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Rapid Biosynthesis of Nano Gold by Dielectric Heat

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ABSTRACT

The development of rapid and reliable processes for the synthesis of nanosized materials is of great importance in the field of nanotechnology. Microwave assisted route for the synthesis of nanomaterials has gained importance in the field of synthetic technology, because of its faster, cleaner and cost effectiveness than the other conventional and wet chemical methods for the preparation of metal nanoparticles. The gold nanoparticles were synthesized using *Cassia auriculata* leaf extract by applying dielectric heat in microwave oven. The nanoparticles were examined using UV-Visible Spectroscopy, Fourier Transform Infrared, X-Ray Diffraction and Transmission Electron Microscopy analysis. The formation of nanoparticles by this method is extremely rapid, requires no toxic chemicals and the nanoparticles are stable for several months. In this study we were able to synthesis nanoparticle within 30sec by microwave irradiation.

KEYWORDS: Nanotechnology, gold nanoparticle, *Cassia auriculata*, dielectric heat.

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INTRODUCTION

Nowadays, nanotechnology has become a part of our daily life in various forms such as cosmetics, electronics, biosensors, pharmaceuticals, and computer sciences. Among the incredible growth of this field of science, bionanotechnology as a leading science plays an important role in the development of biosynthetic and eco-friendly approaches for synthesis of nanostructures. Nanoparticles have found usage in many applications such as catalysis, sensors, drug delivery, optoelectronics, and magnetic devices [1],[2].Gold nanoparticles possess catalytic activity [3], sensors [4], development of biosensors,[5] and in medicine[6].However, spherical gold nanoparticles have been used to generate functional electrical coatings.[7].Metal nanoparticles have also been synthesized by techniques such as sonochemical [8], radiolytic, UV irradiation, Near-IR laser irradiation [9], Ƴ-irradiation [10], laser photolysis [11]. Microwave-assisted carry out the reaction fast, suppress the enzymatic action and to keep the process with clean-green environment [12]. Microwaves are electromagnetic waves. Microwave heating is well known in the food industry and of late has found a number of applications in chemistry especially in organic chemistry [13]. In a microwave device, heating is created by the interaction of the permanent dipole moment of the molecule with high frequency (2.45 GHz) electromagnetic radiation. In comparison with conventional heating, this novel method can shorten reaction time by a factor of approximately 20. Using microwaves, heating is not only quick but also uniform. The maximum attainable temperature higher, but the rate of heating is also much more rapid. Instead of relying on conduction, samples are heated by the coupling of microwave radiation with the solvent, a phenomenon known as dielectric heating. The ability of any material to absorb microwave energy is expressed by its dielectric loss factor combined with the dielectric constant. The microwave radiation heats up a material through its dielectric loss, which converts the radiation energy into thermal energy. This is particularly being exploited for making both metal and semi-conductor nanoparticles [14], [15] as uniform heating may result in narrowly distributed particles. Recently, different nanoparticles have been prepared using the microwave technique [16], [17], [18], [19], [20], [21], [22].

Several plants have been successfully used for efficient and rapid extracellular synthesis of gold nanoparticles. Leaf extracts of geranium (*Pelargonium graveolens*)[23], *Cinnamommum camphora* [24], *Aloevera* [25], tamarind (*Tamarindus indica*)[26] and the bacteria[27], fungi [28]and algae[29] have shown potential in reducing Au(III)ions to form gold nanoparticles Au(0).

Cassia species have been used as traditional medicine for centuries. The whole plants have been employed in herbal medicine around the world [30]. *Cassia auriculata* is a common plant, profoundly used as antipyretic (Wealth of India), hepatoprotective [31], antidiabetic, antiperoxidative and antihyperglyceamic [32], conjunctivitis and ophthalmia [33], ulcers, leprosy, skin and liver diseases. Although there are several reports on synthesis of silver nanoparticles from plants and its antimicrobial activity [34]. On the contrary, gold has low toxicity to biological systems, whether bacteria, animal, or human, due to its elemental properties [35].Gold in nanoscale display novel properties and have diverse activities that make it appropriate for therapeutic use and broad applications in nanobiotechnology [36],[37]. In this paper we report the biosynthesis of pure metallic gold nanoparticles which is rapid, simple and “green” by reducing aqueous gold chloride solution via the extract of *Cassia auriculata* via microwave (MW) irradiation.

MATERIALS AND METHODS

Plant collection and Extract preparation

The healthy leaves of *Cassia auriculata* were collected from the botanical garden Gulbarga University, Gulbarga. The leaves were gently washed with soap solution and bavistine to remove the dust and any other contaminants then shade dried at room temperature for about ten days. Dried leaves were powdered and 1% of aqueous extract was prepared by boiling the powder in distilled water for 5-10 minutes, filtered and used as reducing agent.

