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GREEN SYNTHESIS OF GOLD NANOPARTICLES USING *MUSA BALBISIANA* BRACT EXTRACT

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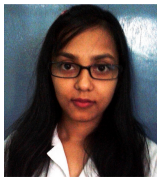
ABSTRACT

Present study explores the biosynthesis and characterization of gold nanoparticles using the ethanolic bract extract of banana *(Musa balbisiana)* flower. On treatment of aqueous solutions of Chloroauric acid with *M. balbisiana* leaf extract, stable gold nanoparticles were rapidly formed in room temperature within 1 hour. The gold nanoparticles were characterized by UV-visible spectroscopy, Transmission Electron Microscopy (TEM), X- ray Diffraction studies (XRD) and Fourier Transform Infra-red Spectroscopy (FTIR). Surface Plasmon Resonance Spectra for gold nanoparticles are obtained at 530nm with pink-red color. Further FTIR analysis was also done to identify the functional groups in gold nanoparticles.

KEYWORDS: ***Musa balbisiana,*** **bract, gold nanoparticles, X ray diffraction**



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INTRODUCTION

In recent years utilization of various plant extracts for biosynthesis of gold nanoparticles has gained much importance due to the enhancement of chemical, physical, biological and optoelectronic properties of the particles formed by this green process[1] .Although various chemical and physical methods may successfully produce pure as well as defined metal nanoparticles, these methods are quite expensive and potentially dangerous to the environment [2] . Studies have shown that even the purest forms of AuNPs synthesized by conventional physical and chemical methods , carry traces of unreacted reducing or stabilizing agents . To overcome such inherent problems associated with AuNPs alternative methods has been explored, which has resulted in exploration of green synthesis. Green methods rely on biological resources that are capable of replace synthetic reducing and stabilizing agents[3] .In recent years the biosynthesis of AuNPs by various plants such as Aloe vera [4], Papaya [5], Lemongrass [6], *Cinnamommum camphora* [7], Neem [8], Tamarind [9] , *Emblica officinalis* [10] , Clove [11] and *Syzygium aromaticum* [12] has been reported. A survey of literature reveals that banana bract (*M. balbisiana*) extract has not been used for the synthesis of AuNPs . In the present study, we describe a method of green synthesis of AuNPs using ethanolic bract extract from inflorescence of *Musa balbisiana.* The *Musa balbisiana*, a herbaceous plant with medicinal properties belonging to the family *Musaceae* . It is commonly known as Banana in English and 'Athia kol' in Assamese. It has been reported that banana contains flavonoids, polyphenols, anthocyanins, minerals, bioactive amines such as dopamines, serotonin etc [13],[14]. Flavonoids and polyphenols naturally occur in the plant kingdom and generally present in fruits, vegetables, leaves, nuts, seeds, flowers and barks [15]. It has been reported that *Musa balbisiana*, contain nonmethylated anthocyanin, delphinidin-3-rutinoside, and cyanidin-3-rutinoside[16] . Qualitative test of the Ethanolic Bract Extract (EBE) of *Musa balbisiana* has confirmed the presence flavanoids, polyphenols and anthocyanin. Banana bracts are abundant edible residues of banana production and are consumed as a vegetable in most banana producing countries, including India.

MATERIALS AND METHODS

(i)PREPARATION CHLOROAURIC ACID ($HAuCl_4.3H_2O$)

The Chloroauric acid ($HAuCl_4.3H_2O$) was purchased from Hi-Media chemicals. 1mM $HAuCl_4$ stock solution was prepared using double distilled water. All other reagents used in the experiments were of analytical grade.

(ii)PREPARATION OF THE EXTRACT

Musa balbisiana inflorescence was collected from banana farm, near Gauhati University,Assam (Figure-2). Prior to the experiment, bracts were cleaned thoroughly with deionized water and dried at room temperature(25^0C) for 2 days. For the extraction 10 grams of dried bracts were homogenized in a mortar and pestle and mixed with 100 ml ethanol and incubated under room temperature . After 24 hrs the ethanolic bract extract (EBE) was filtered and stored at 4 ◦C for further experiments.

