported that it has multiple restorative properties like anthelmintic, antibacterial, antidiuretic and recently it has received considerable attention to treat Diabetes. *C. bonducella* F. (family: Caesalpiniaceae) is a large, scandent, prickly shrub found throughout the hotter and southern parts of India. It is found to be an aphrodisiac and general tonic helping in the rejuvenation of the body.[4] The seed powder is used as an antileprotic, anti-inflammatory, antidiabetic, antiperiodic, antipyretic, etc.

The seeds contain various chemical constituents such as furanoditerpene's: α-caesalpin, β-caesalpin, γ-caesalpin, δ-caesalpin, η-caesalpin, and caesalpin –F; fatty acids: palmitic, stearic, octadeca-4-enoic, octadeca-2, 4-dienoic, lignoceric, oleic and linoleic acids, phytosterinin, β-sitosterol, homoisoflavone bonducellin; amino acids: aspartic acid, arginine, and citrulline; carbohydrates: starch and sucrose; β-carotene, glycoside-bonducin, gums, and resins. Hence the addition of the seed extract to aqueous $AgNO_3$ solution resulted in the formation of silver nanoparticles.

II. MATERIALS AND METHOD

A. *Materials*

Analytical reagent grade $AgNO_3$ (silver nitrate, ≥99.9%) and seeds of caesalpinia bonducella was used to synthesis silver nanoparticle.

B. *Synthesis of silver nanoparticles*

Co-precipitation method was adopted to synthesis the present sample. The seeds of caesalpinia bonducella were purchased and washed thoroughly with distilled water to make them free from dust particles and surface contamination and dried well. Afterwards, the seeds were powdered and 5gm of dried seed powder was added to 50 ml of double distilled water and stirred continuously at 60^0 C for 2 hours. The extract was filtered and used for the synthesis process.

$AgNO_3$ solution of 0.1 M was prepared using double distilled water. The prepared seed extract of caesalpinia bonducella was added drop wise into the $AgNO_3$ solution until the precipitate forms. The solution was stirred continuously for four hours. The observed color change from white to dark brown is shown in fig. 1. The precipitate obtained was filtered using whatman filter paper and washed twice with double distilled water and collected in a petri dish and dried in the hot air oven for one day at 80^0C.

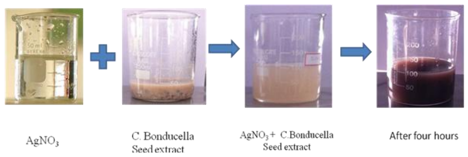

Figure 1: Reaction and synthesis process

III. CHARACTERIZATION

The diffraction patterns of prepared Ag NPs were recorded at room temperature using a X-Ray Powder diffractometer (X'pert pro PANalytical) with monochromatic beam of Cu Kα radiation (1.5406 A°). An accelerating voltage of 40 kV and a current of 30 mA with a scan rate of 0.01° s^{-1} were used. It is used to identify the structure, lattice parameters, particle size, etc,.

IV. RESULTS AND DISCUSSIONS

XRD patterns of the synthesized silver nanoparticles are depicted in fig.2. The peak position explains crystal parameters, whereas the peak intensities gives the details about the electron density inside the unit cell. The four major peaks appeared in the XRD pattern at 2θ = 38.2855°, 44.4032°, 64.6269° and 77.5669° was indexed to the (111), (200), (220) and (311) planes of pure silver respectively. The obtained values were well coincidence with the JCPDS file No:87-0720 shown in fig 2. Thus, the comparison confirms the presence of Ag phases in the present specimen and found to have cubic structure with lattice constant a= 4.077 A˚. The average crystalline size was found to be 20 nm using the following Debye Scherrer formula [5].

$$D_{hkl} = \frac{K\lambda}{\beta cos\theta} \quad (1)$$

Where, D_{hkl} is the 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 [6]

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

$$\text{Micro Strain } (\varepsilon) = \beta \cos\theta / 4 \quad (3)$$

The dislocation density in the sample that is the average dislocations in a unit volume of the crystalline material is found to be 3.2771×10^{15} m^{-2} and the amount of average deformation due to the applied force (micro strain) is found to be 1.9313×10^{-3}.

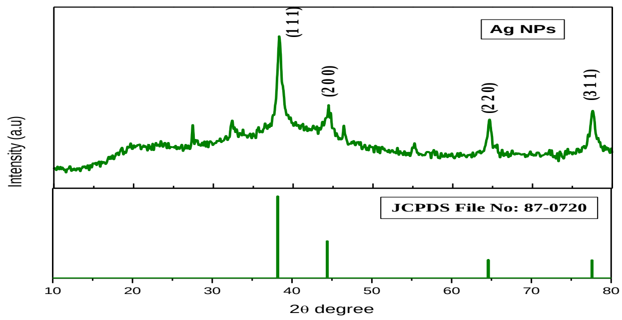

Figure 2: XRD Pattern

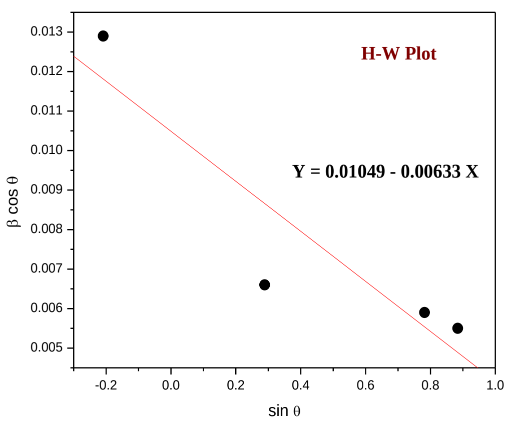

Figure 3: Hall-Williamson plot

Hall-Williamson plot (figure 3) was also used to determine the particle size of the synthesized Ag NPs [7] using the relation

β cosθ = (0.9 λ/D) + (η sinθ). The crystallite size was found to be around 13 nm and which is much smaller than the some of previous reports of Ag NPs using different bio extracts [8-11]. The difference obtained in particle size of the sample by scherrer formula and Hall-Williamson plot may be due to the strain on the nanoparticles.

CONCLUSION

The present method of green synthesis of silver nanoparticle is low cost at ambient condition. And the aqueous extract of caesalpinia bonducella seeds is the easy, economic and eco-friendly way to synthesize metallic nanoparticles. The size and structure of synthesized nanoparticles were determined from the XRD data. Moreover this seed mediated synthesis method represents a considerable improvement in the preparation of AgNPs since it require less time for reaction process and no need of additional capping agent. During the biosynthesis self-assembling of the chemical components of the seed extracts around the the Ag^+ ion is the reason for reduction of Ag^+ ion from $AgNO_3$. From the XRD studies it is confirmed that the structure of the synthesized nanoparticles (Ag) is cubic.

Acknowledgment

The authors are grateful to the management of Sadakathullah Appa College, Tirunelveli for the encouragement given to us to carry out the research work. Research supports given by Manonmaniam Sundaranar University, Tirunelveli is gratefully acknowledged.

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