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RAPID SYNTHESIS OF COPPER AND SILVER NANOPARTICLES USING *ZINGIBER OFFICINALE* DRIED RHIZOME EXTRACT

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ABSTRACT

An important area of research in nanoscience is to develop reliable, nontoxic and ecofriendly methods for the synthesis of nanoparticles. Use of biological systems and biomolecules is one of the options to achieve this objective. Present work demonstrates synthesis of silver and copper nanoparticles by an economical and eco-friendly method using aqueous extract of dried rhizome powder of *Zingiber officinale* (Common name: ginger). Characterization of the nanoparticles was carried out using UV-Vis spectrophotometer and Quant 200 FPEI Scanning Electron Microscope. Peak absorbance due to localized surface plasmon resonance (SPR) was found to be 550 nm for silver nanoparticles and 450-500 nm for copper nanoparticles. Peak absorbance was constant for 48h for silver and 72 h for copper. Scanning electron micrographs revealed uniform spherical size, less than 100 nm for both the particles. Energy-dispersive X-ray spectroscopy confirmed the purity of nanoparticles. Phytochemical analysis showed the presence of flavonoids in the aqueous extract. The short reduction time and stability of nanoparticles by this method make it a viable alternative to chemical synthesis methods. The silver and copper nanoparticles synthesized by this method can be used in biomedical and other applications.

KEY WORDS: ***nanoparticles, copper, silver, Zingiber officinale, rhizome, SEM***

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INTRODUCTION

Nanotechnology mainly deals with the fabrication of nanoparticles having various shapes, size and managing their chemical and physical parameters for further beneficial use.[1] Their unique properties contribute to their potential applications in various fields like biosensors, bioremediation of radioactive wastes, functional electrical coatings, synthesis of enzyme electrode and particularly in medicine such as delivery of drugs, antigen for vaccination and gene delivery for treatment or prevention of genetic disorder.[2-4] This has inspired the scientists to develop effective procedures for the synthesis of nanoparticles. In recent years, metal nanoparticles have received significant attention owing to their unique properties and practical applications.[5] The traditional chemical methods used to synthesize nanoparticles are expensive and often raise questions of environmental risk due to use of toxic, hazardous chemicals. Further, these synthetic methods normally use organic solvents because of hydrophobicity of the capping agents used.[6] Hence, the search for cleaner, nontoxic methods of synthesis has ushered in developing approaches that use biological systems.[7-8] The biological synthesis of metal nanoparticles (especially gold and silver nanoparticles) using plants (inactivated plant tissue, plant extracts and living plant) and microorganisms has received more attention as a suitable alternative to chemical procedures and physical methods.[8-9] Synthesis of metal nanoparticles using plant extracts is very cost effective, and therefore can be used as an economic and valuable alternative for the large-scale production of metal nanoparticles. Nanoparticles of silver (Ag), gold (Au) and platinum (Pt) have been reported to be synthesized by using extracts of plant parts such as onion, lemon grass, neem leaves and others.[10-16] Extracts of plants have been found to provide reducing and capping agents in nanoparticle synthesis. Among the metal nanoparticles, copper (Cu) nanoparticles are potentially attractive, due to their good optical, electrical, thermal and catalytic properties, superior strength and their antibacterial and antifungal activity.[17] Further copper nanoparticles are considered safe for human beings for applications such as food packaging and in water treatment and are economical as compared to noble metals such silver, gold and platinum. Copper nanoparticles have been successfully synthesized by various methods such as γ-radiolysis, laser irradiation, thermal decomposition, thiol-induced reduction electron beam irradiation, micro-emulsion techniques, wire explosion and in situ chemical synthesis.[17] Those methods have been performed in non-aqueous media to prevent spontaneous oxidation of copper to copper oxide. In addition, without proper protection copper nanoparticles have been found to aggregate rigorously. Starch, polyethylene glycol and polyvinyl pyrrolidone have been used to control the growth of nanoparticles and protect them from oxidation and aggregation.[18-19] Further, these methods suffer from drawbacks such as unsafe reaction conditions, use of expensive chemicals and instruments and longer reaction time. To overcome these problems, some green methods for synthesis of copper nanoparticles, using plant leaf extracts of *Capparis zeylanica* Linn, tamarind, lemon juice, *Ocimum sanctum, Artabotrys odoratissimus* and others have been reported.[20-24] The rhizome of *Zingiber officinale* (Common name ginger, adrakh) belonging to the ginger family i.e Zingebereceae, is a common condiment for various foods and beverages. The constituents present in ginger have been known to possess potent antioxidant and anti-inflammatory activities.[25] Leaf extract of *Zingiber officinale* has been used for synthesis of gold and silver nanoparticles.[9] The objective of this study was the synthesis of copper nanoparticles by a green method and their characterization using Uv-Vis spectroscopy, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) techniques. In the present study, stable silver and copper nanoparticles were rapidly synthesized using the dried rhizome extract of *Zingiber officinale*.