Figure 1
***Musa balbisiana* inflorescence**

(iii)SYNTHESIS OF GOLD NANOPARTICLES

To study the effect of EBE concentration on AuNP synthesis, different aliquots of the extract were taken (1%,2%, 3%, 4%,5%,6%, 7%,8%,upto 9%) and mixed with 1mM aqueous Au^{3+} solution.

To carry out the experiments a final reaction volume of 4 ml was maintained and observed for color changed in the aforementioned range of EBE (1 to 9 % volume). All the experiments were performed at room temperature(25^0C) and stirred continuously for 2-3 minutes.

(iv)CHARACTERIZATION OF GOLD NANOPARTICLES

The resulting gold nanoparticles were characterized with conventional instrument based analysis. Product samples were subjected to UV-vis spectroscopic studies [Shimedzu(UV 1601PC)] , which is the most confirmatory tool for the detection of surface plasmon resonance property (SPR) of AuNPs.

Morphological details of the synthesized AuNPs were revealed under a transmission electron microscope (JEOL,JEM-2100 Electron Microscope,180 kV). To prepare for TEM, one or two drops of the AuNP solution was deposited onto carbon-coated copper grids and air-dried well, before mounting. Crystalline nature of AuNPs was confirmed by X-ray diffractograms (XRD). For XRD measurement AuNPs solution was spread on a cleaned glass slide and subsequently air-dried completely. The measurement was performed on a Bruker D8 ADVANCE . X-ray powder diffractometer using CuKα (k = 1.54 A °)) in the 2Ɵ range of 0–90 operated at a voltage of 40 kV and a current of 40 mA.. The interactions of bract extract and AuNPs were analyzed with Fourier transform infra-red spectroscopy (FTIR). For FTIR measurements, AuNPs solution was centrifuged at 20,000 rpm for 20 min. The pellet was washed three times with copious amount of deionized water by centrifugation to get rid of the EBE biomolecules not capped on AuNPs surfaces followed by re-dispersion of the pellet in deionized water. The purified sample was lyophilized to get the dried and powdered form of AuNPs. The AuNPs sample was analyzed using a FT–IR spectrophotometer (Bruker Vector 26 spectrophotometer) in the range of 400–4000 cm^{-1}.

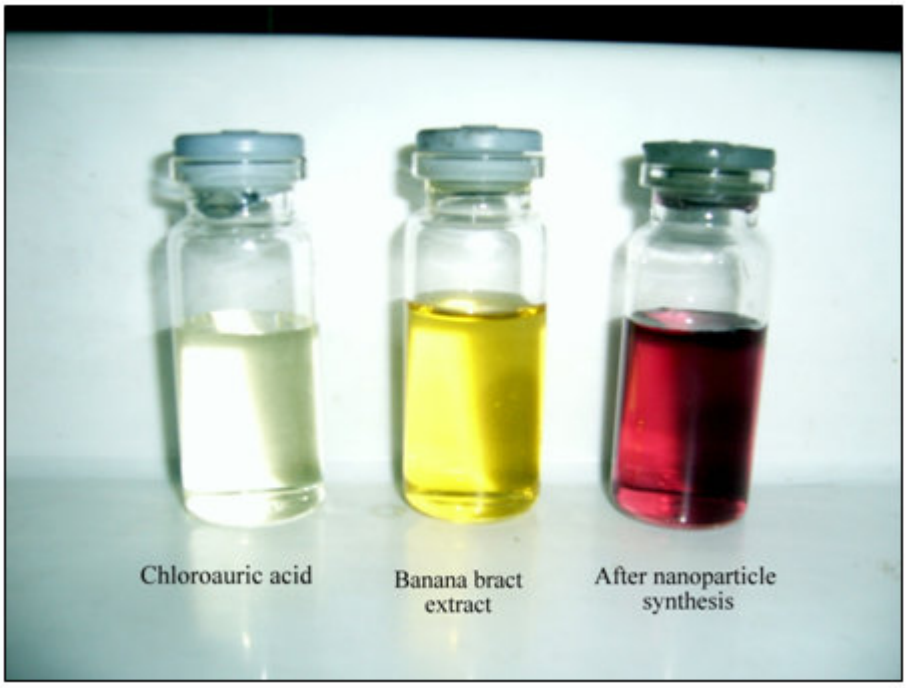

Figure 2
Photograph showing 1mM Au^{3+} solution, ethanolic bract extract (EBE) and solution containing gold nanoparticle .

