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BIOSYNTHESIS AND CHARACTERIZATION OF GOLD NANOPARTICLE FROM *COCCINIA GRANDIS* AND ITS CATALYTIC ACTIVITY

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Keywords:

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ABSTRACT: The fabrication of spherical gold nanoparticles (AuNPs) using the reducing agent and stabilizing agent *Coccinia grandis* is reported here. Irradiation of the reaction mixture under a domestic microwave oven enabled the formation of gold nanoparticles. The successful formations of AuNPs were characterized by UV-Visible spectroscopy (UV-Vis), Fourier transforms infrared spectroscopy (FTIR), X-ray powder diffraction and transmission electronic microscopy (TEM). Chemical components are inherent in the leaf extract which reduces the gold were identified using FTIR Spectra. The crystal structure of the AuNPs was established as a face-centered cube by the Powder XRD analysis. TEM results suggested that under optimized synthetic conditions monodispersed and spherical nanoparticles with an average diameter of 10 ± 2 nm could be achieved. The nanoparticles effectively showed catalytic activity for the reduction of environmental pollution causing methylene blue dye. The study concludes that the synthesized nanoparticles could be considered as environmental protectants due to its potent catalytic activity.

INTRODUCTION: Several methods for the synthesis of noble metal nanoparticles (Ag, Au, Pb, and Pt) are reported in the earlier studies [1-4]. Gold nanoparticles are one of the spotlight materials among noble metal nanoparticles due to their optical properties and wide range of applications in many areas including pharmaceutical, medical, catalysis, and sensors, *etc*. [5-9] Generally, AuNPs are prepared by different types of methods such as ultrasound-assisted processes, laser ablation, electrochemical, thermal decomposition, physical and chemical methods, *etc*. [10-15]

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These methods are the use of toxic substances and expensive which are main factors that make them not so favored methods of synthesis of nanoparticles. Interestingly, green synthesis methods, alternatives to these chemical methods, have been developed recently, replacing the reducing agents with natural compounds. Green synthesis of gold nanoparticles using microorganisms and plant extracts has been extensively studied.

But, the synthesis from plant extracts became the best method due to the efficacy in the reduction of metal ions by the principle biomolecules present in plant extracts and usage of no chemicals that are harmful to the living organisms and environment [16-22]. Earlier reports suggest that the *Coccinia grandis* has been widely studied for its pharmacological activities and regarded as Universal Panacea in Ayurvedic.

The plant parts of *C. grandis* such as leaves, fruits, and roots possess antioxidant, antimalarial, anthelmintic, antipyretic, antiulcer, anticancer and antibacterial activities, *etc*. [23, 24] Hence, the present study aimed to synthesize gold nanoparticles and studying their characterization and catalytic activity.

MATERIALS AND METHODS:

Materials: Auric chloride ($HAuCl_4$) was purchased from Sigma Aldrich, India and all other chemicals used were of analytical grade.

Preparation of *C. gran*dis Leaf Extract: Fresh leaves of *C. grandis* were collected in our home town and the experimentation carried out in Osmania University, Hyderabad. Voucher specimen number - 137. The leaves washed thoroughly using tap water followed by distilled water. 5 grams of 2 day air-dried leaves were taken in a round bottom flask fitted with a condenser and heated for 30 min with 100 ml of distilled water at 40 ºC. It is allowed to reach room temperature and filtered through Whatman no. 1 filter paper. The filtrate kept at 4 ºC in refrigeration for further use.

Synthesis of Gold Nanoparticles: In the microwave-assisted synthesis of gold nanoparticles, 4 ml of leaf extract and 2 ml of 1m MHAuCl$_4$ were taken. It was irradiated in a domestic microwave oven operating at a power of 700 W and frequency of 2450 MHz. The generation of gold nanoparticles was visualized by the onset of red color to the reaction mixture. The monitoring and conformation of the formation of gold nanoparticles were done by taking the UV-Vis spectra.

