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Green Synthesis of Gold Nanoparticles Using *Elettaria cardamomum* (ELAICHI) Aqueous Extract

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Abstract: In the present study we explore the reducing and capping potential of aqueous extract from seed pod of Elaichi for synthesis of gold nanoparticles. The extract with different concentration reduced with $HAuCl_4$ aqueous solution at room temperature. The color change, pH change and UV-Visible spectroscopic analysis reveal the Surface Plasmon Resonance (SPR) of the final reaction product which confirms the reduction of Au^{3+} ion to gold nanoparticles. XRD, Particle size analysis result represents strong reducing potential of Elaichi aqueous extract which can also be tested in the green synthesis of other metallic nanoparticles.

Key words: Aqueous extract · Gold nanoparticles · Surface Plasmon Resonance (SPR) · Capping · Elaichi

INTRODUCTION

Metallic nanoparticles exhibit unique optical, electronic and catalytic properties which are primarily based on their small size and their high surface to volume ratio. The properties of these materials are often different from corresponding bulk materials of the same kind and are usually influenced by the particle size [1, 2, 3]. One of the important applications of nanotechnology is the use of gold nanoparticles (AuNPs) in biomedical research due to their unique optical and thermal and catalytic properties [4-7]. In last few years researchers have realized the possible toxicities of AuNPs due to toxic chemicals are utilized in several of the processes for production of nanoparticles, either in the form of reducing agents to reduce various metal salts to their corresponding nanoparticles, or as stabilizing or capping agents to prevent agglomeration of nanoparticles. For example, hydrazine and sodium borohydride are powerful reducing agents that are currently used to produce gold and other metallic nanoparticles [8, 9]. These reducing agents are highly toxic to living organisms and to the environment and due care must be exercised in their proper handling and disposal of toxic chemicals. Nature's ability to reduce metal salts to their corresponding nanoparticles [10]. This initiated the exploration of new natural sources that can synthesize metallic nanoparticles. Recently, this concept has gained tremendous importance as evident from the number of reports revealing reducing and capping potentials of different biomaterials sourced mostly from plants *Ocimum sanctum*, Green tea leaf, *Cinnamomum zeylanicum, Diopyrus kaki, Centella asiatica* and microbes *Yarrowia lipolytica,* edible mushroom [11-18]. Due to toxic chemicals, non ceofriendly and various other deleterious effects of traditional chemical and physical methods that are being employed for the generation of gold nanoparticles, focus has now being targeted towards "green chemistry" for synthesis of gold nanoparticles [1, 25].

Bioresources like plants and various plant spices which possess phytochemicals may serve as long lasting and environmentally benign reservoirs for production of metallic nanoparticles. In the present work, we describe a very simple and time benign method of green synthesis of AuNPs, just by simple mixing of an aqueous solution of hydroxy tetrachloroauric acid ($HAuCl^4$) with an aqueous extract of *Elettaria Cardamomum* seed pod. A kind of spices belongs to family: *Zingiberaceae*, well known as "Cardamon" and Choti elaichi in Hindi or Alleicha in Odia according to Indian Medicinal System [20]. The main part of use is its fruit contains three chambers, each chamber consists of two row of seeds upto 5 to 10 in number. Cardamom is used as an aromatic, a carminative and stimulant. It is used in the form of compound tincture [19].

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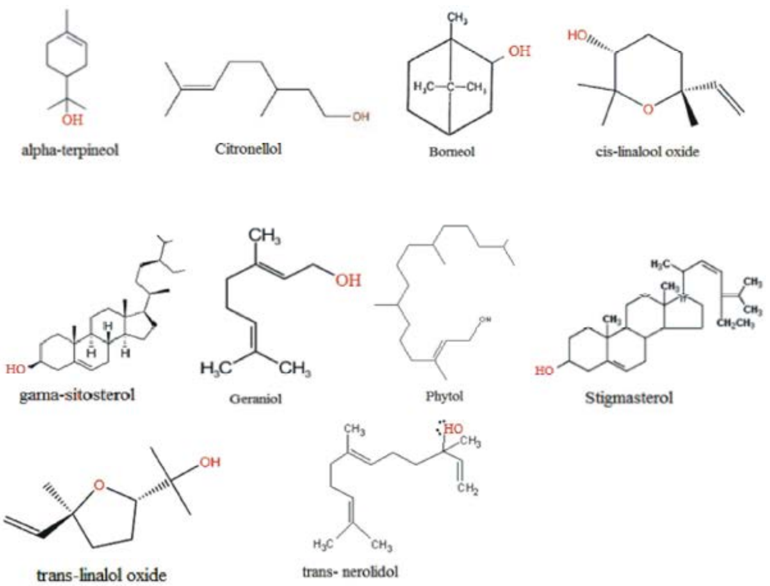