RESULTS AND DISCUSSION

The unique surface plasmon resonance (SPR) property of AuNPs originating from the collective oscillation of conduction band electrons on absorption of visible light provides an easy way for visual detection of AuNPs synthesis. The change in the original yellow color of gold aqueous solution containing gold cations to different shades of red color indicates colloidal gold that can be best studied with UV–vis absorption scanning of the colloidal solution. In the AuNPs synthesis experiment with 9 different volume fractions (1–9%) of EBE at room temperature, the change in the original yellow color of the reaction mixtures within 1 hr visually confirmed successful reduction of $HAuCl_4$ to AuNPs. UV–vis scanning of the product showed SPR absorption bands and peaks (Figure-3).

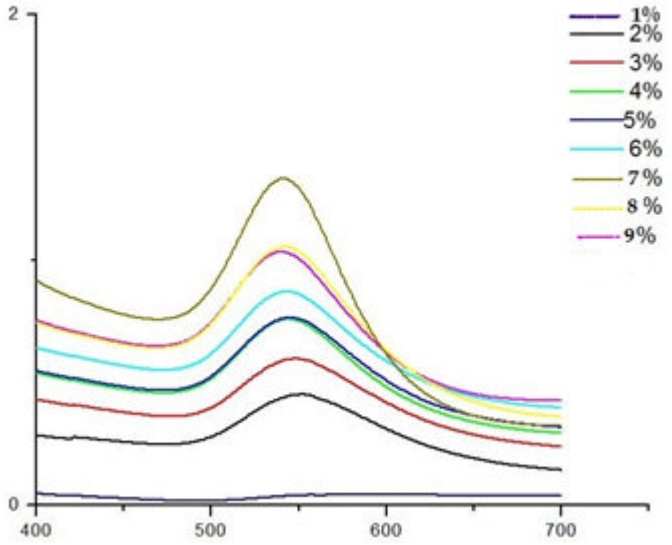

Figure 3
UV-vis spectra of AuNPs synthesized by reacting 1mM $HAuCl_4$ aquous solution with different volume fractions(1-9%) of EBE of Musa balbisiana.

1% EBE was unable to reduce Au^{3+}. Reduction of Au^{3+} ions occurred from 2%of EBE and the SPR band intensities were less and broad which suggest partial reduction of Au^{3+} ions and formation of larger AuNPs . From 4% of EBE promising results were obtained in the sense that SPR intensities changed drastically with blue shifted SPR peaks. Further increase in the EBE volume fractions (5%,6%, 7%,8%,9%) caused change in both in SPR intensities and peaks. For 7% EBE concentration aborption peak occured at around 530nm. Furthermore, increase in EBE concentration (8% to 9%) did not always induce nanoparticle synthesis. Henceforth, 7% concentration of EBE is optimum for AuNP synthesis, beyond which, no significant increase in nanoparticle concentration was observed. Noruzi *et al.* 2011 reported the synthesis of AuNPs from *Rosa hybrida* petal extract and recorded UV-Vis spectra in the range of 200-1000 nm and found that at extract concentration of 10% there was no synthesis; they also investigated the effect of extract quantity and found that surface plasmon resonance band decreases when extract quantity increased which is similar to present findings. Earlier AuNP synthesis was also reported from *Rosa damascene* flower extract and surface plasmon band was obtained at a UV-vis range of 510-550nm. It was also reported that with an increase in extract concentration, the peak absorbance also increases which is contradictory to our result. [17,18] TEM analysis of AuNPs synthesized from 9% EFE volume fraction and 1 mM $HAuCl_4$ at room temperature revealed abundance of spherical particles (Figure-4A). Selected-area electron diffraction pattern (SAED) confirmed the crystalline nature of AuNPs (Figure-4B). Here observed four Debye – Scherrer's rings corresponding to the (1 1 1), (2 0 0), (2 2 0) and (3 1 1) gold crystalline planes. The high resolution TEM (HRTEM) image displayed clear lattice fringes on the particle surface (Figure-4C). The average particle size was calculated to be around 8.0 ± 2 nm [18-19] (Figure-4D).

