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Green Synthesis of Silver Nanoparticle using *Erythrina indica* Flower Extract

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ABSTRACT

This study was to investigate an efficient and sustainable route of AgNP preparation from $AgNO_3$ using flower extracts of *Erythrina indica*. The AgNPs were characterized by UV-visible (vis) spectrophotometer, scanning electron microscopy (SEM). Fourier transform infrared spectrometer (FTIR) analysis was carried out to determine the nature of the capping agents in each of these flower extracts. The green synthesis method is eco-friendly, of low cost and capable of producing AgNPs at room temperature. Here, *Erythrina indica* flower extract used as both reducing and stabilizing agents. The AgNPs were characterized by UV–Vis, FTIR and SEM analysis. The UV–Vis spectral studies confirmed the surface plasmon resonance of green-synthesized silver nanoparticles. Biomolecules were responsible for reducing and capping of AgNPs, which were confirmed by FTIR measurements. SEM studies revealed spherical and uniform-shaped silver nanoparticles with size in the range 10–40 nm. In this present study, flavonoids in the *Erythrina indica* flower extract play an important role in the formation of silver nanoparticles.

1. Introduction

Nanotechnology is a new and emerging field of science that is bound to have tremendous impact on mankind by helping solve major challenges facing humanity in health and energy. This is due to the practical applications of metal nanoparticles in various areas such as medicine [1]. Nanotechnology is an important field of modern research dealing with synthesis, strategy and manipulation of particle's structure ranging from approximately 1 to 100 nm in size. Nanoparticles can be synthesized using various approaches including chemical, physical, and biological methods [2]. Different types of nano materials like copper, zinc, titanium, magnesium, gold, alginate and silver nanoparticles have reported to be greatest antimicrobial efficacy against bacteria, viruses and other eukaryotic microorganisms [3]. Of these, silver nanoparticles are playing a major role in the field of nanotechnology and nano medicine.

Plant and plant products used for nanoparticles synthesis as they are non toxic as well as provide natural capping agents. Many such experiments have already been started such as the synthesis of various metal nanoparticles using *Azadirachta indica (Neem)* [4], *Aloe* vera [5] and *Emblica officinalis (Amla, Indian Gooseberry)* [6] in the field of pharmaceutical applications and biological industries. The medicinal value of the chosen plant *Erythrina indica* flower has not been extensively worked out. Therefore, the present study was to investigate the synthesis and characterization of silver nanoparticles from *Erythrina indica* flower extract.

2. Experimental Methods

2.1 Chemicals

All the experiments were conducted at room temperature. Materials used for the synthesis of silver nanoparticles are AR grade silver nitrate ($AgNO_3$) purchased from Merck, India.

2.2 Collection of Plant Materials

The mature *Erythrina indica* flowers were collected in April 2015 from Kodaikanal, Dindugal district, Tamil Nadu, India. The flower were identified and authenticated by Botanist, Prof. Dr. S. John Britto, Director, The Rapinat Herbarium, St. Josephs College, Tiruchirappalli, Tamil Nadu, India.

2.3 Synthesis of Ag Nanoparticles using Flower Extracts

The dried flowers were pulverized well with mortar and pestle to make a powder. Twenty grams of powder sample was mixed into 100 mL of deionized water and the mixture was boiled for 10 min. After cooling the flower extract was filtered with Whatman No. 1 filter paper. The filtrate was stored at 4 °C for further use.

For the Ag nanoparticles synthesis, 5 mL of *Erythrina indica* flower extract was added to 45 mL of 1 mM aqueous $AgNO_3$ solution in a 250 mL Erlenmeyer flask. The flask was then incubated in the dark at 5 hrs (to minimize the photo activation of silver nitrate), at room temperature. A control setup was also maintained without flower extract. The Ag nanoparticle solution thus obtained was purified by repeated centrifugation at 10,000 rpm for 15 min followed by re-dispersion of the pellet in de-ionized water. Then the Ag nanoparticles were freeze dried using SEM analysis [7].

2.4 UV and FTIR Spectroscopic Analysis

The reduction of pure Ag^+ ions was examined under visible and UV light for proximate analysis. For UV and FTIR spectrophotometer analysis, the extracts were centrifuged at 3000 rpm for 10 min and filtered through Whatmann No. 1 filter paper by using high pressure vacuum pump. The sample is diluted to 1:10 with the deionized water. The reduction of pure Ag^+ ions were scanned in the wavelength ranging from 300-900 nm using Perkin Elmer Spectrophotometer and the characteristic peaks were detected. FTIR analysis was performed using Perkin Elmer Spectrophotometer system, which was used to detect the characteristic peaks in ranging from 400-4000 cm^{-1} and their functional groups. The peak values of the UV and FTIR were recorded. Each and every analysis was repeated twice for the spectrum confirmation.