Synthesis and Characterization of Gold Nanoparticles

100 mL aqueous solution of 1mM $HAuCl_4$ Chloroauric chloride was mixed with 10mL of *Cassia auriculata* leaf extract in a 250 mL conical flask and immediately the whole mixture was put in a domestic microwave oven (Samsung Model GW73BD). The mixture was subjected to several short burst of microwave irradiation at frequency of 2.45 GHz, at power output of about 100W in a cyclic mode (on 15 s, off 15 s) to prevent overheating as well as aggregation of metals. The irradiation process was conducted for a minimum of 1 up to maximum of 23 cycles. The main advantages of microwave assisted methods over conventional synthetic methods are increase in the kinetics of reaction by two orders of magnitude, rapid initial heating and generation of localized heat at reaction sites, thereby increasing the rate of reaction [38]. The microwave assisted synthesis of gold nanoparticles was carried out by irradiating the mixture (Fig.5).The reduction of Au^+ ions was monitored by sampling an aliquot (2 ml) of the solution after 1,3,5,7,9,12 and 15 cycles and measuring the UV-Vis spectra of the solution. Absorption measurements were carried out on a JASCO dual-beam spectrophotometer (model V-570) operated at a resolution of 1nm. The spectra were recorded at room temperature using a quartz cuvette. After complete reduction of gold ions by the *Cassia auriculata* leaf broth, the solutions of gold nanoparticles were centrifuged at 5000 rpm for 20min. The nanoparticle pellets obtained after centrifugation was redispersed in water and centrifuged 3 times. Further the synthesized gold nanoparticles were characterized by Fourier Transform Infrared, measurements were carried out on a Perkin-Elmer (Model-783) in the diffuse reflectance mode operating at a

resolution of 4 cm^{-1}. XRD measurements of the bioreduced nanoparticles drop-coated on glass were done on a powder X-ray diffractometer instrument (PXRD-6000 SCHIMADZU) in the angle range of 10˚C-80˚C at 2θ, scan axis: 2:1 sym. TEM measurements were performed on a JEOL model 1200EX instrument operated at an accelerating voltage at 80 kV.

Results and Discussion

Here we report fast biosynthesis of gold nanoparticles under microwave oven using *Cassia auriculata* leaf extract and characterization of gold nanoparticles(Fig.1).It has been reported that medicinally valuable angiosperms have the greatest potential for the synthesis of metallic nanoparticles with respect to quality and quantity [39].The formation of pure metallic nanoparticles and bimetallic nanoparticles by reduction of the metal ions is possibly facilitated by reducing sugars or terpenoids [40]. As the plant *Cassia auriculata* also possess important phytochemicals [41] and essential amino acids [42] which might facilitate the synthesis and stabilization of nanoparticles. The ability of microwave irradiation to bring about reduction of Au^{+} to Au^{0} within 30sec is an indication of the superiority of the method. We reported a fast synthesis as compared to others who got in 90secs [18] and 5min [43]. The template method provides good control over the shape and dimensions of nanoparticles and is faster under the microwave irradiation method. The microwave irradiation effectively utilizes the internal heat generated within the matrix and is able to bring about the complete reduction within short duration of time. A solution containing ions, ions moves through the solution under the influence of an electric field, resulting in expenditure of energy due to an increased collision rate, converting the kinetic energy to heat.

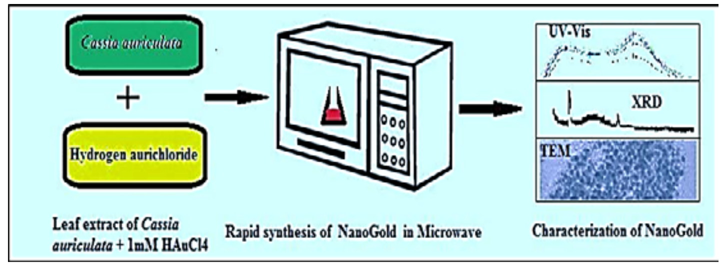

Fig.1.Graphical presentation of Biosynthesis and Characterization of Gold nanoparticles.

The reduction of aqueous $AuCl4^{-}$ ions during reaction with the *Cassia auriculata* leaf extract may be easily followed by UV-Vis spectroscopy (Fig.2). It was found that the colorless solution turned ruby red within 30 s of microwave irradiation, the UV-Vis absorption spectra recorded shows a strong resonance at 524 nm is clearly seen in curve 2 and arises due to the excitation of surface plasmon vibrations in the gold nanoparticles.

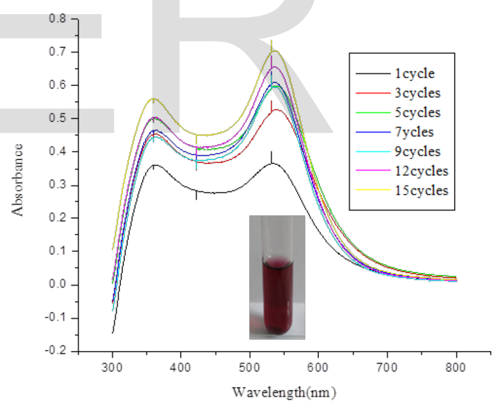

Fig.2. UV-VIS absorption spectra of Gold nanoparticles of *Cassia auriculata*.