Cardamom of Indian sub continent, contains wide variety of compounds, among them few of hydroxyl group containing are α-terpineol, citronellol, borneol, trans-nerolidol [21], cis/trans-linalol oxides [22], γ-sitosterol, phytol [23], geraniol, stigmasterol [24] and other non hydroxyl groups are myrcene, subinene, limonene, cineol, α-phellandrene, menthone, α and β pinene [21] β-sistostenone, eugenyl acetate [23], bisabolene, p-cymene, geranyl acetate and terpinene [24].

Such reports of the phytochemical possessing hydroxyl, amino and other proton donating functional groups for reduction of precursor molecules, as a good source for reducing and stabilizing agent.

These factors motivate us to select *Elettaria Cardamomum* for the present study. To the best of our knowledge, this is the first ever report on *Elettaria Cardamomum* (Elaichi) mediated green synthesis of gold nanoparticles.

MATERIALS AND METHODS

Reagents and Chemicals: Tetrachloroauric acid ($HAuCl_4$•XH_2O) was obtained from Sigma Aldrich Chemicals. Freshly prepared triple distilled water was used throughout the experimental work.

Preparation of Elaichi Aqueous Extract: In our synthesis procedure, elaichi aqueous extract were used as reducing and capping agent. Extract was prepared by soaking 2 gm of seed pod in 20 ml deionized water for overnight and crush it with mortar and pestle, the mixture was boiled for 10-15 minute at 70-80°C. The extract was followed by centrifuge for 15 minute at 5000 rpm, collected supernatant was then filtered by standard sterilized filtration method. Extract was then stored at 4°C for further use.

Synthesis of Gold Nanoparticles: In a typical experiment, AuNPs synthesis protocol was optimized by stirring a mixture of elaichi aqueous extract at three different concentrations with 1mM $HauCl_4$ aqueous solution (1;1, 5;1, 10;1) at 200 rpm at room temperature for 1 hour. Within a particular time change in color was observed indicating nanoparticle synthesized.

UV-VIS Spectra Analysis: The reduction of pure Au^{3+} to nanoparticle was monitored by measuring the UV-Vis spectrum the most confirmatory tool for the detection of surface Plasmon resonance property (SPR) of AuNPs, by diluting a small aliquot of the sample in distilled water. UV-Vis spectral analysis was done by using UV-Vis spectrophotometer Systronics 118 at the range of 300-600 nm.

X-ray Diffraction (XRD) Analysis: XRD measurement of biologically synthesized AuNPs from tertrachloroauric acid, AuNPs solution drop-coated on glass were done on a Bruker axs- D8 Advance instrument operating at a voltage of 40 KV and current of 20 mA with Cu Kα radiation.

Particle Size Analysis: Size analysis of gold nanoparticles were carried out on Brookhaven 90 Plus Nanoparticle Size Analyzer with following measurement parameter, Refractive index fluid-1.330, Angle-15.00, Average count rate-5.2kcps with run completed 3 times.

RESULTS AND DISCUSSION

Image of green elaichi plant shown fruit ripening from flower (Fig. A) and fruits with seeds (Fig. B).

