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A Green Synthesis and Characterization of *Erythrina variegata* Decorated Silver Nanoparticles

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Abstract: The bio-synthesis of nanoparticles (NP) has been proposed as a cost effective and environmental friendly alternative to chemical and physical methods. Plant mediated synthesis of NPs is a green chemistry approach that interconnects nanotechnology and plant biotechnology. In the present study, synthesis of silver NP has been demonstrated using extracts of Erythrina variegata leaves. Thus obtained Ag NPs were characterized by FTIR spectroscopy, UV-visible spectroscopy, XRD, SEM and AFM analysis. The XRD pattern showed the characteristic Bragg peaks of d_{111}, d_{200}, d_{220} and d_{311} facets of the face centered cubic (fcc) silver NP and confirmed the crystalline nature of Ag NP. The different types of biomaterials presented in the Erythrina variegata extract synergistically reduce the Ag metal ions via polyol methodology, as each one is unique in terms of its structure and its function. This work proved the capability of biomaterial towards the synthesis of silver NPs with less polydispersity of shape and size.

Key words: Synthesis; decoration; nano silver; erythrina variegata; characterization.

INTRODUCTION

The bio-synthesis of NPs is a kind of bottom up approach where the main reaction occurring is reduction/oxidation. The need for biosynthesis of NPs rose as the physical and chemical processes were costly. Often, chemical synthesis method leads to presence of some of the toxic chemical absorbed on the surface that may have adverse effects in the medical applications[1]. This is not an issue when it comes to biosynthesis via green synthesis route. The search of cheaper pathways for NPs synthesis, scientists used microbial enzymes and plant extracts (phytochemicals). With their antioxidant or reducing properties they are usually responsible for the reduction of metal ions into their respective NPs. Green synthesis provides advancement over chemical and physical method as it is cost effective, environment friendly, easily scaled up for large scale synthesis and in this method there is no need to use high pressure, energy, temperature and toxic chemicals. Silver NPs have been used extensively as antimicrobial agents in health industry, food storage, textile coatings and a number of environmental applications. Antimicrobial properties of silver NPs caused the use of these nano metals in different fields of medicine, various industries, animal husbandry, packaging, accessories, cosmetics, health and military[2].

The main phytochemicals present in the plant extracts are terpenoids, flavones, ketones, aldehydes, amides and carboxylic acids. It was suggested that the phytochemicals are involved directly in the reduction of the ions and formation of silver NPs[3]. Many research papers reported the synthesis of silver NPs using plant extracts such as Artocarpus heterophyllus[4], Sesbania grandiflora[5], Punica granatum[6], Pithecellobium dulce[7], Malva parviflora[8], Iresine herbstii[9], hibiscus cannabinus[10], Hevea brasiliensis[11], Euphorbia prostrate[12], Cissus quadrangularis[13-15], Catharanthus reseus[16], Coccinia grandis[17], Ixora coccinea[18], Lippia citriodora[19], Manilkara zapota[20], Piper pedicellatum[21], Prosopis juliflora[22], Semecarpus anacardium[23], Nicotiana tobaccum leaf[24], Ocimum tenuiflorum, Solanum trilobatum, Syzygium cumini, Centella asiatica and Citrus sinensis leaves[25], Arbutus unedo leaf[26], Ficus benghalensis leaf[27], Mulberry leaves[28] and Olea europaea leaves[29].

Erythrina variegata belonging to the family Fabaceae is commonly known as Kalyan-Morangai (Tamil). Different parts of Erythrina variegata have used in traditional medicine as nervine sedative, febrifuge, anti-asthmatic and antiepileptic. The leaves are used in fever, inflammation and joint pain. The juice of the leaves is used in traditional medicine system. To the best of our knowledge, this is the first report for the synthesis of Ag NPs using Erythrina variegata leaf extract[30-35]. The novelty of the present investigation is synthesis of Ag NP with uniform size and shape even though the process is slow.

