Green synthesis of silver nanoparticles obtained from plant extracts and their antimicrobial activites

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Nanomaterials have antibacterial properties, metallic nanoparticles being the most useful, from this point of view. Biosynthesis of nanoparticles by plant extracts is currently under exploitation. Plant extracts are not expensive and eco-friendly and thus can be an economic and efficient alternative for the large-scale synthesis of nanoparticles. In the present report, synthesis of silver nanoparticles was achieved trough simple route. The silver nanoparticles formed by reaction of biomass of aqueous extracts from plants with aqueous solutions of silver nitrate ($AgNO_3$) at ordinary temperature. The synthesised nanoparticles was confirmed by UV–visible spectroscopy, scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FTIR).

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1. Introduction

Nanotechnology can be considered as a description of activities at the level of atoms and molecules that have applications in all fields, like electronic, magnetic, optoelectronics, biology, medicine [1-3]. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications. Nanomedicine has generated great enthusiasm in recent years due to important discoveries, especially in cancer therapy [4].

The synthesis, characterization and application of biologically synthesized nanomaterials have become an important branch of nanotechnology. Many chemical routes are known to use toxic chemicals for the synthesis of the nanoparticles. The need-of-the-hour, however is to evolve procedures for nanoparticles synthesis through environmentally benign routes. Researchers in this field, therefore, have been eagerly looking at biological systems as alternative ecofriendly or nontoxic systems [5].

Chemical synthesis methods lead to presence of some toxic chemical absorbed on the surface that may have adverse effect in the medical applications. Green synthesis provides advancement over chemical and physical method as it is cost effective, environment friendly, easily scaled up for large scale synthesis and in this method there is no need to use high pressure, energy, temperature and toxic chemicals [6].

The importance of bactericidal nanomaterials is due to the increased resistant strains of bacteria against most potent antibiotics. This has promoted research in the well known activity of silver ions and silver-based compounds, including silver nanoparticles. It is known that silver is usefulness as an antimicrobial agent. Many years, silver has been used as an anti-bacterial agent by people.[1-7].

The present work was carried out to examine the formation of silver nanoparticles by different type of plants as the reducing agent. Silver nanoparticles was investigated employing UV/Visible spectrophotometry, SEM (Scanning Electron Microscopy), and FTIR (Fourier transform infrared spectroscopy). Pelargonium peltatum was found to exhibit strong potential for rapid reduction of silver ions. It was observed that there is no correlation always between the colour development and the increase in absorbance exhibited by the nanometal synthesised.

2. Experimental part

2.1 Plants and synthesis of silver nanoparticles

The extract used for reduction of Ag^+ ions to Ag^0 was prepared by taking 50g of thoroughly washed and finely cut geranium leaves (fig. 1) in a 500 mL Erlenmeyer flask with 250 mL of distilled water. The suspension was boiling for 5 min. Solution was then allowed to cool and was filtered. Over 10 mL of this was added 10^{-3} M aqueous solution of $AgNO_3$ and kept over night at room temperature. The bioreduction of the Ag^+ ions was monitored first by measuring the UV-vis spectra of the solution.

Fig. 1. Pelargonium Peltatum leaf.

Apparatus

To measure the aqueous solution absorbance and the molar absorption spectra for each sample, was used a M400 Carl Zeiss Jena UV spectrophotometer with a 1 nm slit width, 1 nm step size, 0.3 nm/s average scan rate, deuterium lamp, double beam, microprocessor and quartz cell.

SEM analysis has been achieved with Quanta 200 Scanning Electron Microscope (SEM), which produces enlarged images of a variety of specimens, achieving magnifications of over 100000x providing high resolution imaging in a digital format. This important and widely used analytical tool provides exceptional depth of field, minimal specimen preparation.

The operation of the SEM consists of applying a voltage between a conductive sample and filament, resulting in electron emission from the filament to the sample. This occurs in a vacuum environment ranging from 10^{-4} to 10^{-10} Torr. The electrons are guided to the sample by a series of electromagnetic lenses in the electron column.

Finally, the silver nanoparticles were analyzed by FTIR GX, Perkin Elmer, at 400-4000 field.

3. Results

As the geranium extract was mixed in the aqueous solution of the silver ion complex, it started to change the color from watery to yellowish brown [9], and at the finally in green-black (fig. 2) due to reduction of silver ion which indicated formation of silver nanoparticles.

Fig. 2. Colours of 10^{-3} M $AgNO_3$ solution (M) and of silver nanoparticles geranium extract solution (Ag)

It is recognized that UV–Vis spectroscopy could be used to examine size- and shape-controlled nanoparticles in aqueous suspensions [8]. The UV-VIS spectrum of the geranium extract is shown in fig. 3. The reduction of pure Ag^+ ions was monitored by measuring the UV-Vis spectrum. UV-Vis spectral analysis was done by using UV-VIS spectrophotometer M42. The strong resonance centered at 445 nm was clearly observed and increased in intensity with time. It might arise from the excitation of longitudinal plasmon vibrations in silver NPs in the solution. Also it was observed that the solution containing the nanoparticles remained stable for more than two weeks, with no signs of aggregation or precipitate.