Characterization Techniques: Spectroscopic studies were carried out using a Shimadzu UV-Vis 3600 spectrophotometer. FT-IR Spectrum was recorded using Shimadzu IR Affinity-1, spectrometer. Powder XRD analysis carried out on a Rigaku-Miniflex method with Cu-Kα radiation. Morphological investigations were obtained from High Resolution-Transmission Electron microscopic (HR-TEM) images using a JEOL JEM-2100.

Catalytic Reduction of MB Dye: In emblematic reduction reactions, the reductions of MB dye were carried out in the presence of $NaBH_4$, AuNPs were used as the catalyst. In this procedure, 3ml of 1 mM MB was mixed with 1 ml of 9 mM $NaBH_4$ and the reaction mixture made up to 10 ml using double distilled water and stirred well-using stirrer for 5 min. 4 ml of these reaction mixtures were taken in a cuvette, and sufficient quantities of AuNPs were added. UV-Vis spectra were recorded at different time intervals and the data was analyzed for the characterization.

RESULTS:

UV-Vis Spectrometer: UV-Vis spectroscopy is used to determine the size and stability of nanoparticles. Usually, the formation of AuNPs was primarily detected using UV-Visible spectroscopy. The change in color is attributed to the SPR occurrence. The UV-Visible absorption spectra showed a maximum peak in the wavelength range of around 520-540 nm **Fig. 1**, which is attributed to the SPR band for AuNPs.

