Green synthesis of silver nanoparticles and its characterization of *maranta arundinacea*

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Silver nanoparticles (Ag NPs) synthesized through eco-friendly and sustainable methods have gained significant attention due to their diverse applications and reduced environmental impact. In this study, the green synthesis of Ag NPs using *Maranta arundinacea*, commonly known as arrowroot, as a bio-reducing agent is represented. Arrowroot, abundant in phytochemicals, offers an environmentally benign approach to nanoparticle production. The description of the synthesis process, characterizing the Ag NPs using various techniques such as UV-Vis spectroscopy, Transmission Electron Microscopy (TEM), Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). These analyses reveal the formation of well-defined Ag NPs with unique properties. This research contributes to the growing field of green nanotechnology and underscores the potential of *Maranta arundinacea* as a valuable resource for sustainable nanoparticle synthesis. The characterized Ag NPs hold promise for various applications, including medicine, catalysis and environmental remediation and provide a foundation for further exploration in these domains.

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1. Introduction

The control and manipulation of matter at the nanoscale, often at dimensions smaller than 100 nanometers (nm), is the subject of the interdisciplinary scientific and technology topic known as nanotechnology. At this size, innovative materials, gadgets and systems with unheard-of qualities and applications may be designed and built by scientists and engineers with the help of the unique properties and behaviours that arise as a result of quantum and surface effects. As an example of the link between bulk materials and atomic or molecular structures, nanoparticles are now of great scientific interest. The main difference between these two types of materials is that bulk materials have eight physical qualities that remain constant regardless of size, whereas nanostructures have physical properties that vary in size (Hsieh, 2011; Grassian, 2008).

According to Rai *et al.*, (2009), silver nanoparticles (Ag NPs) are nanoscale silver particles with special physicochemical features that have made them widely used in a variety of industries, including medicine, electronics, catalysis and environmental science. These nanoparticles, which are generally between 1 and 100 nanometers in size, differ from bulk silver in that they have a high surface area-to-volume ratio. Ag NPs are versatile materials with a wide range of applications have antibacterial, optical and catalytic capabilities (Sharma *et al.,* 2009). Due to its eco-friendly and sustainable approach to nanoparticle manufacturing, green synthesis of silver nanoparticles (Ag NPs) has attracted a lot of interest recently.

As long as humans have existed, plants have served as medicine. Plants have been a traditional source of all-natural remedies for maintaining human health. Many of the more than 150,000 plant species have been examined for their beneficial chemicals and expanded investigation of compounds for pharmaceutical applications. The World Health Organization

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claims that medicinal plants may be the finest source of a wide range of medications. According to Hasler and Blumberg (1999), phytochemicals, which are physiologically active, naturally occurring chemical compounds present in plants, have health advantages for people beyond those offered by macronutrients and micronutrients. They contribute to the color, perfume, and flavor of the plant and shield it from illness and harm. Phytochemicals are often referred to as plant compounds that shield plant cells from environmental dangers such as pollution, stress, dehydration, UV exposure, and pathogenic assault (Gibson *et al.,* 1998; Mathi, 2000). Due to the presence of phytochemical elements, medicinal plants are helpful for both treating and curing human ailments (Nostro et al., 2000). The medicinal herbs, leaves, vegetables, and roots contain phytochemicals that are naturally occurring defensive mechanisms for numerous ailments. Primary and secondary compounds are phytochemicals.

Although silver ions (Ag+) and their compounds have minimal toxicity towards animal cells, they are very toxic to microorganisms and have a substantial biocidal impact on many kinds of bacteria. According to Taylor *et al.,* (2005), the bactericidal behavior of nanoparticles is related to the existence of electronic effects that are brought about by a change in the local electronic structure of the surface as a result of smaller sizes. In contrast to traditional chemical processes, natural sources including plants, microorganisms and biomolecules are essential in the reduction of silver ions to generate Ag NPs.