2.5 SEM Analysis of Silver Nanoparticles

In this research work, VEGA 3 SEM machine were used to characterize mean particle size, morphology of nanoparticles. The freeze dried sample of AgNPs solution was sonicated with distilled water, small drop of this sample was placed on glass slide allowed to dry. A thin layer of platinum was coated to make the samples conductive VEGA 3 SEM machine was operated at a vacuum of the order of 10-5 torr. The accelerating voltage of the microscope was kept in the range 10-20 kV.

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3. Results and Discussion

The ex vivo synthesis of nanoparticles has investigated in plants and this method is very expensive and can therefore be used as an alternative for the synthesis of metal nanoparticles. In current research, nanotechnologies have evolved from a biological research concept to a primary scientific field. The fast growth of new technologies has led to the development of nanoscale device components. In addition to biological approaches is a new, simple and cheaper strategy to synthesize metal nanoparticles utilizes bacteria, yeasts, fungi, and plants as compared to chemical and physical methods. Hence, this research work is mainly focused on simple process as a green technology using aqueous extract of *Erythrina indica* flowers for the biosynthesis, and characterization of silver nanoparticles.

3.1 Synthesis of Silver Nanoparticles

A study on phytosynthesis of Ag nanoparticles by the aqueous flower extract of *Erythrina indica* was carried out in this work. During the visual observation, silver nitrate incubated with flower extract showed a color change from yellow to brown within 5 hrs whereas no color change could be observed in silver nitrate without flower extract. The appearance of brown color in flower extract treated flask is clear indication for the formation of Ag nanoparticles (Fig. 1). This color arises due to excitation of surface Plasmon vibrations in Ag nanoparticles. Sivakumar *et al.* [8] reported that colour change was observed at 90 minutes from light green to light brown colour, indicating the formation of silver nanoparticles which also indicated the presence of silver nanoparticles. This present work has demonstrated the efficiency of *Erythrina indica* flower extract in the rapid synthesis of silver nanoparticles possessing a variety of fascinating morphologies owing to its diverse groups of phytochemicals like phenolics, favonoids, polyphenols, reducing sugars, anthraquinones, terpenoids and anthrones.

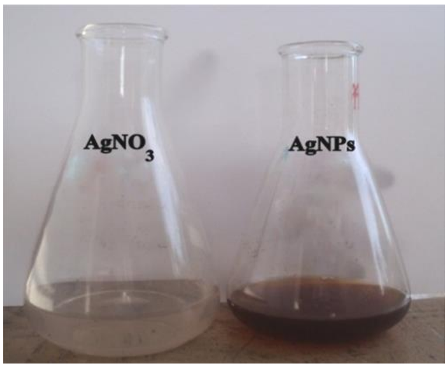

Fig. 1 Colour changes before (Plant extract) and after (AgNPs) the process of reduction of Ag^+ to Ag nanoparticles and control ($AgNO_3$) ($AgNO_3$ = 1 mM $AgNO_3$ without *Erythrina indica* extract; AgNPs = 1 mM $AgNO_3$ with *A. Erythrina indica* extract after 5 hrs of incubation (Brown colour)

3.2 UV-VIS Spectral Analysis

The nanoparticles were primarily characterized by UV–visible spectroscopy, which proved to be a very useful technique for the analysis of nanoparticles. The UV–vis spectra of reaction medium recorded as a function of reaction time using silver nitrate and *Erythrina indica* flower broth. It is observed that the maximum absorbance of Ag nanoparticles occurs at 401nm (Fig. 2). According to Njagi [9], this band corresponds to the absorption by colloidal silver nanoparticles in the region (400–450 nm) due to the excitation of surface plasmon vibration. Appearance of this peak, assigned to a surface plasmon, is well-documented for various metal nanoparticles with size ranging from 2 nm to 100 nm [10, 11].

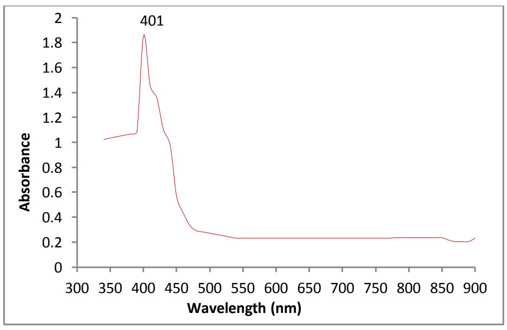

Fig. 2 UV-Vis Spectral analysis of AgNPs

3.3 Fourier Transform Infra-Red Spectral Analysis

FTIR spectrum of Ag nanoparticles examined to identify the possible biomolecules responsible for capping and efficient stabilization of the Ag nanoparticles synthesized by plant flower extract. The peaks observed (Fig. 3 and Table 1) for Ag nanoparticles formed through reduction by *Erythrina indica* at 3387 cm^{-1} (Alcohol, Phenol), 1415 cm^{-1} (Aromatic) and 1112 cm^{-1} (amine) suggest the presence of flavonoids and phenols adsorbed on the surface of Ag nanoparticles. The analysis of IR spectrum also provided an idea about biomolecules bearing different functionalities which are present in the underlying system [12]. The results of FTIR analysis confirmed the presence of alcohol, phenol, alkanes, aldehydes, carboxylic acid, aromatics and aliphatic amines compound.