EXPERIMENTAL

Materials: Silver nitrate ($AgNO_3$) was purchased from nice chemicals, India and used as received. Double distilled (DD) water was used for experimental work. Erythrina variegata leaves were collected from S.F.R College for Women, Sivakasi, Virudhunagar district.

Preparation of Erythrina variegata leaves extract: Fresh leaves of Erythrina variegata washed several times with water to remove the dust particles and then dried to dark condition to remove the residual moisture and grinded to form powder. The plant extract was prepared by mixing 15 g of Erythrina variegata dried leaf powder poured in to soxhlet apparatus and DD water in a 150 mL of round bottom flask (RBF) then heated to 100^0C for 6 hours. Then the solution was incubated for 30 minutes. The

Erythrina variegata leaves extract was stored at room temperature to be used for the biosynthesis of silver NPs.

Synthesis of Silver NPs: In the typically synthesis process of silver NPs, add 12 mL of Erythrina variegata dried leaf powder extract into the 88 m of silver nitrate solution under stirring condition at room temperature. The bioreduced component was confirmed by using UV-visible spectrophotometer. A reduction of Ag NPs was clearly observed when Erythrina variegate leaves extract was added with $AgNO_3$ solution within 20 min. The dark brown solution was changed to light brown color which indicates the formation of silver NPs.

Characterization techniques: UV-visible absorption spectrum was measured using Shimadzu UV-2400 spectrophotometer, Japan. Crystalline metallic silver NPs were examined using an X-ray diffractometer equipped with using Cu-Kα radiation (λ= 1.54060 Å) at 60 kV over the range of 2θ = 10°-90° with a step size of 0.01708 and step time of 15.5076s. Phase purity and grain size are determined by XRD analysis. Fourier transform infrared (FTIR) spectra for Erythrina variegata leaves extract end capped silver NPs was obtained in the range 4000 to 400 cm^{-1} by KBr pelletization method by using Shimadzu 8400S, Japan model instrument. Scanning electron microscopy (SEM) analysis of synthesized silver NPs was done using a SEM PHILIPS XL 30 machine. The topography of the Ag NP was analyzed with the AFM (Model: XE 70, Park Systems-S. Korea).

RESULTS AND DISCUSSION

UV-visible spectral analysis: The mixture of leaf extract and $AgNO_3$ solution was subjected to UV-visible spectroscopy analysis and it shows a peak at 420 nm corresponds to the wavelength of the Surface Plasmon Resonance of Ag NPs (**Figure 1**). Various reports have established that the resonance peak of silver NPs appears around this region[36].

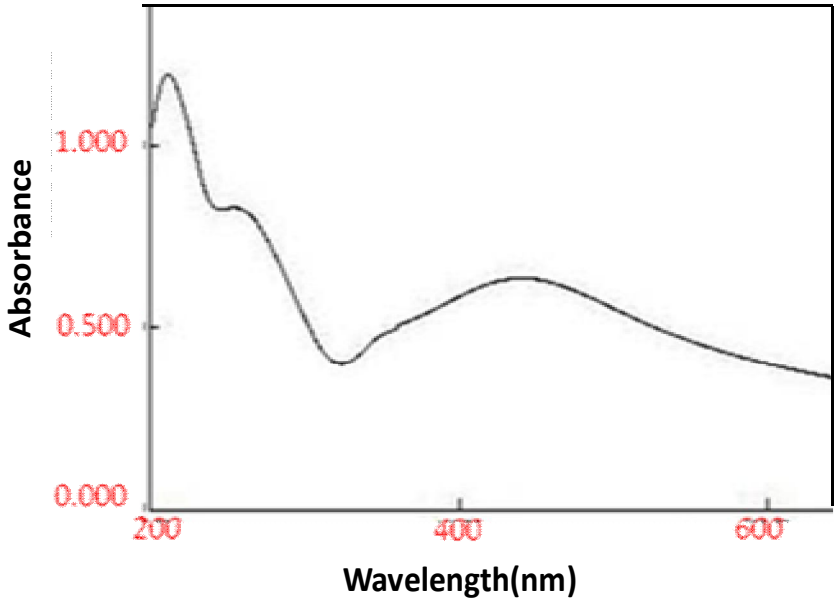

Figure 1: UV-visible spectrum of Erythrina variegata leaf extract decorated Ag NP

