

Green Synthesis and Characterization of Gold Nanoparticles from *Erythrina Variegata* Plant Extract

Abdulsalam Mirdin ali; Hassanain Hataf Jaber

Masters of Science in Nano Biotechnology, Department of Nano-biotechnology, Acharya Nagarjuna University

Jaafar Badr Obald

Masters of Environmental Science, Department of Environmental Science, Acharya Nagarjuna University

Abstract:

To develop a reliable, eco-friendly and easy process for the synthesis of gold nanoparticles using leave extracts of medicinal plant "*Erythrina Variegata*". The use of plant material not only makes the process eco-friendly but also the abundance makes it more economical. In the present research program, cost effective and environment friendly gold nanoparticles were synthesized using the *Erythrina Variegata* leave extract as the reducing agent. The biosynthesized gold nanoparticles were analysed by UV-Vis, FTIR, XRD, EDX, SEM and TEM. The broadening of peaks in the XRD patterns was attributed to particle size effects. On whole, the aunts obtained by the biogenic syntheses have potential biological and medical applications. UV-visible spectrum of the aqueous medium containing gold nanoparticles showed a peak around 537nm. FT-IR analysis confirmed reduction of Au^{3+} ions to Au^0 ions in synthesized gold nanoparticles. The leave extract of "*Erythrina Variegata*" quickly reduces Au^{3+} to Au^0 and enhances the synthesis of gold nanoparticles.

INTRODUCTION

Nanomaterials have received much attention because of their structure and properties differ significantly from those of atoms, molecules, and bulk material.[1] The synthesis of metal nanoparticles has been widely discussed in the literature due to their small sizes, large surface area and unique physical and chemical properties, which have many potential applications.[2-4] Biosynthesis of nanoparticles is budding into a significant approach in nanotechnology.[5,6]

Green chemistry approach method highlights the usage of natural organisms as nontoxic, eco-friendly, reliable and simple.[7,8] Synthesis of nanoparticles using microorganisms, enzyme and plant extract, have been proposed by several researchers[9,10]. Gold nanoparticles have wide range of application which includes biomedical imaging, cancer therapy, diagnosis, biological and chemical sensing. Green synthesis of gold nanoparticles using plants extract such as Neem [11-13], Alfalfa, *Emblica officinalis*, *Cinnamomum camphora*, *Hibiscus rosasinensis*,

Camellia Sinensis, *Coriander leaves*, *Sugar beet pulp Menthapiperita* and *Aegle Marmelos*[14-22] have been reported.

"*Erythrina Variegata*" belonging to the family Fabaceae is commonly known as Tiger claw. *Erythrina Variegata* is a most important species used to treat several ailments in traditional system of medicine.[23-26] "*Erythrina Variegata*" was reported for its antidiarrhoeal, anticancer[27-29], thyroid gland stimulating properties. Since, the plants are rich in phytoconstituents, it was considered as a principle source in pharma and nutraceutical industries.. It has been known to possess antibacterial, antidiabetic, analgesic, antiinflammatory, nephroprotective, and thyroid hormoneregulating activity.[30]

It is a thorny deciduous tree growing to 27 m (89 ft) tall. The leaves are pinnate with a 20 cm petiole and three leaflets, each leaflet up to 20 cm long and broad. It has dense clusters of scarlet or crimson flowers and black seeds.[31-32] It is valued as an ornamental tree. Several cultivars have been selected, including 'Alba'

with white flowers.[33]It was designated the official flower of Okinawa Prefecture in 1967. The deigo flower features in the popular song "ShimaUta" by The Boom, one of the most well-known songs associated with Okinawa. In addition, the use of the wood of the deigo tree is one of the unique characteristics of Ryukyuanlacquerware.[34-35] In our present study, we have demonstrated a suitable green route for the synthesis and characterisation of gold nanoparticles using "Erythrina Variegata" leave extract as reducing agent.[36]

MATERIALS AND METHODS

Materials

Chloro Auric acid (HAuCl₄) was purchased from National Scientific Company, Madurai, India and used as received. Double distilled (DD) water was used for experimental work. Erythrinavariegata leaves were collected from S.F.R College for Women, Sivakasi, Virudhunagar district.

Preparation of Erythrinavariegata leaves extract:

Fresh leaves of Erythrinavariegata washed several times with water to remove the dustparticles and then dried to dark condition to remove the residual moisture and grinded to form powder. 10g Erythrina variegata leaves powder is taken in a beaker and added 100ml of distilled water. Then it is heated and stirred in magnetic stirrer. It is allowed for 30 mins. The Erythrina variegata solution is filtered in ice cold condition and the plant extract is prepared. The extract is stored at room temperature and is used for the biosynthesis of gold Nps.