Due to its rich phytochemical composition and potential as a bio-reducing agent, *Maranta arundinacea*, also known as arrowroot, stands out as a viable choice in this context for the green synthesis of Ag NPs. A perennial, arrowroot may reach a height of between 0.3 and 1.5 meters (five feet). It has lance-shaped leaves. Rhizomes are the components of the plant that may be eaten. A 90-day planting period results in twin clusters of tiny white flowers blooming. Rarely does the plant generate seeds; instead, a portion of a rhizome with a bud is usually planted to reproduce. A well-known meal is *Maranta arundinacea*, sometimes known as arrowroot. In the kitchen, it is used to make jams, jellies, cakes, baby food and many other things that call for a thickening agent. There are various medical applications for arrowroot. Baby and those recuperating from illness or medical treatment are given this nutritious starch since it is simple to digest and easy to ingest. Arrowroot tea aids with urinary issues due to its antibacterial effects on the urinary tract. It lowers cholesterol when taken consistently. An overview of the green synthesis of Ag NPs using *Maranta arundinacea* is given in this introduction, along with an explanation of the methods used to characterize the Ag NPs and determine their characteristics.

2. Materials and methods

2.1. Collection of plant materials

The fresh samples of *Maranta arundinacea* were collected randomly from the Yercaurd Hills, Tamil Nadu. Sample materials were washed under running tap water, air dried, and then homogenized to fine powder and stored in airtight bottles in the refrigerator.

2.2. Preparation of extracts

Crude *Maranta arundinacea* Sample extract was prepared by the Soxhlet extraction method. About 20gm of powdered sample, material was uniformly packed into a thimble and extracted with 250ml of different solvents Ethanol, and ethyl acetate extract separately. The process of extraction has to be continued for 24 hours or till the solvent in the siphon tube of extractor becomes colorless. After that, the extract was taken in a beaker kept on a hot plate and heated at 30-40ºC till all the solvent evaporated. The dried extract was kept in the refrigerator at 4ºC till future use.

2.3. Phytochemical screening

Preliminary phytochemical analysis was carried out for all the Ethanol and ethyl acetate extracts of *Maranta arundinacea* as per standard methods described by Brain and Turner, 1975 and Evans, 1996.

2.4. Synthesis of silver nano-particles

The silver nitrate solution 1 mM solution was prepared in a 100 ml flask. 1 ml of plant extract was mixed with 9 ml of 1 mM of silver nitrate. The aqueous leaf extracts of the *Maranta arundinacea* leaf and silver nitrate solution were used as a control throughout the experiment (Smetana *et al*., 2005). The final solution was 200 ml and centrifuged at 18,000 rpm for 25 min. The collected pellets were stored at -4^{0}C. The supernatant was heated at 50^{0}c to 95^{0}C. A change in the color of the solution was observedduring the heating process.

2.5. Characterization of silver nanoparticles

2.5.1. UV-Vis analysis

The optical property of Ag-NPs was determined by UV-Vis Spectrophotometer (Perklin- Elmer, Lamda 35, Germany). After the addition of $AgNO_3$ to the plant extract, the spectra were taken in different time intervals up to 24 hours between 350 nm to 500 nm. Then the spectra were taken after 24 hours of $AgNO_3$ additions.

2.5.2. FTIR analysis

The chemical composition of the synthesized silver nanoparticles was studied by using an FTIR spectrometer (perkin-Elmer LS-55- Luminescence spectrometer). The solutions were dried at 75^o C and the dried powders were characterized in the range 4000–400 cm $^{-1}$ using KBr pellet method.

2.5.3. SEM analysis

The morphological features of synthesized silver nanoparticles from *Maranta arundinacea* plant extract were studied by Scanning Electron Microscope (JSM-6480 LV). After 24 hours of the addition of $AgNO_3$ the SEM slides were prepared by making a smear of the solutions on slides. A thin layer of platinum was coated to make the samples conductive. Then the samples were characterized in the SEM at an accelerating voltage of 20 KV.