MATERIALS AND METHODS

Dried ginger was procured from a local shop for Ayurvedic medicines, Mumbai, India

All chemicals were of AR grade and obtained from E. Merck and SRL Pvt. Ltd.

Preparation of ginger extract

Ginger extract was prepared by the method described earlier[12] with modifications.

Dried ginger was powdered in a blender. Dried ginger powder was mixed with distilled water to make a 10 % solution. This was placed on a magnetic stirrer for 20 min and then filtered through Whatmann filter paper. Filtrate was the aqueous extract used for synthesis of nanoparticles.

Synthesis and characterization of silver and copper nanoparticles

Equal amount of 10% aqueous extract of dried ginger was added drop wise to the conical flask containing 1mM silver nitrate solution or 1mM copper nitrate solution and placed at room temperature on a shaker.[21] The synthesized nanoparticles were subjected to UV-Vis spectroscopy and Scanning electron microscopy (SEM).

UV-Visible analysis of nanoparticles

The solutions of nanoparticles were subjected to UV-visible analysis. Absorbance readings were recorded at varying wavelengths ranging from 250-800 nm using a spectrophotometer (Equiptronics, model EQ825)

SEM analysis

The topography of copper and silver nanoparticles was studied by subjecting them to SEM analysis. A drop of synthesized nanoparticle solution was placed on a carbon and aluminum coated grid and subjected to a vacuum for 15min. The images obtained were scanned under SEM. Measurements were performed on a FEI QUANTA 200 SEM machine equipped with an energy-dispersive X-ray spectrometer (EDS) at ICON analytical Pvt. Ltd, Worli, Mumbai. EDS analysis was carried out at an acceleration voltage of 20.0 kV.

Phytochemical screening of extract

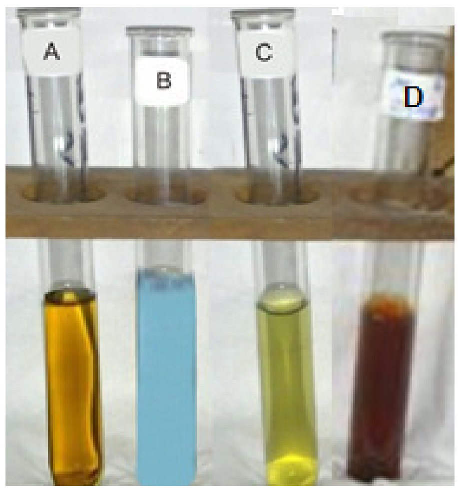
The methods described by Harborne were used for screening of alkaloids, steroids, flavanoids, glycosides, saponins, tannins and terpenoids.[26]

RESULT AND DISCUSSION

In the present work, an attempt has been made to synthesize copper and silver nanoparticles through green method. Aqueous extract of dried rhizome powder of *Zingiber officinale* was used for the synthesis of nanoparticles.