UV-VIS Spectroscopic Analysis of AU Nanoparticles: The appearance of violet color evident that the formation gold nanoparticles in the reaction mixture and the efficient reduction of the Au^{3+} to Au^0 (Fig. 2B), the formed color solution allowed to measure the absorbance against distinct wave length to conform the formation of gold nanoparticles. The corresponding UV-Vis absorption spectra are shown in Fig. 2A. The change in Ph of aqueous gold solution 2.95 and elaichi extract 5.97 to 4.99 of elaichi gold nanoparticles solution in 1hour. In the present work, AuNPs synthesis with three different concentration of elaichi extract with fixed concentration of gold solution as ratio 1;1, 5;1, 10;1. UV-Vis scanning of reaction product showed SPR absorption band and peaks (Fig. 2a). Reaction mixture with 1;1 ratio, in which reduction of Au^{3+} ions just to occurred and SPR band intensities was less and peak is broad which suggest partial reduction of Au^{3+} ion and formation of larger AuNPs with SPR at 550 nm. And in reaction mixture ratio 1;10 the observed intensity of SPR peak is more with small sharpness in the peak compare to the reaction mixture 1;1 with SPR at 530 nm. Where as in reaction mixture 1;5 the SPR band intensity and peak is highest indicating complete reduction of gold ions with SPR at 540 nm. Thus maximum yield of reduced sized AuNPs at reaction ratio 5;1 suggested as optimum reaction condition under room temperature condition.

XRD Analysis: The crystalline structure of biologically synthesized AuNPs using Elaichi extract were analysed by XRD measurements. A typical XRD pattern of the Au was found by Bragg reflections corresponding to (111), (200) and (220) sets of lattice planes are observed that may be indexed on the bases of the fcc structure of gold. The characteristic peaks corresponding to (111), (200) and (220) are located at 2θ= 38.80°, 44.13° and 64.82° respectively and the weak intensities of peaks indicates that gold nanocrystals are embedded in the film, shown in Figure 2.

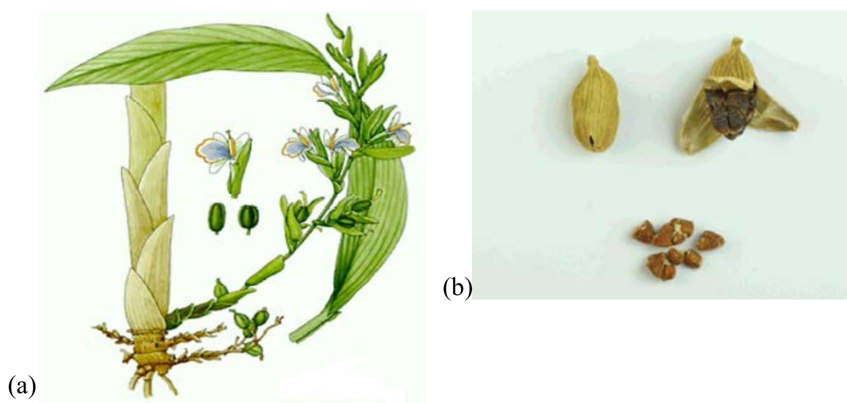

Fig. 1: A Image of Green elaichi plant with fruit, B Image of fruit and its internal seeds