Synthesis of Gold NPs:

In the typically synthesis process of gold NPs, add 2ml of Erythrina variegatedried leaf powder extract into the 8 ml of goldchloride solution under stirring at 60°C temperature. The bio reduced component was confirmed by using UV-Visible spectrophotometer. A reduction of AuNps was clearly observed when Erythrina variegataleaves extract was added with gold chloride solution within 10 mins. The dark brown solution changed to ruby red colour which indicates the formation of goldNps.

Characterization techniques

UV-visible absorption spectrum was measured using Shimadzu UV-2400 spectrophotometer, Japan. Crystalline metallic gold NPs were examined using an X-ray diffractometer equipped with using Cu-K α radiation ($\lambda = 1.54060 \text{ \AA}$) at 40 kV over the range of $2\theta = 10^\circ - 90^\circ$ with a step size of 0.020 and step time of 160.0s. Phase purity and grain size are determined by XRD analysis. Fourier transform infrared (FTIR) spectra for *Erythrina Variegata* leave extract end capped gold 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) with Energy Dispersive X-Ray Spectrometer (EDS) analysis of synthesized gold NPs was done using a SEM CARL ZEISS EVO 18 and EDS Quantax 200 with X-Flash – Bruker machine. The morphology of the Au NP was analyzed with the TEM (Model JEOL - 2100EX).

RESULTS AND DISCUSSION

UV-visible spectral analysis:

The mixture of leaf extract and HAuCl₄ solution was subjected to UV-visible spectroscopy analysis and it shows a peak at 537 nm corresponds to the wavelength of the Surface Plasmon Resonance of Au NPs (**Figure 1**). Various reports have established that the resonance peak of Gold NPs appears around this region.

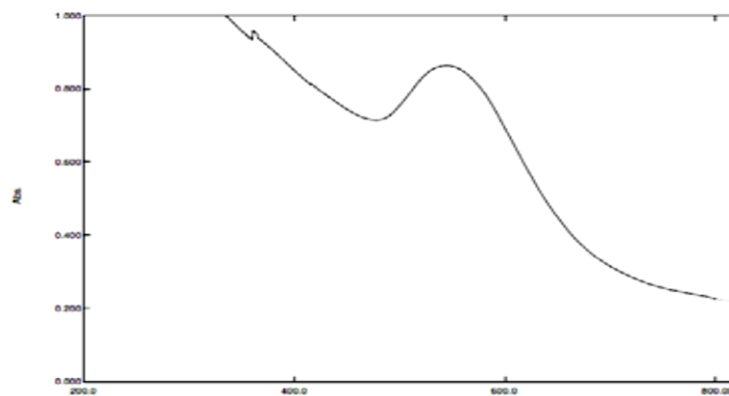


Figure 1: UV-visible spectrum of *Erythrina Variagate* plant extract decorated Gold Nano Particle.

FTIR spectroscopy:

FTIR analysis was performed to identify the possible functionalities of biomolecules responsible for the reduction of the Au⁺ ions and capping of the reduced AuNPs synthesized using *Erythrina Variagate* leaf extract (**Figure2**) showed strong bands at 3379, 2924, 1643, 1550, 1041, 833,763,663,524 and 439 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 1651 and 1041cm⁻¹ due to the C=C stretching and C-O-C stretching respectively. Hence, the main components such as steroids, saponins, tannins, Phenolic compounds, flavonoids, and glycosides present in the leaf extract of *Erythrina Variagate plantare* prime responsible for the observed reduction and capping during the synthesis of AuNPs. The two strong bands recorded at 763 and 439 cm⁻¹ in the spectrum of the synthesized material were assigned to the C-H bending and metal-oxide (Au-O), respectively. The C-H bending peak is due to the reduction of HAuCl₄ to Au NPs by the leaf extract.