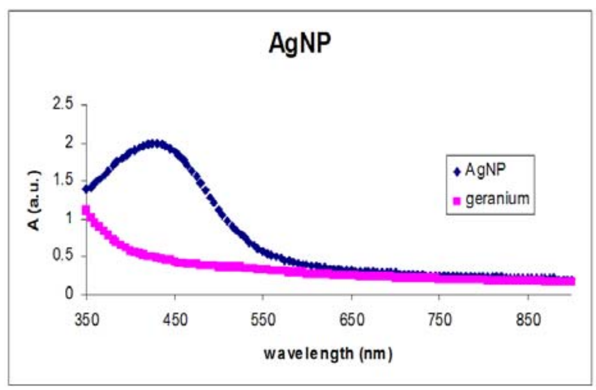

Fig. 3. UV-VIS spectra of silver nanoparticles in geranium leaf extract.

The biosynthesised silver nanostructure was demonstrated and confirmed by the characteristic peaks observed in the structural view under the scanning electron microscope (Fig. 4). The SEM image showing the high density silver nanoparticles synthesized by the geranium leaf extract further confirmed the development of silver nanostructures.

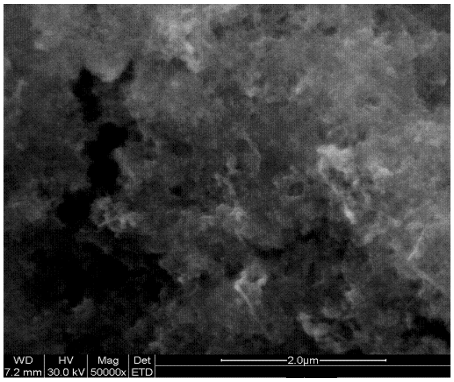

Fig. 4. SEM micrograph of the silver nanoparticles

FTIR analysis was used for the characterization of the extract and the resulting nanoparticles (Fig. 5). FTIR absorption spectra of water soluble extract before and after reduction of Ag ions are shown in the region 3500 cm^{-1}. The peaks 3333.33 cm^{-1} and 2364.00 cm^{-1} were assigned to O–H stretching and aldehydic C–H stretching, respectively. Absorbance bands wich are observed in the region of 500–2400 cm^{-1} are 1175.74, 1318.56, 1636.83, 2106.33 cm^{-1}. These absorbance bands are known to be associated with the stretching vibrations for –C C–C O, –C C– [(in-ring) aromatic], –C–C– [(in-ring) aromatic], C–O (esters, ethers) and C–O (polyols), respectively. The peak at 1636.83 cm^{-1} corresponds to amide I, arising due to carbonyl stretch in proteins. The 1175 cm^{-1} corresponds to C-N streching vibrations of the amine. The 1318 cm^{-1} band arises most probably from the C–O group of polyols such as hydroxyflavones and catechins. Dates of literature confirmed the fact that the carbonyl group form amino acid residues and proteins has the stronger ability to bind metal indicating that the proteins could possibly form a layer covering the metal nanoparticles (i.e., capping of silver nanoparticles) to prevent agglomeration and thereby stabilize the medium [7,10].

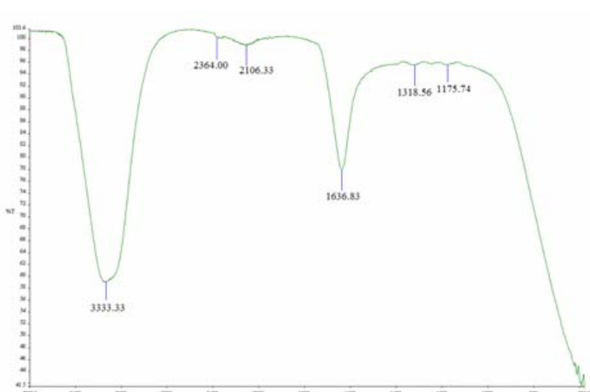

Fig. 5. FT-IR spectra of silver nanoparticles from geranium leaf extract.

4. Discussion

Reduction of the silver ions was observed immediately when the silver nitrate solution was contacted with geranium (*Pelargonium peltatum*) leaf extract, and the color was changed from water color to yellowish brown and then green-black color, due to excitation of surface plasmon vibrations, which indicated formation of silver nanoparticles. Date of literature confirm that silver nanoparticles can exhibit a size-dependant characteristic surface plasmon resonance band that can be measured using ultra violet visible spectroscopy [11].

The reduction of the metal ions through leaf extracts leading to the formation of silver nanoparticles of fairly well-defined dimensions.

SEM analysis showed the particle size as well the cubic structure of the nanoparticles. FTIR analysis confirmed that the bioreduction of Ag+ ions to silver nanoparticles are due to the reduction by capping material of plant extract.

5. Conclusion

In conclussion, the bio-reduction of aqueous Ag^+ ions by the plant extract of the geranium plant extract has been demonstrated. In this present study we found that this plant can be also good source for synthesis of silver nanoparticles. This green chemistry approach toward the synthesis of silver nanoparticles has many advantages such as, ease with which the process can be scaled up, economic viability, etc. Applications of such eco-friendly nanoparticles in bactericidal, wound healing and other medical and electronic applications, makes this method potentially exciting for the large-scale synthesis of other inorganic materials (nanomaterials).

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