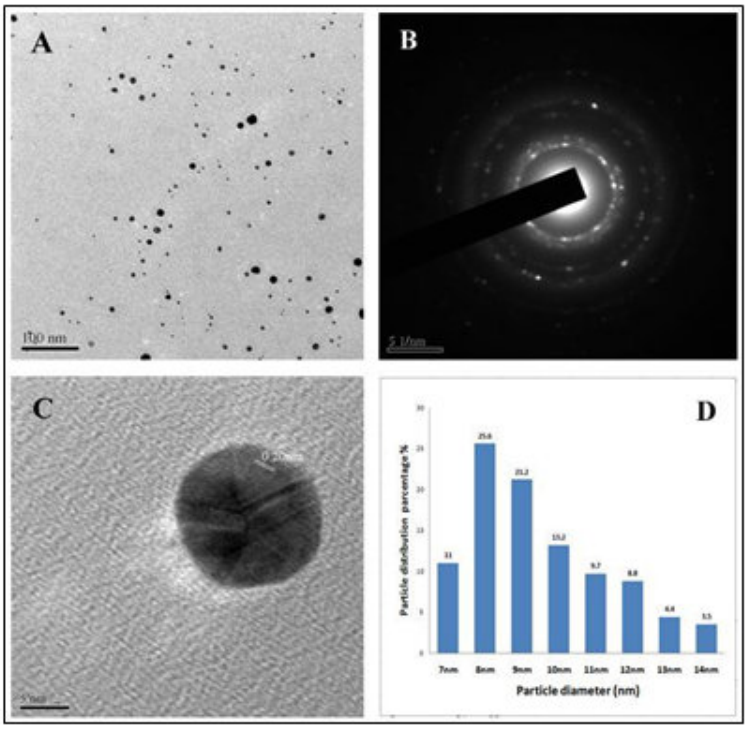

Figure 4
A.TEM, B.SAED, C. HRTEM of AuNPs synthesized with optimized EBE volume fractions, D.size distribution histogram.

XRD pattern of the AuNPs showed four prominent Bragg reflections which were indexed on the basis of fcc structure of gold (Figure-5). The intensities as confirmed from JCPdf 00-001-1172,of the (1 1 1), (2 0 0) and (2 2 0) diffraction peaks were corresponded to 38.2^0, 45.2^0,and 65.8^0 respectively and confirmed the crystalline nature of the synthesized GNPs [3, 18,19,20].

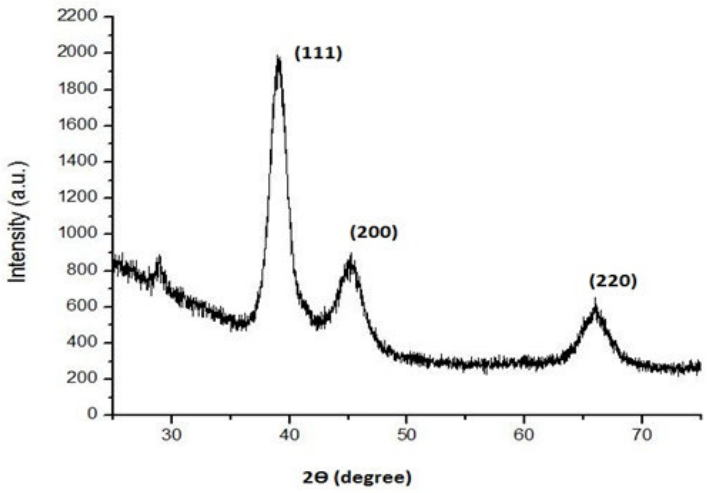

Figure 5
XRD pattern of AuNPs synthesized with optimized Musa balbisiana bract extract.