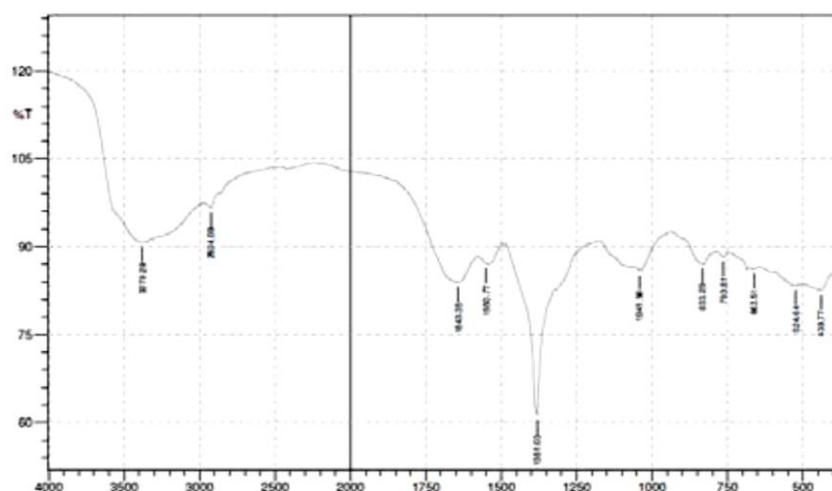


Figure2:FTIR spectrum of *Erythrina Variagate* leaf extract decorated AuNP

X-ray diffraction analysis

X-ray diffraction (XRD) pattern was recorded for the synthesized Au NPs is given in (Figure 3). Three distinct diffraction peaks at 38.73° , 45.03° , 65.41° and 78.26° were indexed with the planes d111, d200, d220 and d311 and these peaks are matched with the face-centered cubic (fcc) structure of gold as per the JCPDS card no.011174. The well resolved and intense XRD pattern clearly showed that the Au NPs formed by the reduction of Au^+ 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 78.26° belongs to d311 crystal plane.

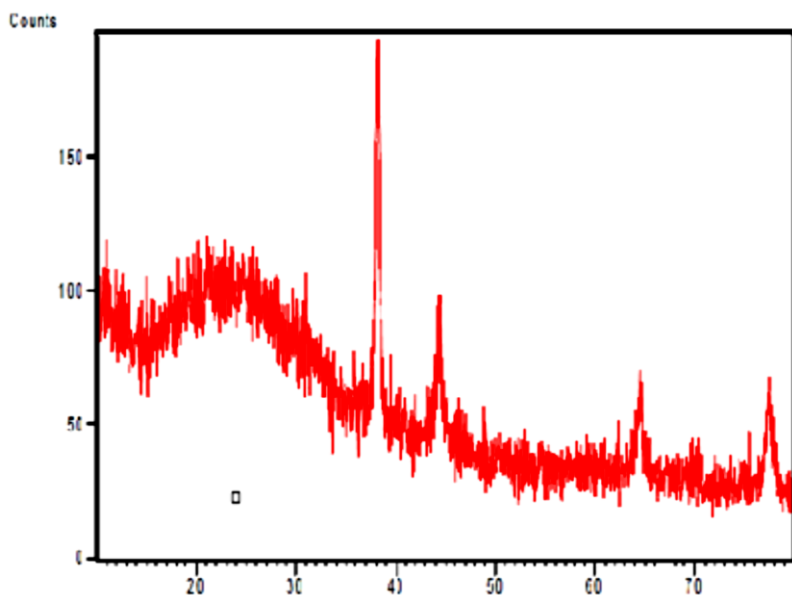


Figure 3: XRD pattern of *Erythrina Variegata* leaf extract decorated AuNP

EDX analysis

Energy-dispersive X-ray analysis (EDX) was performed to determine the elemental composition of the AuNPs synthesized and stabilized by the *Erythrina Variegata* leaf extract. Strong peaks of Au in the area-profile analysis of the synthesized nanoparticles (Fig.4) confirm the formation of AuNPs.