2.6. Antimicrobial susceptibility test

The disc diffusion method (Bauer *et al.,* 1966) was used to screen the antimicrobial activity. *Invitro* antimicrobial activity was screened by using Muller Hinton Agar (MHA) obtained from Hi-media (Mumbai). The MHA plates were prepared by pouring 15 ml of molten media into sterile petri plates. The plates were allowed to solidify for 5 minutes 0.1% inoculum suspension was swabbed uniformly and the inoculums were allowed to dry for 5 minutes. The concentration of extracts is 40 mg/disc was loaded on a 6 mm sterile disc. The loaded disc was placed on the surface of the medium and the extract was allowed to diffuse for 5 minutes the plates were kept for incubation at 37^{o}C for 24 hrs. At the end of incubation, inhibition zones formed around the disc were measured with a transparent ruler in millimeters.

3. Results and discussion

3.1. Yield obtained

Yield from the plant material of *Maranta arundinacea* was obtained from the solvent's ethanol and ethyl acetate extract. The ethanol extract proved to give a higher yield than be 28.54 extract. So further analysis was carried out using the ethanol extract of *Marantha arundicinacea*.

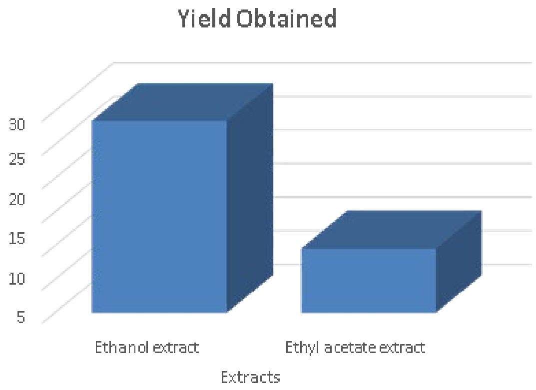

Fig. 1. Yield obtained in maranta arundinacea.

3.2. Phytochemical analysis

The qualitative phytochemical analysis was carried out for both the extracts of ethanol and ethyl acetate of *Maranta arundinacea*. The phytoconstituents present in ethanol extract are Alkaloids, Steroids, Terpenoids, phenols, Saponin, tannin and Carbohydrates, whereas in ethyl acetate extract Steroids, Terpenoids, Saponin, tannin, Carbohydrates, oils and resins were present (Table 1). Flavonoids are potent water-soluble antioxidants and free radical scavengers that prevent oxidative cell damage and also have strong anticancer activity (Rio *et al.,* 1997; Salah *et al.,* 1995). It also helps in managing diabetes-induced oxidative stress.

Terpenoids have been found to be useful in the prevention and therapy of several diseases, including cancer. Terpenoids are also known to possess antimicrobial, antifungal, anti-parasitic, antiviral, antiallergenic, antispasmodic, anti-hyperglycemic, anti-inflammatory and immune-modulatory properties (Rabi *et al*., 2009; Wagner *et al.,* 2003). In addition, terpenoids can be used as protective substances in storing agricultural products as they are known to have insecticidal properties as well (Sultana and Ata, 2008). Alkaloids represent a class that affects the central nervoussystem, reduces appetite and behaves as a diuretic (USDA, 2010).

Table 1. Phytochemical analysis of maranta arundinacea.

Phytochemicals	Ethanol extract	Ethyl acetate extract
Alkaloids Mayer's test Wagner's test	+ +	+ +
Flavonoids Lead acetate test H_2SO_4 test	- -	- -
Steroids Liebermann-Burchard test	+	+
Terpenoids Salkowski test	+-	-
Arthroquinone Borntrager's test	-	-
Phenols Ferric chloride test Lead acetate test	+- +-	- -
Saponin	-	-
Tannin	+	+
Carbohydrates	++	+
Oils and Resins	-	+