Figure-6 represents the FTIR peaks for detection of functional groups n the EBE. The FTIR spectra obtained after synthesizing AuNPs revealed that after interaction of AuNps the original transmittance value of EBE were altered considerably . Farther the FTIR analysis strongly supports the capping behavior of EBE which ultimately imparts high stability to the synthesized AuNPs. The peaks obtained from EBE corresponds to various phytochemicals present in it. FTIR spectrum of dried EBE shows strong IR bands at the regions of 1036 cm^{-1} (aliphatic amines),1306cm^{-1}(aromatic amines),1647cm^{-1}(amide), 2934cm^{-1}(alkane), 3579cm^{-1} (hydroxyl). After synthesis these values change to 1047cm^{-1}(amine),1399cm^{-1}(aromatic amines),1639cm^{-1}(C=C of benzene),2939cm^{-1}(alkane),3414cm^{-1}(hydroxyl), which confirms interaction of EBE during AuNP synthesis. [21-24]

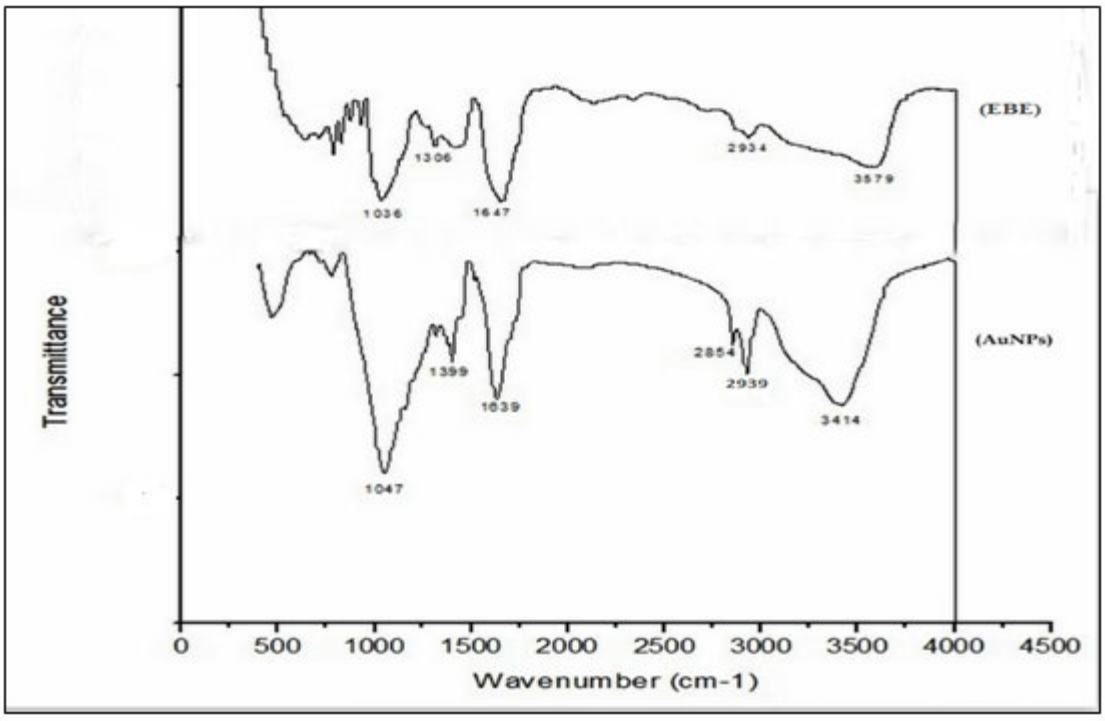

Figure 6
FT-IR spectra of EBE and AuNPs synthesized from EBE under optimized conditions.

The antioxidant compounds present in *M. balbisiana* bract extract act as reducing agents, reversing oxidation by donating electrons and hydrogen ions. We can presume that the various phytochemical such as anthocyanins, polyphenols, flavanoids present in *M. balbisiana* bract extract appear to be responsible for accelerated reduction and capping of *M. balbisiana* bract extract.

CONCLUSION

In conclusion *M. balbisiana* bract extract is found suitable for the rapid green synthesis of AuNPs within 1 hour. The concentration of leaf extract play an important role in green synthesis of AuNPs. Further the formation of AuNPs was observed from the results of UV-vis, TEM, XRD. AuNPs thus synthesized was found stable for over a period of one year. The FTIR results revealed strong interaction of EBE during AuNP synthesis as detected by change in IR bands. This simple, efficient

and rapid procedure for green synthesis of AuNPs can be used in various biomedical and biotechnological applications in future.

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