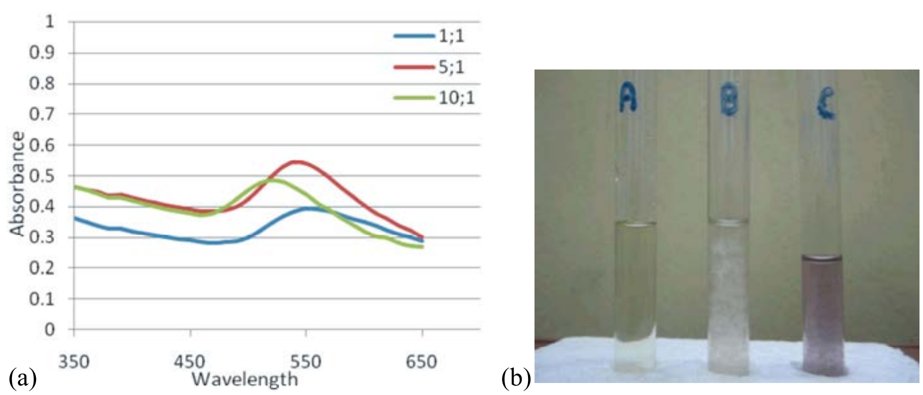

Fig. 2: XRD of gold nanoparticles

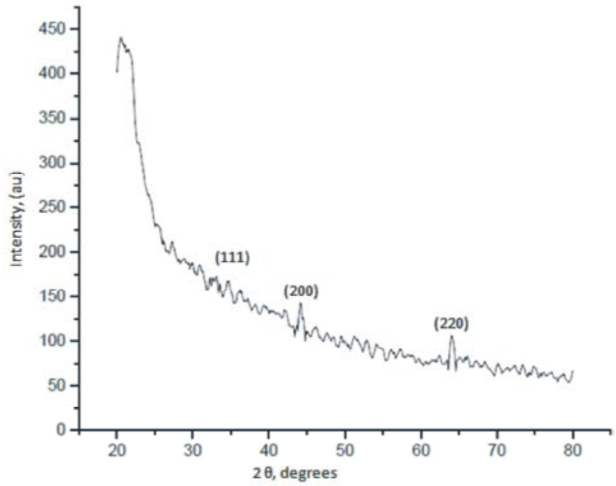

Fig. 2: A UV-Vis spectra of AuNPs synthesized by reacting different concentration of *Elettaria Cardamomum* extract with 1Mm HAuCl^4 aqueous solution (5;1, 10;1, 1;1) at room temperature. B Tube A- contain yellow color gold solution, Tube B- contain white color *Elettaria Cardamomum* extract, Tube C- contain violet color gold nanoparticles solution

Effective Diameter:	**432.3 nm**
Polydispersity:	**0.416**
Baseline Index:	**0.0/ 10.19%**
Elapsed Time:	**00:03:00**

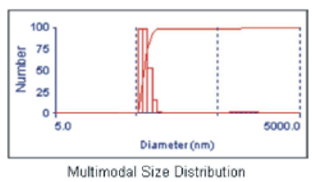

Fig. 3: Particle size analysis

Particle Size Analysis: Laser diffraction particle size analyzer provides the detail about the particle nature, such as monodispersed, didispersed and polydispersed. Our investigation revealed that nanoparticles show polydispersity at 0.146 indexing and various sizes of nanoparticles ranging with effective diameter around 432.3 nanometer, lognormal summary given below in Figure 3.

CONCLUSION

The study demonstrates the rapid synthesis of gold nanoparticles with small sized and high crystalline. The reduction of the metal ions and stabilization of the gold nanoparticles is believed to occur by the proton releasing hydroxyl group [26], containing α-terpineol, citronellol, borneol, trans-nerolidol, cis/trans-linalol oxides, γ-sitosterol, phytol, geraniol, stigmasterol or any other secondary metabolites and various acids present in extract. The concentration of elaichi extract and metal ions plays a crucial role for the synthesis of gold nanoparticles of desired size with reaction conditions. The spectroscopic characterizations using UV-Vis, XRD and Particle size analysis were useful in providing the formation of nanoparticles and also to confirm their characteristic. From literature study proposed that hydroxyl and amine group containing components are responsible as an active reductant and capping agent, but further FTIR analysis can give evidance to understand the appropriate chemical and molecular interactions which could be responsible for the gold salt reduction. As, the appearance of single peak in UV-Vis spectrum represents spherical shape of generated nanoparticles which can be further confirmed by representing the Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM) images.