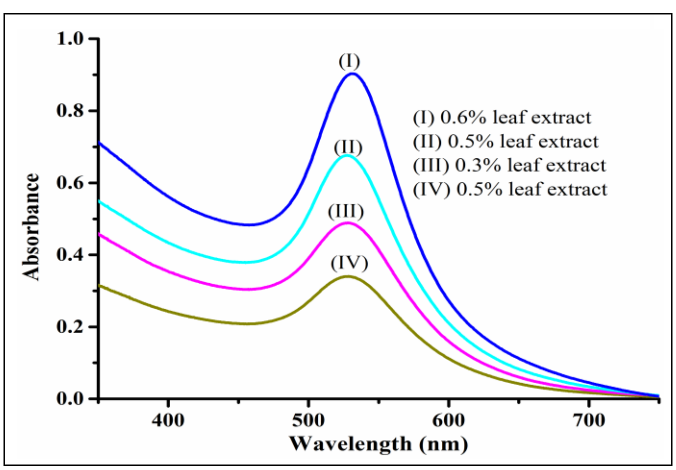

FIG. 1: UV-VISIBLE SPECTRA OF AuNPs SYNTHESIZED WITH DIFFERENT CONCENTRATION OF *C. GRAN*DIS LEAF EXTRACT

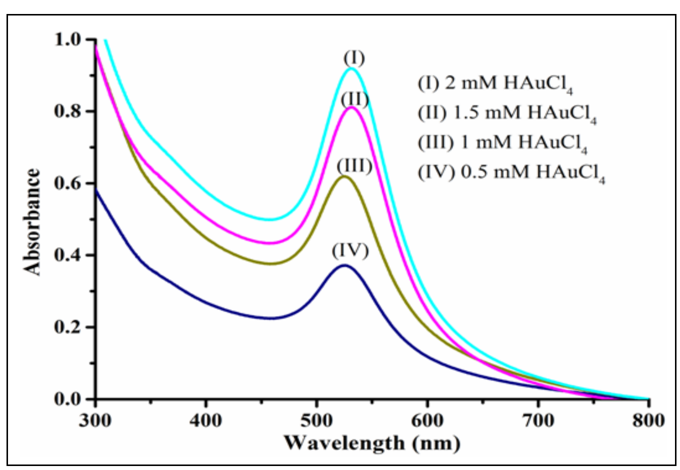

FIG. 2: UV-VISIBLE SPECTRA OF AuNPs SYNTHESIZED WITH DIFFERENT CONCENTRATION OF $HAuCl_4$

Fig. 1 shows the UV-Vis spectra of the synthesized AuNPs with different concentrations of leaf extract (0.2-0.6%) with 2 mM $HAuCl_4$. **Fig. 1** clearly indicates that the formation of AuNPs was increased with an increase in leaf extract concentration. The synthesis of nanoparticles was also examined by changing the concentration of $HAuCl_4$ and the reaction was studied with 0.6% leaf extract **Fig. 2**. The obtained results indicate that with an increase in $HAuCl_4$ concentration, there is an augmentation in the formation of nanoparticles.

FTIR: Fig. 3a and **b** indicate the FTIR spectra of leaf extract and leaf extract capped AuNPs, respectively. The major stretching frequencies in the spectrum of leaf extract are observed at 3386, 1629, 1436 and 1071 cm^{-1} [curve (a) of **Fig. 3**], while the leaf extract capped AuNPs showed characteristic stretching frequencies at 3357, 1605, 1441, 1321 and 1121 cm^{-1} [curve (b) of **Fig. 3**]. The bands observed at 3357 cm^{-1}suggest the –OH group, at 1605 cm the carbonyl stretching vibration, at 1367 cm^{-1} symmetrical stretch of carboxylate, at 1121 cm^{-1} the C-O stretching vibration of ether and alcohol groups. A shift in the peaks of the FTIR spectrum of leaf extract capped AuNPs was observed from 3386 to 3357 cm^{-1}, 1629 to 1505 cm^{-1}. Since, hydroxyl and carboxyl groups were detected by FTIR, it strongly suggested the presence of certain natural products in the reaction medium responsible for AuNPs biosynthesis.

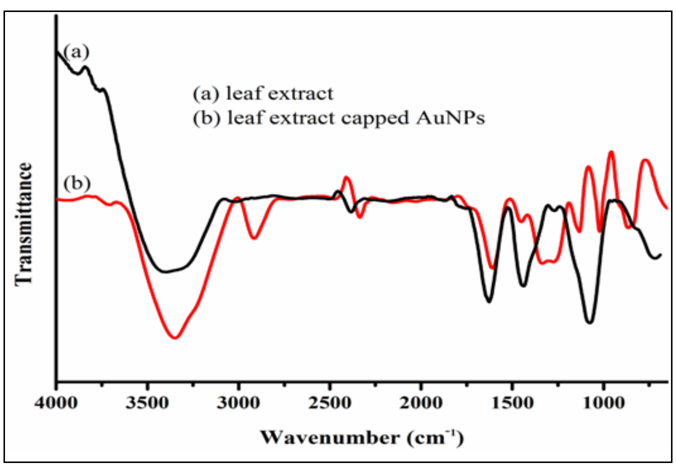

FIG. 3: FTIR SPECTRA OF THE LEAF EXTRACT (A) AND LEAF EXTRACT CAPPED AuNPs (B)

XRD: The XRD pattern indicates the crystalline nature of AuNPs and confirms the crystal structure of AuNPs. There were four well-defined characteristic diffraction peaks at 38.6º, 44.67º, 64.9º and 77.91º respectively, corresponding to (111), (200), (220) and (311) planes of face-centered cubic crystal structure of AuNPs **Fig. 4**. Crystalline size of AuNPs was calculated using the Scherer's formula from the XRD pattern and was found to be around 8.64 nm. The observations from the XRD analysis are in good conformity with the TEM analysis (10 ± 2 nm).