3.3. Synthesis of silver nanoparticles

The generation of nanoparticles by physical and chemical processes takes a lot of time, thus a new advancement in nanotechnology uses biological systems to speed up the synthesis of nanoparticles. Because of surface plasmon vibrations, silver nanoparticles (Ag NPs) look yellowish brown in aqueous media (Krishnaraj *et al*., 2010). The color of the solution changed as the leaf extracts were added to an aqueous silver nitrate solution, going from a faint light to a yellowish brown to a reddish brown and finally to a colloidal brown, indicating the formation of Ag NP (Lalitha *et al*., 2013; Singhal *et al*., 2011). This confirmed that the reaction between the leaf extract and $AgNO_3$ was complete. Both the aqueous extract and the crude extract of a plant sample were used to create the silver nanoparticles. According to Philip and Unni, (2011), the colour variations seen suggested the creation of silver nanoparticles.

3.4. Antibacterial activity

In this study, the antimicrobial property of Ag NPs was investigated by growing *Bacillus subtilis, Escherichia coli, Salmonella typhi, Bacillus cereus* and *Enterococcus faecalis* colonies on nutrient agar plates supplemented with Ag NPs. The antibacterial activity was carried out in five organisms. The inhibition zones obtained indicate the maximum antibacterial activity of the prepared test sample. Results obtained in previous studies also support the antibacterial potential of Ag NPs. The Zone of inhibition was found to be high in *Bacillus cereus* (14 mm), *Enterococcus faecalis* (14 mm) and next to it is *Bacillus subtilis* (13 mm), *Escherichia coli* (13 mm).

Table 2. Antibacterial activity in synthesised ethanol extract of maranta arundinacea

Organisms	Control	Concentration (µl)			
		S30	S40	C30	C40
Bacillus subtilis	18	10	13	11	16
Escherichia coli	19	11	13	12	19
Salmonella Typhi	23	10	12	11	14
Bacillus cereus	19	11	14	12	15
Enterococcus faecalis	18	12	14	13	16

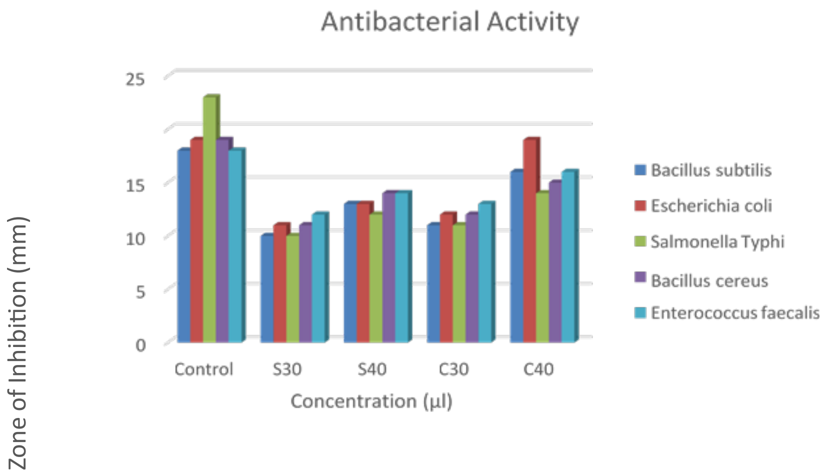

Fig. 2. Antibacterial activity in synthesised ethanol extract of maranta arundinacea.

The antibacterial activity of silver nanoparticles synthesized from the ethanol extract of *Maranta arundinacea* was evaluated by measuring the zone of inhibition against *Salmonella typhi and Escherichia coli* for different concentrations of the extract. The sizes of the zones of growth inhibition are presented in Table 2. According to the findings, all of the tested strains were effectively inhibited by silver nanoparticles' antibacterial activity. In general, the findings indicated that the concentration of silver had an increasing inhibitory impact. The outcomes for the organically produced Ag NPs matched those attained for the control.

3.5. Spectral studies

3.5.1. UV analysis

UV-Vis analysis refers to absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region. This means it uses light in the visible and adjacent ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum,molecules undergo electronic transitions.