FTIR measurements were carried out to identify the possible biomolecules in the *Cassia auriculata* leaf extract responsible for the reduction of $AuCl4^{-}$ ions and also the capping agents responsible for the stability of the biogenic nanoparticle solution. (Fig.3) The peaks in the region between 3233 cm^{-1} to 1597 cm^{-1} and 532 cm^{-1} were assigned to stretching of N-H, O-H and C=O of primary, secondary amides and acid groups present in the leaf extract. FTIR analysis reveals the dual function of biological molecules possibly responsible for the reduction and stabilization of silver nanoparticles in the aqueous medium.

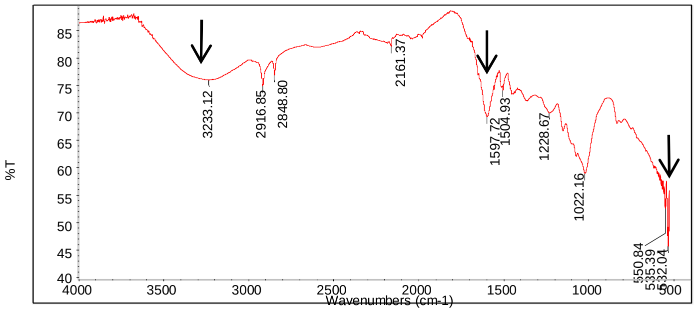

Fig.3. Infrared spectrum of Gold nanoparticles.

The formation of gold nanoparticles synthesized was further supported by X-ray diffraction (XRD) measurements (Fig.4a). The Bragg reflections corresponding to the (111), (200), (220), (310) sets of lattice

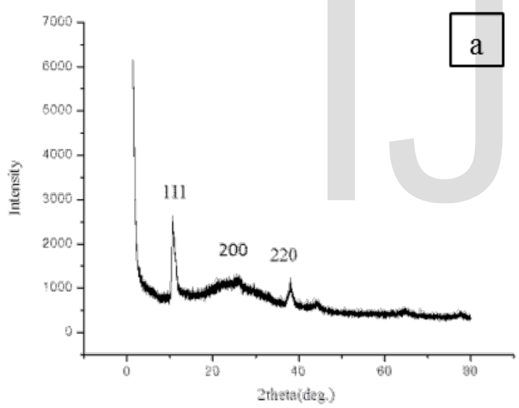

Fig.4 (a).X ray pattern of Gold nanoparticles.

planes are observed that may be indexed on the basis of the FCC structure of gold. All the peaks match well with the standard JCPDS file 04-0783 of Au. The XRD pattern thus clearly shows that the gold nanoparticles are crystalline in nature. TEM image recorded of the biologically synthesized gold nanoparticles (Fig.4b). The TEM image shows that the gold nanoparticles are predominantly spherical in morphology with their size ranging from 10 to 20 nm.

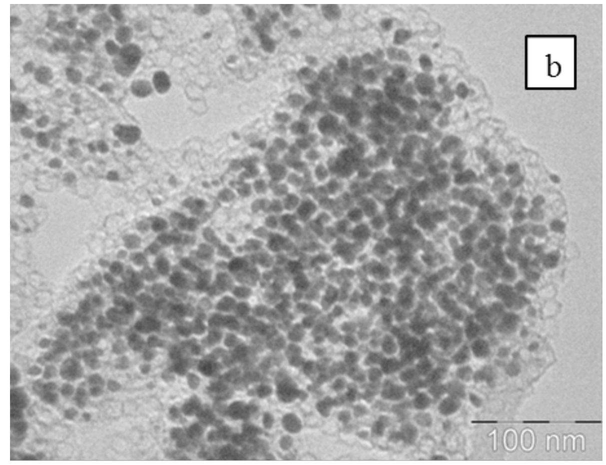

Fig.4(b).Transmission Electron Microscopic images of Gold Nanoparticles.

CONCLUSION

The present study demonstrated the rapid extracellular synthesis of gold nanoparticles from leaf extract of *Cassia auriculata*. It provides efficient, simple and good control over the particle. While very high temperatures were required to carry out the reduction, the same was possible within seconds under microwave irradiation. Absorption spectra confirm the presence of surface plasmon resonance at 524 nm, characteristic of Au nanoparticles. Compared to other methods investigated the microwave irradiation is considered as better for reduction to gold nanoparticles. The gold nanoparticles produced in this manner, therefore, are potentially suitable for medical or biological applications, enabled by the non-toxic stabilizing agent.

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