Formation and characterization of silver nanoparticles

Appearance of red coloration (Fig 1), after 30 min, indicated the reduction of Ag^{+} to Ag. Reduction of Cu^{2+} to Cu was indicated by appearance of greenish yellow coloration, after 10 min (Fig 1). The aqueous extract of dried ginger powder resulted in stable nanoparticles without agglomeration. When absorbance of nanoparticles at varying wavelengths (300-800 nm) was studied, maximum absorbance for silver nanoparticles was observed at 550 nm and that for copper nanoparticles was found to be 450-500 nm (Table 1). This characteristic absorbance which was a result of surface plasmon resonance exhibited by the nanoparticles did not show a change even after 48 h in case of silver and 72 h in case of copper. This implies stability of the nanoparticles without addition of any capping or stabilizing agents. Nanoparticles synthesized by chemical methods require addition of capping agents like cetyl trimethyl ammonium bromide, sodium dodecyl sulphate or polyvinylpyrrolidone.[27] Further, the nanoparticles were scanned under scanning electron microscope (SEM) for their shape and size. The scanning electron micrographs showed size below 100 nm and uniform spherical shape of silver (Fig 2) and copper nanoparticles (Fig 4). Uniform spherical silver nanoparticles using ginger extract have been reported earlier.[12] However, previous study on green synthesis of copper nanoparticles has demonstrated aggregates of non-spherical copper particles.[21] Present study implies efficient use of ginger extract for obtaining uniform spherical copper nanoparticles. Single peak in the EDS plots for silver (Fig 3) and copper (Fig 5) showed purity of nanoparticles.



***A**: 10 % Dried ginger powder extract, B: 0.001 M copper nitrate, C: Reduction of Cu^{2+} to Cu, D: Reduction of Ag^{+} to Ag*

Figure 1
Formation of silver and copper nanoparticles by aqueous extract of dried ginger.

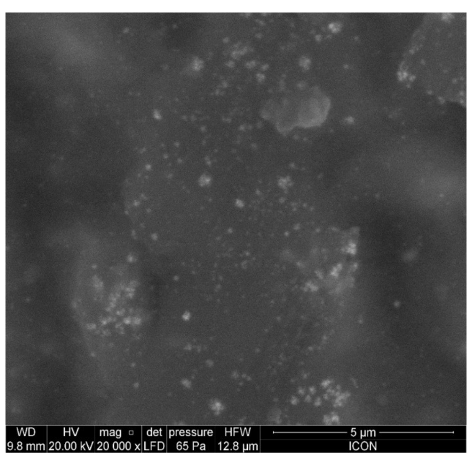


Figure 2
Representative SEM image of silver nanoparticles

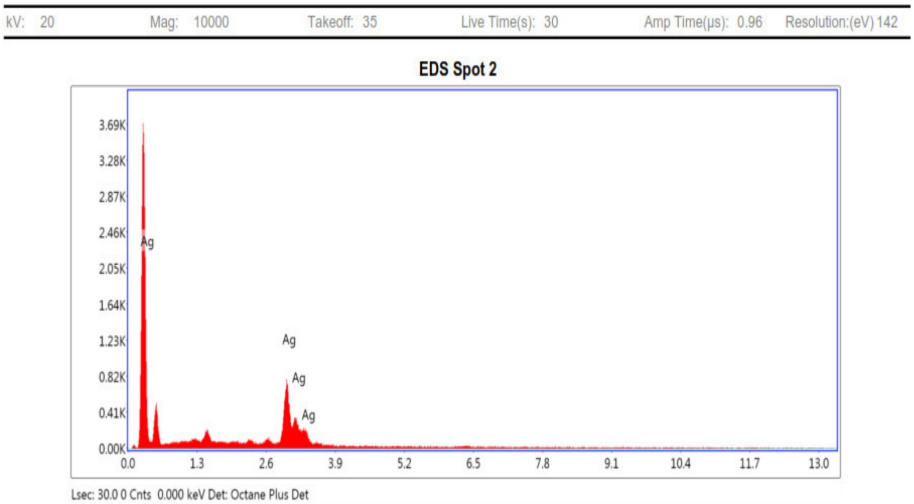


Figure 3
EDS plot for silver nanoparticle

Table 1
UV-Vis analysis of silver and copper nanoparticles

Wavelength (nm)	Absorbance of silver nanoparticle	Absorbance of copper nanoparticle
250	0.00	0.0
300	0.00	0.0
350	0.00	0.0
400	0.09 ± 0.01	0.18 ± 0.01
450	0.22 ± 0.01	**0.67 ± 0.01**
500	0.68 ± 0.005	**0.66 ± 0.02**
550	**0.99 ± 0.02**	0.41 ± 0.02
600	0.42 ± 0.02	0.22 ± 0.03
650	0.07 ± 0.01	0.08 ± 0.01
700	0.00	0.07 ± 0.02
750	0.00	0.0