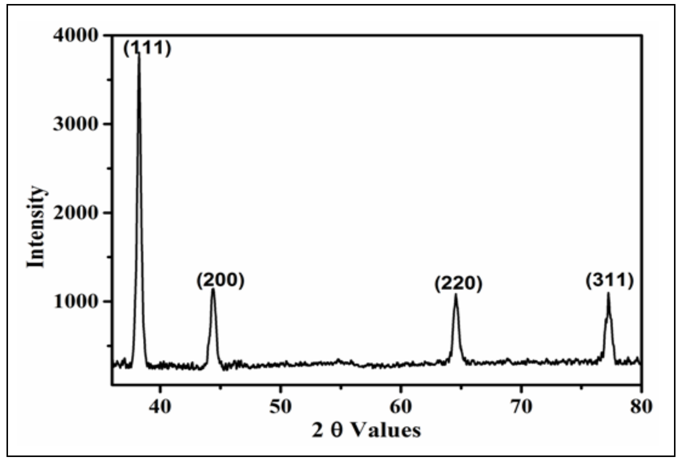

FIG. 4: X-RAY DIFFRACTION PATTERN OF AuNPs, INDICATING FACE-CENTRED CUBIC CRYSTAL STRUCTURE

TEM: In order to reveal the morphology of synthesized AuNPs, we have carried out TEM. It was noticed that the nanoparticles are spherical in shape and nearly monodispersed in nature **Fig. 5**. The size of the particles ranged from 5-25 nm, and the average particle size obtained from the corresponding diameter distribution was about 10 ± 2 nm **Fig. 5**.

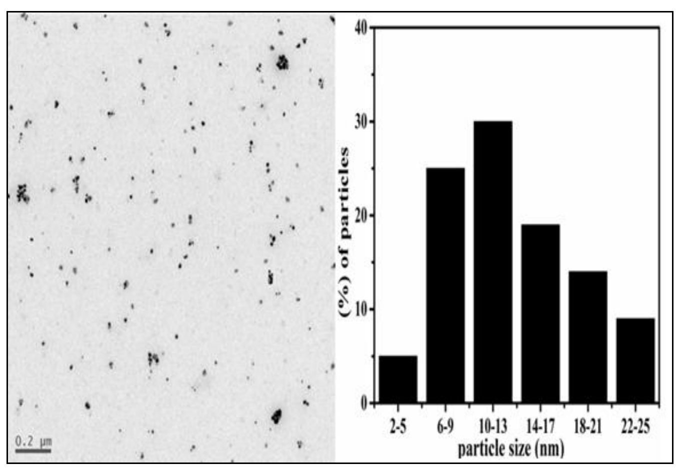

FIG. 5: TEM MICROGRAPH OF AuNPs AND HISTOGRAM SHOWING SIZE DISTRIBUTION OF AuNPs

Catalytic Activity: The catalytic reduction of Methylene blue dye by $NaBH_4$ was preferred to evaluate the performance of the AuNPs as a catalyst. The reaction progress was monitored by UV-Vis spectroscopy. In aqueous medium, MB shows the absorption peak at 462 nm. **Fig. 6** shows the UV-Vis spectra of MB with $NaBH_4$ recorded in the absence of AuNPs for a period of 120 min at room temperature when the AuNPs were added to the mixture of MB and $NaBH_4$, the absorption intensity of MB rapidly decreased at absorption peak 452 nm. **Fig. 7** shows a continuous decrease of MB absorption peak at 462 nm by increasing time. The rate constant (k) was determined from the linear plot of ln (A_O/A_t) versus reduction time **Fig. 8**. The rate constant was found to be 0.212 min^{-1}. Thus, the results suggest that AuNPs have good catalytic activity.