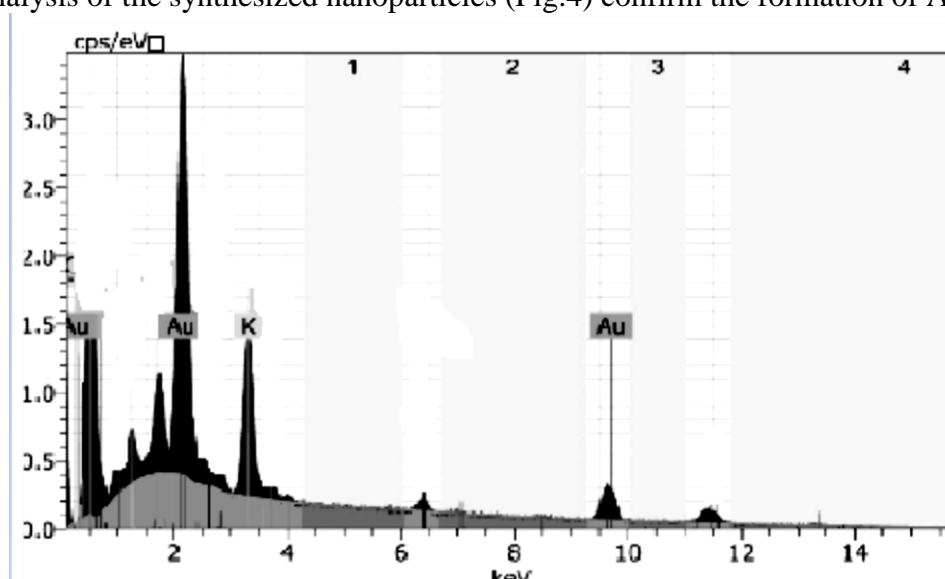


Figure 4. EDAX profile of AuNPs synthesized from *Erythrina Variegata* plant extract.

SEM analysis

The SEM image (**Figure 5**) of plant extract decorated Au NP exhibited the distorted cubical morphology with agglomerated structure. The size was determined as 20-50 nm. The important point noted here is polydispersity of size and shape is minimised.

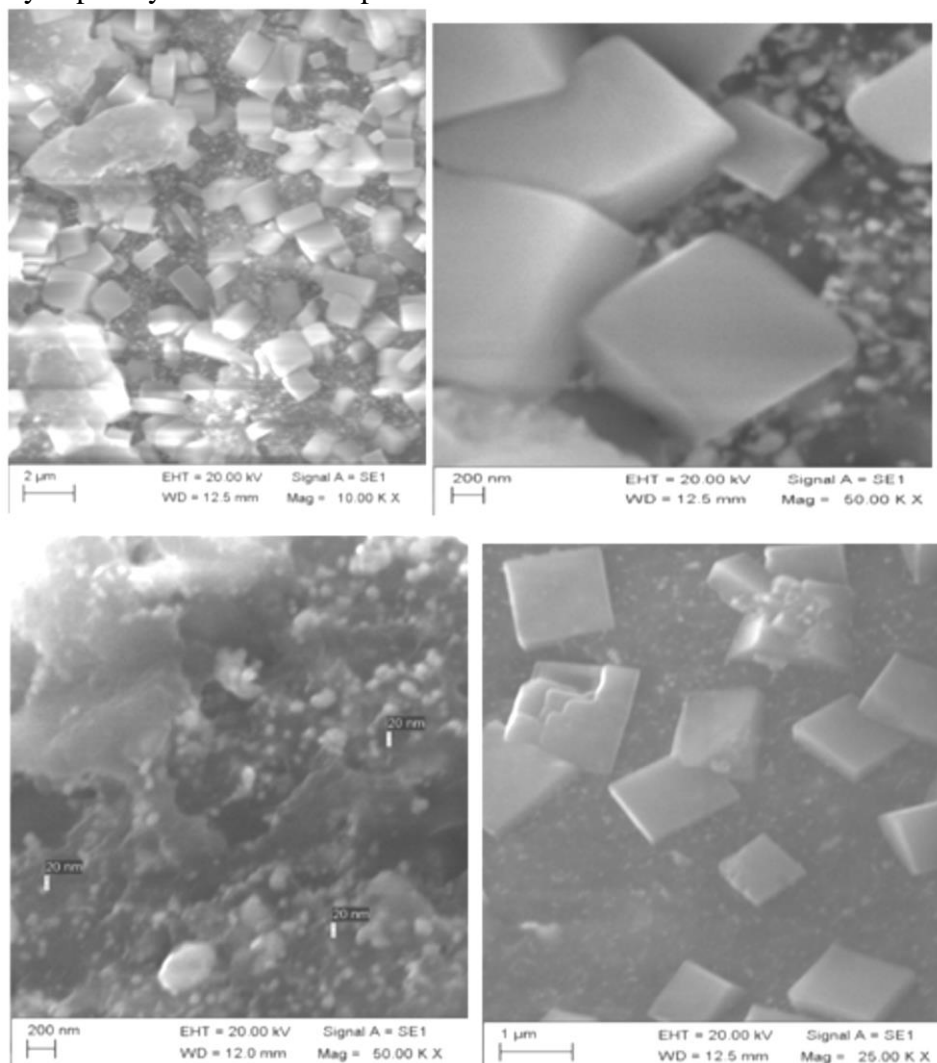


Figure 5: SEM image of *Erythrina Variegata* leaf extract decorated Au NP

TEM Measurements

TEM measurements were performed on a JEOL model 2100EX instrument operated at an accelerating voltage at 200 kV TEM. A TEM study reveals the size and shape of nanoparticles. The shape of gold nanoparticles prepared in this study is cubic with size in the range of 20–50 nm (Figure 6). Some nanoparticles are seen as aggregated. In the surface of the nanoparticles some light colour of materials found that may be the stabilizing agent responsible for the nanoparticles synthesis. The separation between nanoparticles was observed from TEM image due to the presence of capping agent which is characteristics to well dispersed nanoparticles formation in the optimized conditions.