Absorbance values are mean ± SD of readings from experiments done in triplicate

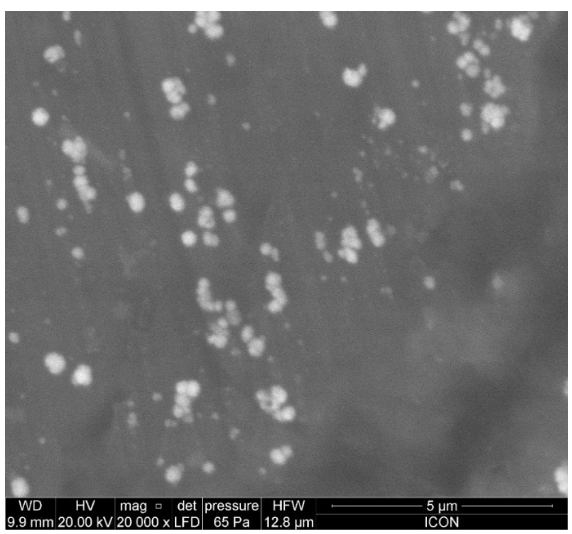


Figure 4
Representative SEM image of copper nanoparticles

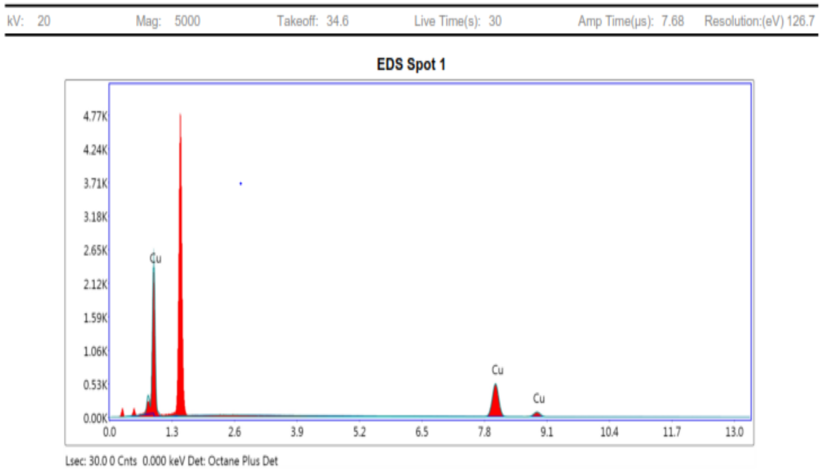


Figure 5
EDS plot for copper nanoparticle

Phytochemical analysis

Phytochemical analysis of aqueous extract revealed the presence of flavonoids in abundance and alkaloids in moderate amounts (Table 2). Other constituents such as tanins, saponins, glycosides, terpenoids and phlobotanins were found to be present in trace quantities. The phytochemicals responsible for nanoparticle formation have been identified as terpenoids, flavones, ketones, aldehydes, amides and carboxylic acids by IR spectroscopic studies.[18] Previous report has identified the main water soluble phytochemicals like flavones, organic acids and quinones responsible for immediate reduction of metal ions.[19] Hence the antioxidant or reducing property of aqueous ginger extract may be attributed to flavonoids. However further analysis with FTIR or HPTLC is required for understanding the mechanism of formation of stable metal nanoparticles.

Table 2
***Phytochemical analysis of aqueous extract of dried ginger rhizome*.**

Phytochemical	Observation
Alkaloids	++
Tannins	+
Glycosides	+
Saponins	+
Steroids	-
Flavonoids	+++
Terpenoids	+
Phlobotanins	+

Key: +++ Abundantly present, ++ moderately present, +trace, - Absent

CONCLUSION

Present study demonstrates rapid synthesis of stable silver and copper nanoparticles using aqueous extract of dried ginger powder. It is an easy, fast, and economical technique. The method is eco-friendly as it doesn't involve addition of harmful and environmentally toxic chemicals. Rapid synthesis coupled with stability of nanoparticles make the present method a viable alternative to chemical synthesis methods. The silver and copper nanoparticles synthesized by this method can find use in biomedical and other applications.

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CONFLICT OF INTEREST

Conflict of interest declared none

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