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Green Synthesis and Characterization of Gold Nanoparticles Using Terminalia chebula Leaf Extract

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Abstract

Biosynthesis of nanoparticles as an emerging highlight of the intersection of nanotechnology and biotechnology has received increased attention due to growing need to develop environmentally benign technologies in material synthesis. In this investigation, a novel technique for biosynthesizing of gold nanoparticles (GNPs) using *Terminalia chebula* leaves as reductant due to presence of phenol groups was reported. The GNPs were characterized by UV–Vis Spectrophotometer, XRD, SEM with EDAX and TEM. The immediate change in color from pale yellow to ruby red indicated the reduction of Au^{3+} ions to Au^0. UV–Vis spectroscopy exhibited an absorption peak at 544 nm. FESEM analysis showed the presence of polydispersed spherical GNPs. The EDAX spectrum of the solution containing GNPs confirmed the presence of elemental gold signals. The TEM results indicated that the GNPs were near spherical in structure and almost 31.84 nm in diameter. X-ray diffraction pattern showed high purity and face centered cubic structure of GNPs.

Keywords: *Terminalia chebula* GNPs, XRD data, TEM, SEM UV-data

1. Introduction

Metallic nanoparticles (NPs) are of great interest because of the modification of properties observed due to size effects, modifying the catalytic, electronic, and optical properties of the monometallic NPs. biosynthesis of NPs have been received considerable attention due to the growing need to develop clean, nontoxic chemicals, environmentally benign solvents and renewable materials metallic NPs are presently applied in different fields such as electronics, biotechnology, chemical and biological sensors, DNA labeling, drug delivery, cosmetics, coatings and packaging [[1–2]. Use of biological organisms such as microorganisms, plant extract or plant biomass could be an alternative to chemical and physical methods for the production of NPs in an eco-friendly manner [3–5]. Various properties of gold nanoparticles (GNPs) like optical, thermal, catalytic and physical depend up on their size and shape had attracted attention toward the synthesis of GNPs. Most of the available chemical processes for synthesis of GNPs involve toxic chemicals that get adsorbed on the surface, leading to adverse effects in medical applications. Presently there is a growing need to develop environmentally benign process for rapid synthesis of NPs [6]. Phytochemical constituents in the plants extract like essential oils (terpenes, eugenols, etc.), polyphenols and carbohydrates these compounds contain active functional groups, such as hydroxyl, aldehyde and carboxyl units which may play important role for reduction of $HAuCl_4$ to GNPs [7]. Green GNPs derived from phytochemicals can be show excellent biocompatibility, such biogenic GNP with high biocompatibility may be clinically useful as contrast enhancement molecular imaging agents for cancer diagnosis [8].

In the present study, we selected the leaves of *Terminalia chebula* (Family: Combretaceae) as reductant for the synthesis of GNPs. It is commonly known as black myrobalan and haritaki, is an important plant used in indigenous systems of medicine as remedy for fever, cough, diarrhoea, gastroenteritis, skin diseases, candidiasis, urinary tract infection and wound infections. *T. chebula* has been reported to possess antioxidant, antidiabetic, anticancer, antimutagenic, antiviral, antibacterial and radioprotective activity [914].

2. Materials and Methods

2.1 Green synthesis of GNPs

1.25 ml of *T. chebula* leaf extract was mixed with 50 ml of 1 mM chloroauric acid in a 100 ml conical flask. The reaction mixture was kept aside in a room temperature for 3 min. The color change from yellow to deep ruby-red indicated the formation of GNPs. The reaction mixture was centrifuged at 14,000 rpm for 15 min and the supernatant was discarded. The GNPs obtained as a pellet was dispersed in deionised water for further studies.

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2.2 Characterization of GNPs

2.2.1 UV–Visible Spectroscopy

UV–visible spectrophotometer is the one of the important techniques for analysis of synthesized GNPs. After the synthesis, the pure GNPs were characterized by UV–visible absorption spectrophotometer (SPECORD 200 plus, Analytikjena, Germany). The color change in reaction mixture (metal ion solution + plant extract) was recorded through visual observation. Synthesized GNPs was confirmed by sampling the absorption maxima was scanned by UV–visible spectrophotometer at the wavelength of 400–800 nm.