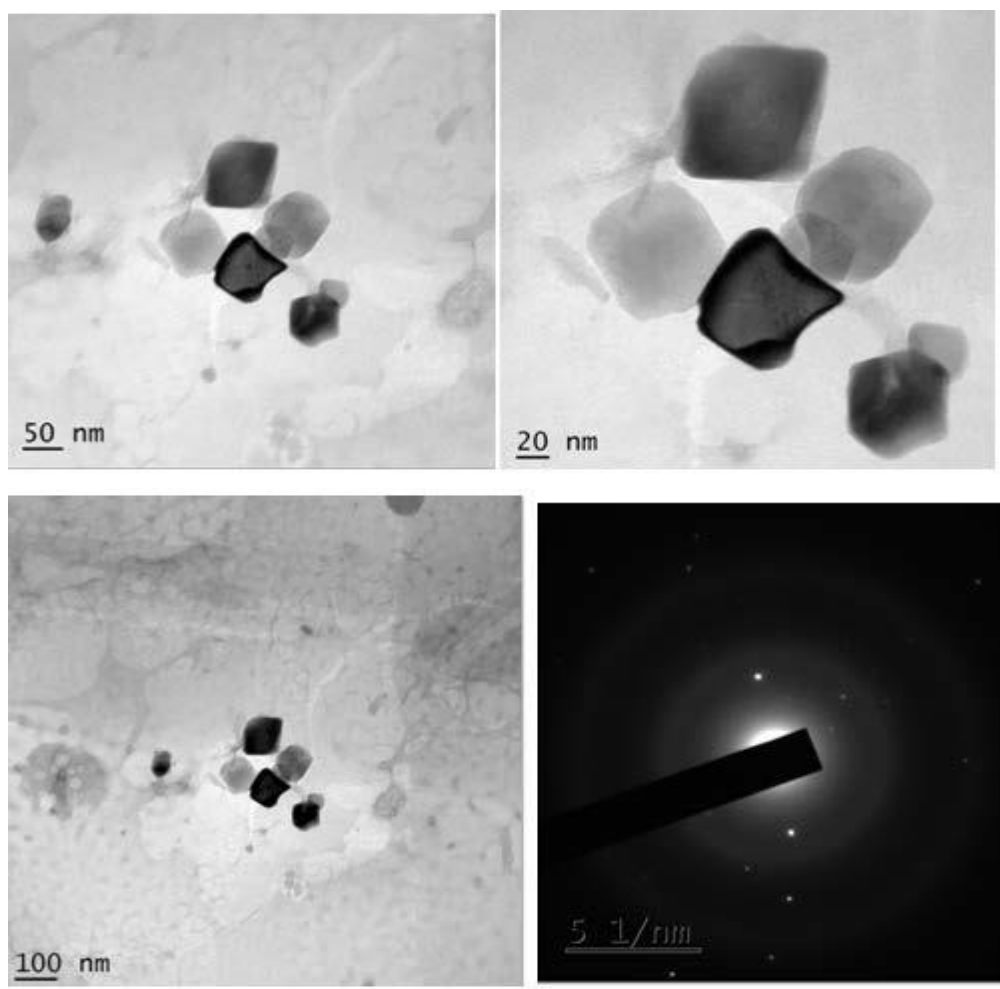


Figure6. TEM image of gold nanoparticle synthesized from *Erythrina Variegata* leave extract

CONCLUSIONS

The reduction of gold ions to gold nanoparticles was achieved using the aqueous extract of *Erythrina Variegata* plant. The nanocube produces many active sites which may be exploited in organic synthesis or in reactions for enhanced catalytic activity. Appearance of a peak at 537 nm confirmed the presence of extract decorated Au NP. FT-IR study showed absorption bands corresponding to the main functional groups present in natural plant extracts. The average particle size of AuNPs was found to be between 20 nm – 50 nm. The AuNPs were crystalline as revealed from XRD studies. The average size of the AuNPs was 20 nm as determined with Debye-Scherrer's equation utilizing XRD data TEM declared the Cubic shaped morphology of Au NP. SEM also confirmed the distorted morphology of Au NP. The present protocol is an eco-friendly and easy

way of gold nanoparticles synthesis under laboratory conditions.

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