FTIR spectroscopy: FTIR analysis was performed to identify the possible functionalities of biomolecules responsible for the reduction of the Ag^+ ions and capping of the reduced Ag NPs synthesized using Erythrina variegata leaf extract. **Figure 2** showed strong bands at 3350, 2924, 2368, 1651, 1396, 1103 and 586 cm^{-1}. Bands appeared at 3350 and 2924 cm^{-1} are corresponding to O-H stretching and aliphatic -C-H stretching respectively. The bands at 2368 and 1651 cm^{-1} due to the CO_2 and C=C stretching respectively. The bands observed at 1396 and 1103 cm^{-1} are ascribed to -C-O and -C-O-C stretching modes respectively. Hence, the main components such as steroids, saponins, tannins, phenols, triterpenoids, flavonoids, glycosides, and glycerides present in the leaf extract of Erythrina variegata are prime responsible for the observed reduction and capping during the synthesis of Ag NPs. The two strong bands recorded at 717 and 463 cm^{-1} in the spectrum of the synthesized material were assigned to the C-H bending and metal-oxide (Ag-O), respectively[37]. The C-H bending peak is due to the reduction of $AgNO_3$ to Ag NPs by the leaf extract.

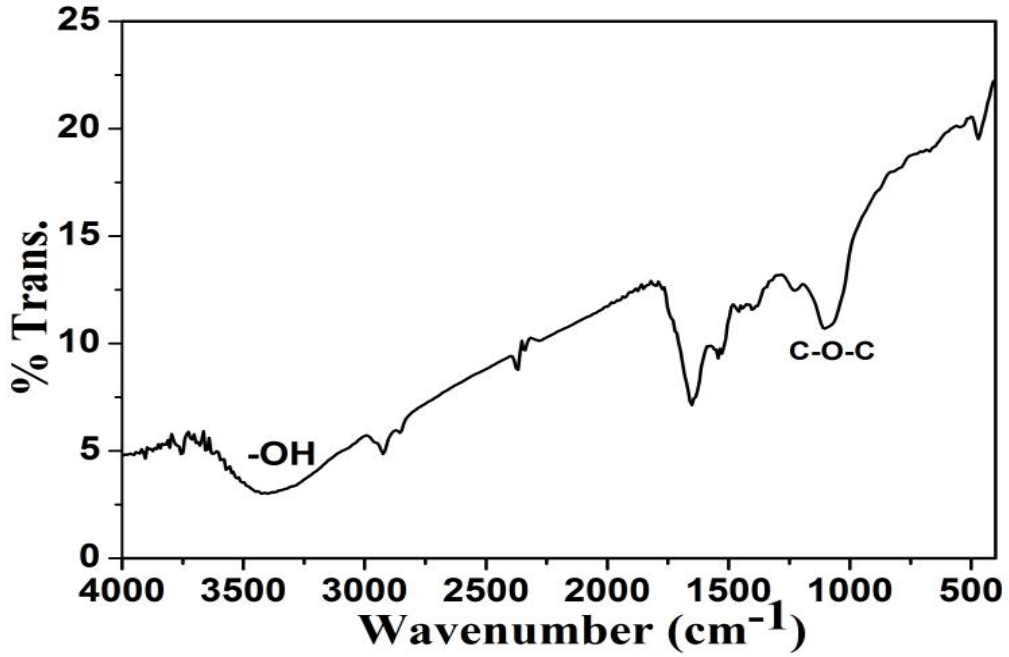

Figure 2: FTIR spectrum of Erythrina variegata leaf extract decorated Ag NP

X-ray diffraction study: X-ray diffraction (XRD) pattern was recorded for the synthesized Ag NPs is given in **Figure 3**. Three distinct diffraction peaks at 38.08°, 44°, and 64.5° were indexed with the planes d_{111}, d_{200}, and d_{220} and these peaks are matched with the face-centered cubic (fcc) structure of silver as per the JCPDS card no. 03-0931. The well resolved and intensed XRD pattern clearly showed that the Ag NPs formed by the reduction of Ag^+ ions using Erythrina variegata leaf extract are crystalline in nature. The results were compared with the literature and found to be matched. The low intense peak at 77.3° belongs to d_{311} crystal plane[38].