2.2.2 SEM with EDAX Spectroscopy

The surface morphology of green GNPs were measured by High Resolution Field Emission Electron Microscope with EDS, nano manipulation system available in SRM University, Chennai. Dry powder of green GNPs was loaded on the stub using double sided adhesive conductive carbon tapes and analyzed.

2.2.3 HR-TEM analysis

HR-TEM images were obtained by using TEM, PHLIPS, CM200, 200Kv in SAIF MUMBAI. The typical HR-TEM images obtained for GNPs sample under different magnifications.

2.2.4 X-ray Diffraction (XRD) Measurement

Determination of crystallinity, phase purity, lattice properties and identification of GNPs was done by XRD studies using powder diffractometer with Cu-Kα radiation, operating at 40 kV and a current of 40 mA (X-ray Diffractometer, XPERT-PRO, at SRM University, Kattankulathur).

3. Results and Discussion

3.1 Visual observation

The preliminary phytochemical analysis shows that *T. chebula* leaves was rich in flavonoids with antioxidant property, would serve as a reducing agent in the preparation of GNPs from chloroauric acid. In a pilot experiment, the extract of *T. chebula* leaves and chloroauric acid were mixed together and irradiated in a microoven for 60 seconds. A clear color change from pale-yellow to ruby-red was observed within a minute, indicating *T. chebula*-mediated transformation of chloroauric acid into GNPs (Fig. 1).

Fig. 1 Formation of GNPs

3.2 UV–Visible Spectral Analysis

As shown in UV–visible spectra (Fig. 2), the SPR bands centered between 500 and 600 nm confirms the formation of GNPs in the solution. The appearance of the peak was due to the size dependant quantum mechanical phenomenon called Surface Plasmon Resonance (SPR). This effect becomes influential when the De-Broglie wavelength of the valence electrons becomes equal to or less than the size of the particle (<50nm) [15]. SPR bands of the colloids are centered at 544 nm. The bands are broad and the intensity increases indicating increase in production of NPs.

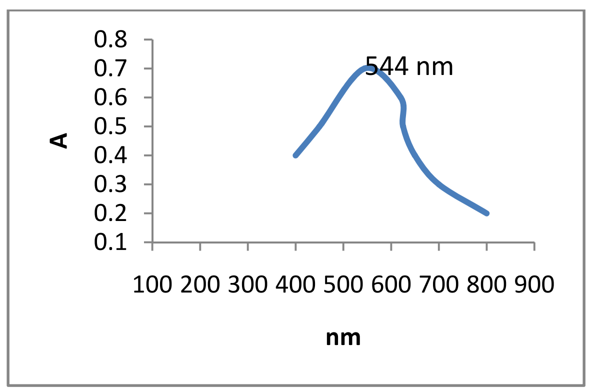


Fig. 2 UV–Vis spectrum of GNP

3.3 SEM with EDAX

The FESEM image (Fig. 3) of the GNPs in sample confirmed that the particles are irregular spherical, hexagonal, triangular and elongated shapes. Analysis through energy dispersive X-ray (EDAX) spectrometers confirmed the presence of elemental gold signal of GNPs shown in Fig. 4. EDAX analysis showed the presence of strong elemental gold peak (95.95 wt%) and weak carbon peak (1.19 wt%). The carbon peak might be due to the presence of biomolecules bound to the surface of GNPs.