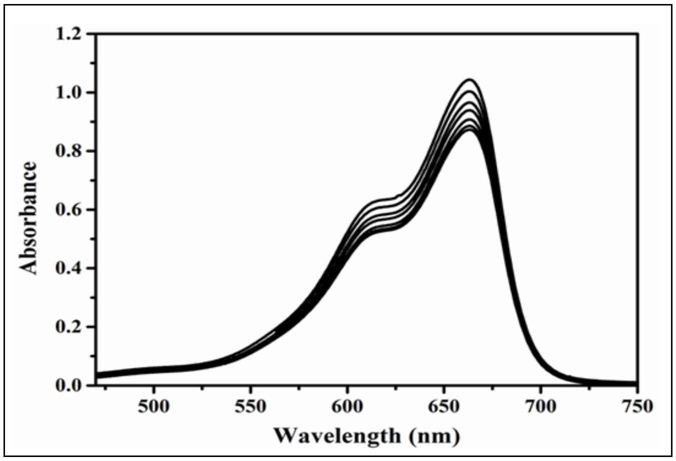

FIG. 6: REDUCTION OF METHYLENE BLUE DYE IN THE PRESENCE OF $NaBH_4$ AND ABSENCE OF AuNPs

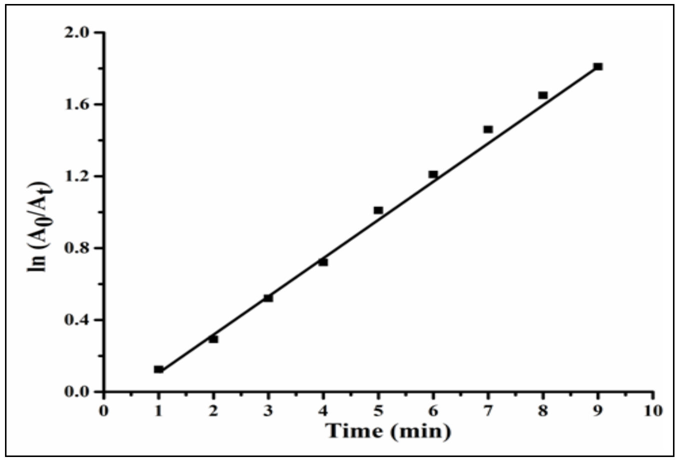

FIG. 8: THE PLOT OF ln (A_0/A_t) VERSUS TIME FOR THE REDUCTION OF METHYLENE BLUE

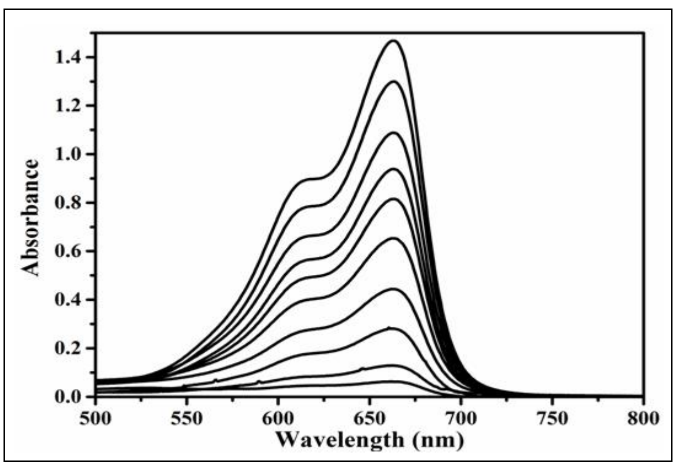

FIG. 7: TIME-DEPENDENT UV–VIS SPECTRA FOR THE CATALYTIC REDUCTION OF METHYLENE BLUE TO LEUCO METHYLENE BLUE BY $NaBH_4$ IN THE PRESENCE OF AuNPs

CONCLUSION: The present study reported an eco-friendly, clean and useful method to synthesis AuNPs by *Coccinia grandis* leaf extract. No chemical material was used in this method. UV-Visible spectroscopy, FT-IR, XRD, TEM techniques were used to characterize AuNPs synthesized. Further, catalytic activity was also studied using methylene blue dye. Gold nanoparticles synthesized with this herb, with a diameter range of 2-25 nm, have a great catalytic effect, in addition, lack of any notable toxicity is another advantage that was evaluated and confirmed during the present study.

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CONFLICT OF INTEREST: Nil

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