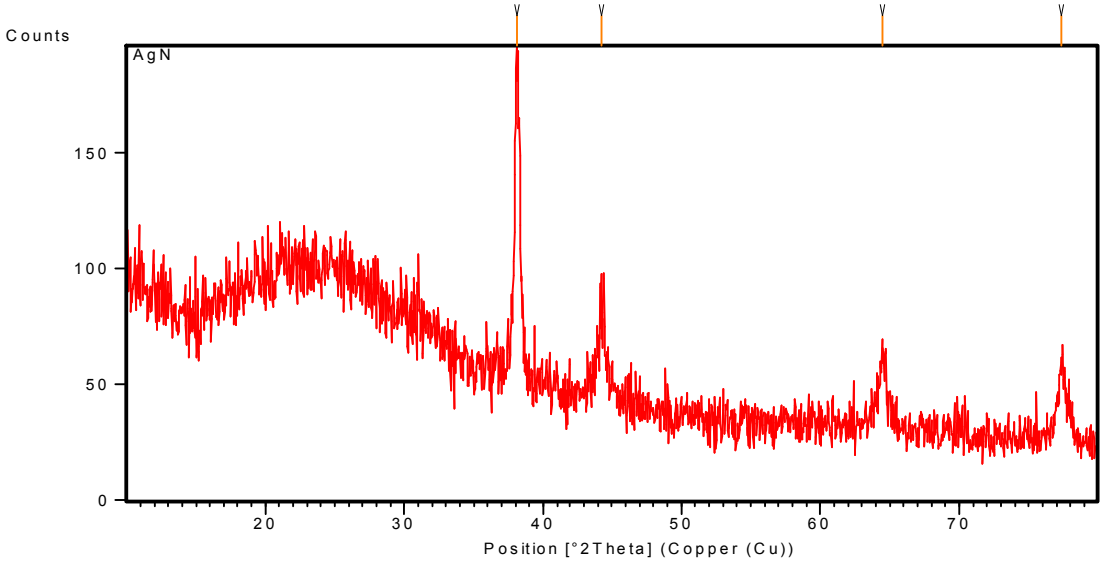

Figure 3: XRD pattern of Erythrina variegata leaf extract decorated Ag NP

Atomic force microscopy (AFM) report: Surface topology of the formulated silver NPs was studied by AFM analysis (**Figure 4**). The micrographs clearly indicated the formulated Ag NPs possess needle shape and have the calculated sizes.