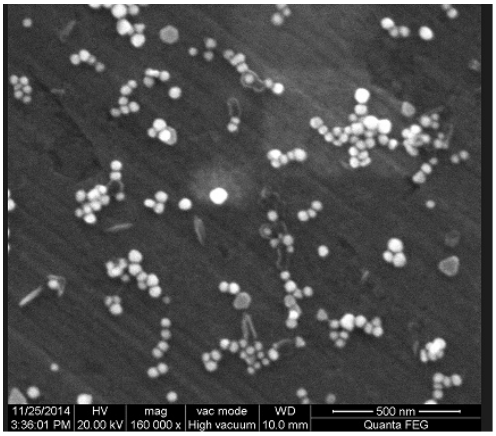


Fig. 3 FESEM of GNPs

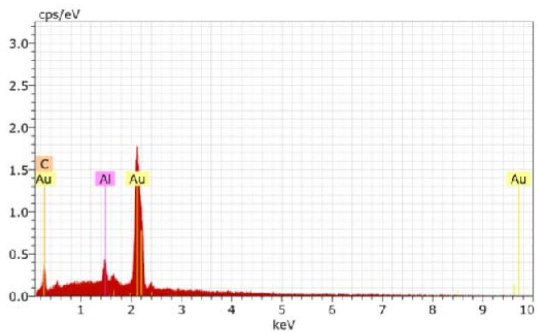
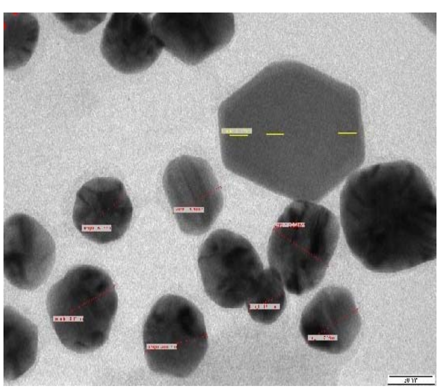


Fig. 4 EDAX of GNPs

3.4 TEM Analysis

Figure 5 shows the HR-TEM image for GNPs synthesized using *T. chebula* leaves. The synthesized GNPs were near spherical and polydisperse with an average diameter of 31.84 nm. Selected Area Electron Diffraction (SAED) pattern for the GNPs were given. The ring like pattern indicated the crystalline structure of GNPs [16].



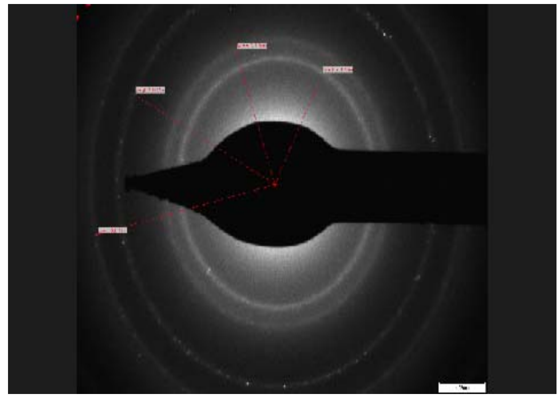


Fig. 5 HR-TEM image of GNPs

3.5 XRD Analysis

XRD spectra of *T. chebula* leaves GNPs (Fig. 6) exhibited diffraction peaks corresponding to (111), (200), (220) and (311) phases in the 2θ range of 30°–90°. In the XRD pattern, diffraction peaks at angles of 38.29°, 44.7°, 65.20° and 78.53° could be assigned to face-centered cubic (fcc) metallic gold (111), (200), (220) and (311) facets of the gold crystals, respectively [17].

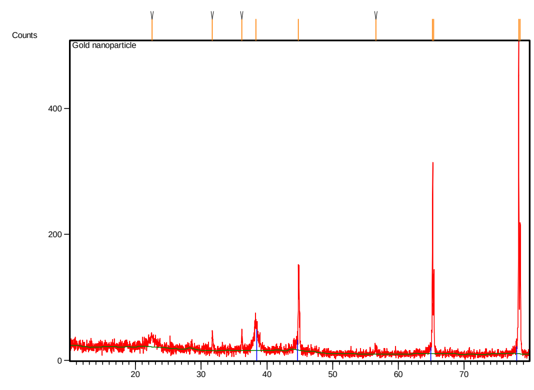


Fig. 6 XRD pattern of GNPs

Conclusions

Green mediated GNPs of are synthesized using methanolic extract of *Terminalia chebula* leaf. The change in color from pale yellow to ruby red indicated the reduction of Au^{3+} ions to Au^0 . SPR bands of the colloids were centered at 544 nm. The colloid obtained by rapid reduction was found to consist of well- dispersed nearly spherical particles having size around 31.84 nm. The nanoparticles are found to be highly crystalline as evidenced by the peaks in the XRD pattern corresponding to Bragg reflections from the (1 1 1), (2 0 0), (2 2 0) and (3 1 1) planes of the fcc structure.

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