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REFERENCES

1. Parida, U.K., B.K. Bindhani and P.L. Nayak, 2011. Green Synthesis and Characterization of Gold Nanoparticles Using Onion (*Allium cepa*) Extract. World Journal of Nano Science and Engineering, 1: 93-98.
2. Lal, S.S. and P.L. Nayak, 2012. Green synthesis of Gold Nanoparticles Using Various Plants and Spices Extract. International Journal of Science Innovation and Discovery, 2: 2.
3. Willets, K.A. and RP. Van Duyne, 2007. Localised surface Plasmon resonance spectroscopy and sensing. Anu Rev Phys Chem., 58: 267-297.
4. Kreibig, U. and M. Vollmer, 2001. 1995. Optical Properties of Metal Clusters. New York: Springer.
5. El Sayeed, M.A., Some Interesting Properties of Metal Confined in Time and Nanometer Space of Different Shapes. Acc Chem Res., 34(4): 257.
6. Narayanan, R. El-Sayed, 2003. M.A. Effect of Catalytic Activity on the Metallic Nanoparticle Size Distribution: Electron-Transfer Reaction between $Fe(CN)_6$ and Thiosulfate Ions Catalyzed by PVP-Platinum Nanoparticles. J. Phys. Chem., B., 107: 12416.
7. Narayanan, R., El-Sayed, 2003. M.A. J. Am. Chem. Soc., 125: 8340.
8. Esumi, K., A. Kameo, A. Suzuki and K. Torigoe, 2001. Preparation of gold nanoparticles in formamide and N, N-dimethylformamide in the presence of poly(amidoamine) dendrimers with surface methyl ester groups. Colloids Surf, A Physicochem. Eng. Asp., 189: 155-61.
9. Feitz, A., J. Guan and D. Waite, 2006. Process for producing a nanoscale zerovalent metal. US Patent Application Publication. US2006/ 0083924 A1.
10. Lovely, D.R., J.F. Stoltz, G.L. Nord and E.J.P. Phillips, 1987. Anaerobic production of magnetite by a dissimilatory iron-reducing microorganisms. Nature, 330: 252-254.
11. Mohanty, L., U.K. Parida, A.K. Ojha and P.L. Nayak, 2011. J. Micro and Antimicro, pp: 3.
12. Song, J.Y. and B.S. Kim, 2010. Rapid biological synthesis of silver nanoparticles using plant leaf extracts. Bioprocess Biosyst Eng, 33: 79-84.
13. Song, J.Y., E.Y. Kwan and B.S. Kim, Biological synthesis of platinium nanoparticles using *Diopyrus kaki* leaf extract. Bioprocess Biosyst Eng., 33: 159-164.
14. Das, R.K., B.B. Borthakur and U. Bora, 2010. Green synthesis of gold nanoparticles using ethanolic leaf extract of *Centella asiatica.* Mat Lett., 64: 1445-1447.
15. Nune, S.K., N. Chanda, R. Sukhla, K. Katti, R.R. Kulkarni, S. Thilakavathy, S. Mekapothula, R. Khanna and K.V. Katti, 2009. Green nanotechnology from tea: Phytochemicals in tea as building blocks for production of biocompatible gold nanoparticles. J. Mat Chem., 19: 2912-2920.
16. Smithaa, S.L., D. Philip and K.G. Gopchandrana, 2009. Green synthesis of gold nanoparticle using *Cinnamomum zeylanicum* leaf broth. *Spectrochim* Acta Part A, 74: 735-739.
17. Agnihotri, M., S. Joshi, A.R. Kumar, S. Zinjarde and S. Kulkarni, 2009. Biosynthesis of gold nanoparticles by the tropical marine yeast *Yarrowia lipolytica* NCIM 3589. Mat Lett, 63: 1231-1234.
18. Philip, D., 2009. Biosynthesis of Au, Ag and Au-Ag nanoparticles using edible mushroom extract. *Spectrochimica* Acta Part A, 73:374-381.
19. Trease and Evans, Pharmacogonosy. W.B Sounders, 15 Edition, pp: 353-354.
20. Shaban, M.A.E., K.M. Kandeel, G.A. Yacout and S.E. Mehaseb, The chemical composition of the volatile oil of Elettaria cardamomum seeds. Pharmazie, 42: 207-208.
21. Noleau, I., B. Toulemonde and Richard H. Voatile, constituents of cardamom Elettaria cardamomum Maton cultivated in Costa Rica. Flavours Frag J., 2: 123-127.
22. Gopalakrishnan, M., C.S. Narayanan and M. Grenz, Non saponifiable lipid constituents of cardamom. J. Agri. Food Chem., 38: 2133-2136.
23. Duke, J.A., Handbook of Phytochemical Constituents of GRAS Herbs and others Economic Plants: Herbal reference liberary, pp: 239-240, CRC Press, London.
24. Lee, S.D., 2009. In Planta “Green Engineering” of variable sizes and exotic shapes of Gold Nanoparticles: An Integrative Eco-friendly Approach. PhD Thesis, pp: 3-5.
25. Singh, A.K., M. Talat, D.P. Singh and O.N. Srivastava, 2010. Biosynthesis of gold and silver nanoparticles by natural precursor clove and their functionalization with amine group. Journal of Nanopart Research, 12: 1667-1675.