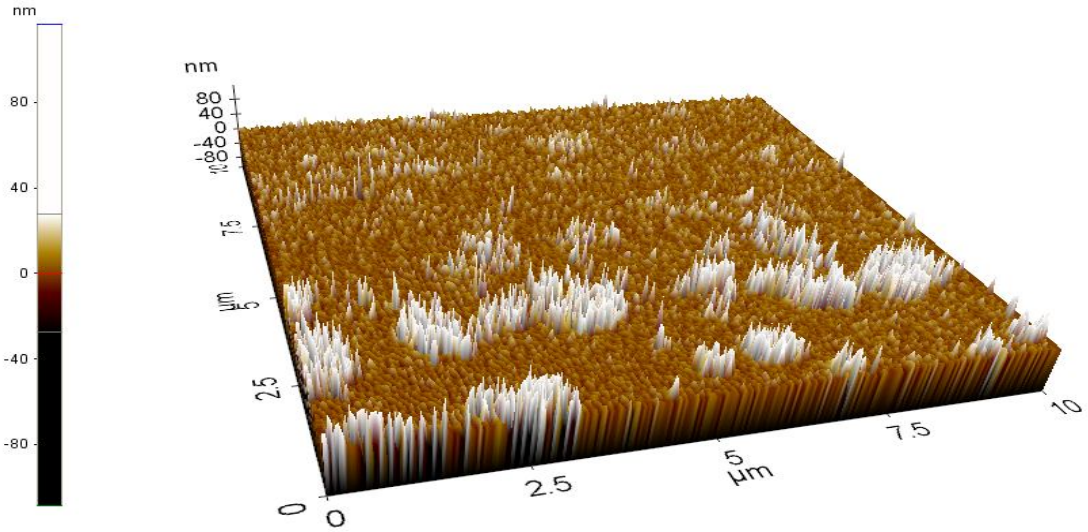

Figure 4: AFM image of Erythrina variegata leaf extract decorated Ag NP

SEM analysis: The SEM image (**Figure 5**) of plant extract decorated Ag NP exhibited the distorted spherical morphology with agglomerated structure. The size was determined as ~2 um. The important point noted here is polydispersity of size and shape is minimized.

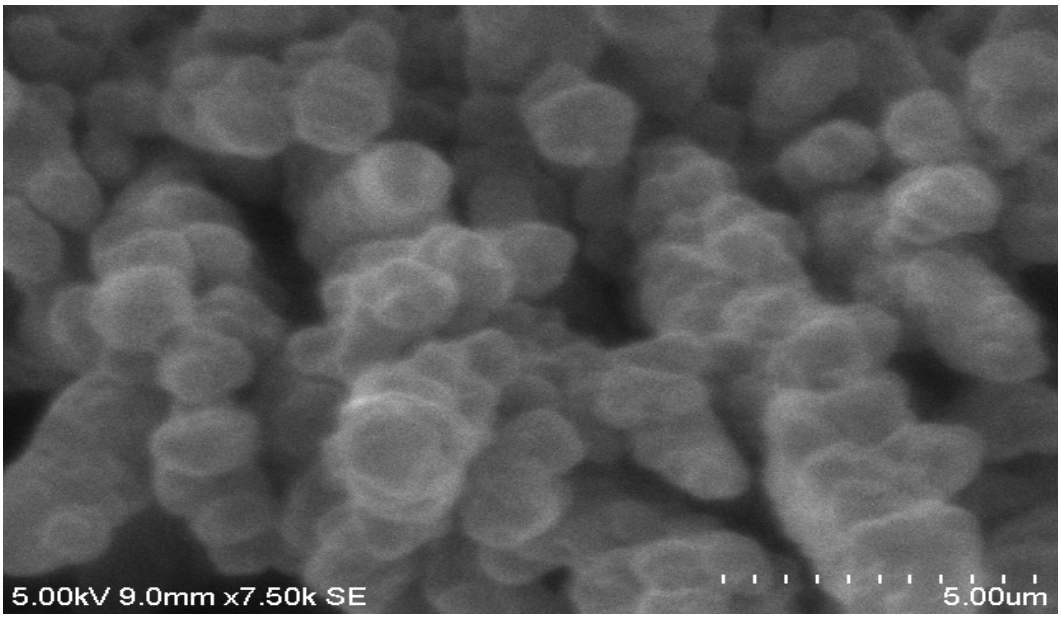

Figure 5: SEM image of Erythrina variegata leaf extract decorated Ag NP

CONCLUSIONS

The important points are summarized here as conclusions. The FTIR spectrum showed the presence of M-O stretching at 463 cm^{-1}. XRD confirmed the crystalline nature of extract decorated Ag NP. Appearance of a peak at 420 nm confirmed the presence of extract decorated Ag NP. AFM declared the smooth needle shaped morphology of Ag NP. SEM also confirmed the distorted morphology of Ag NP. These results concluded that even though the reduction process is a slow, the results are homogeneous one.

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