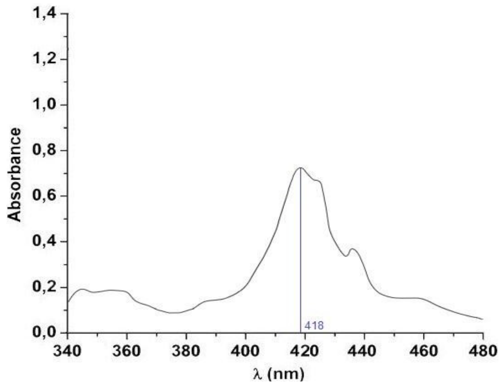

Fig. 3. UV analysis of synthesis of silver nano particles from maranta arundinacea.

The basis of it is the idea that molecules with n- or -electrons, which cannot form bonds, can absorb energy from ultraviolet or visible light to excite these electrons to higher anti-bonding molecular orbitals. The longer the wavelength of light it can absorb, the more easily excited the electrons are (*i.e.,* the lower energy gap between the HOMO and the LUMO). Maximum absorbance for the synthesized *Maranta arundinacea* silver nanoparticles was noted at about 418 nm and was seen as a peak on the spectrum.

3.5.2. FTIR analysis of synthesis of silver nanoparticles from maranta arundinacea

FT-IR spectroscopy is the measurement of absorption of IR radiations by a sample plotted against the wavelength. The interpretation of the IR spectrum involves the correlation of the absorption bands (vibrational bands) with the chemical compounds in the sample (Poovizhi and Krishnaveni, 2015). Fourier TransformInfrared Spectroscopy (FTIR) measurements are carried out to identify the possible biomolecules responsible for the reduction of the Ag+ ions and capping of the bio-reduced Ag NPs synthesized from aqueous extract of *Marantha arunidicea.*

Table 3. FT-IR spectra interpretation of silver synthesized nanoparticles.

S.NO	Infrared Absorption Bands(Wave number in cm^{-1})	Infrared band Assignment
1	3421.75	Bonded N-H/ C-H/ O-H stretching of amines and amides
2	3316.24	Amines (N-H) Medium
3	2775.60	Alkanes (C-H) medium to strong
4	2671.38	Carboxyl acid
5	2071.38	Aromatics (Weak)
6	1648.53	-C=C- Stretching of alkanes
7	1384.18	CH_3CH bending of alkanes
8	1124.70	Alkyl amine
9	683.13	C-Cl stretching alkyl halides

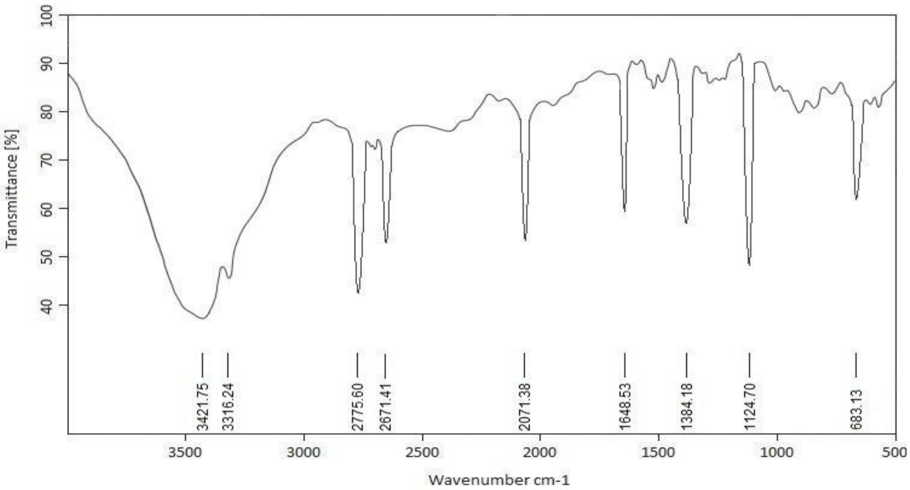

Fig. 4. FT-IR spectra interpretation of silver synthesized nanoparticles.