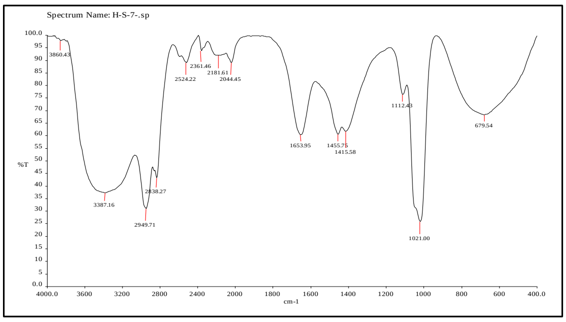

Fig. 3 FTIR spectrum of Ag nanoparticles synthesized by reduction of Ag^+ ions by *Erythrina indica* flower extract

Table 1 FTIR spectrum of AgNPs and their functional groups

S.No.	Peak Values	Functional groups
1	3387.16	Alcohol, Phenol
2	2949.71	Alkanes
3	2524.22	Aldehydes
4	2181.61	Alkeynes
5	2044.45	Alkeynes
6	1653.95	Carboxylic acid
7	1415.58	Aromatics
8	1112.43	Aliphatic amines
9	1021.00	Aliphatic amines
10	679.54	Alkanes

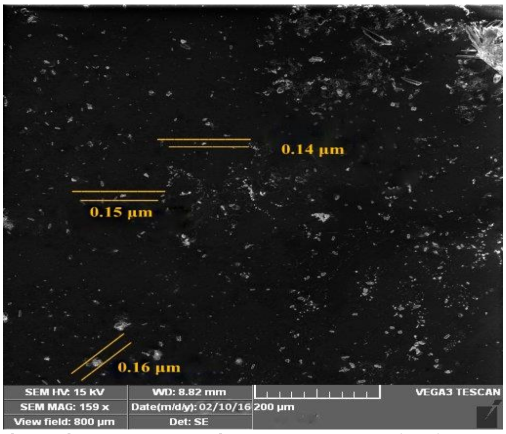

Fig. 4 High resolution scanning electron microscopic (SEM) image of silver nanoparticles (AgNPs). Polydispersed (Cluster) AgNPs ranged between 10–40nm

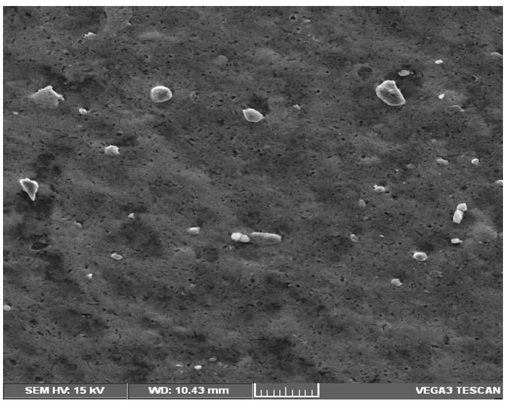

Fig. 5 Capturing a high resolution scanning electron microscopic image of spherical shape of Ag nanoparticles

3.4 Electron Microscopy of Ag Nanoparticles

SEM analysis was carried out to understand the topology and the size of the Ag-NPs, which showed the synthesis of higher density polydispersed spherical Ag-NPs of various sizes. The SEM images Figs. 4 and 5 showing the high density silver nanoparticles synthesized by the flower extract further confirmed the development of silver nanostructures. Most of the nanoparticles aggregated and only a few of them were scattered, as observed under SEM. The SEM analysis showed the particle size between 10-40 nm as well the cubic, face-centred cubic structure of the nanoparticles. Similar results were reported for phyto-synthesised silver nanoparticles [13, 14]. This result strongly confirms that *Erythrina indica* flower extract might act as a reducing and capping agent in the production of silver nanoparticles.

4. Conclusion

The green synthesis method is eco-friendly, of low cost and capable of producing AgNPs at room temperature. Here, *Erythrina indica* flower extract act as both reducing and stabilizing agents. The AgNPs were characterized by UV–Vis, FTIR and SEM analysis. The UV–Vis spectral studies confirmed the surface plasmon resonance of green-synthesized silver nanoparticles. Biomolecules were responsible for reducing and capping of AgNPs, which were confirmed by FTIR measurements. SEM studies revealed spherical and uniform-shaped silver nanoparticles with size in the range 10–40 nm. In this present study, flavonoids in the *Erythrina indica* flower extract play an important role in the formation of silver nanoparticles.

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