3.5.3. SEM analysis of synthesis of silver nanoparticles from maranta arundinacea

The SEM analysis is utilized for the structure of the reaction products that were formed. The figure 5 represents the SEM pictures of silver nanoparticles at different magnifications. These pictures confirm the formation of silver nanoparticles. The SEM analysis substantiates the approximate spherical shape of the nanoparticles.

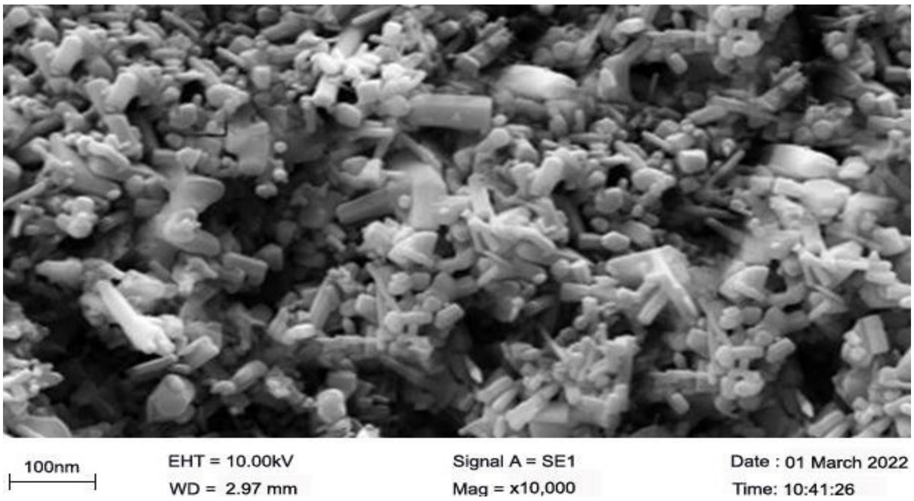

Fig. 5. SEM analysis of synthesis of silver nanoparticles from maranthaarundinacea.

The silver nanoparticles synthesized from *E. heterophylla* extract were characterized by Scanning Electron Microscopy (SEM). SEM is a type of electron microscope that images a sample by scanning it with a high-energy beam of electrons in a raster scan pattern. SEM technique was employed to visualize the size and shape of silver nanoparticles. The SEM images of the Ag NPs are shown in Figure 5.

4. Conclusion

The green synthesis of silver nanoparticles (Ag NPs) using *Maranta arundinacea*, commonly known as arrowroot, has been successfully achieved. Silver nanoparticles were prepared by using plant extract. This method is the best option for the traditional method and is less expensive, eco-friendly and ignore toxic chemical. Silver nanoparticles have varied applications in different industries like rubber, electronics and electrotechnology industry, textile industry and pharmaceutical industry due to their amazing properties like antiseptic, anticorrosive and antifungal.

The synthesis of silver nanoparticles is still in its infancy and more research needs to be focused on the mechanism of nanoparticle formation which may lead to fine-tuning of the process ultimately leading to the synthesis of nanoparticles with strict control over the size and shape parameters. *Maranta arundinacea* extract proved to be an efficient and eco-friendly agent for the green synthesis of silver nanoparticles. The reduction of silver ions to Ag NPs occurred readily under mild conditions without the need for hazardous chemicals, making it an environmentally sustainable approach. The synthesized Ag NPs were characterized by various techniques such as UV-Vis spectroscopy, TEM and XRD. These analyses confirmed the formation of Ag NPs with a relatively uniform size and shape distribution.

The average size of the nanoparticles was found to be within the desired range, typically in the nanometer scale. The green synthesis of silver nanoparticles using *Maranta arundinacea* extract is a viable and sustainable approach that yields nanoparticles with promising properties. These nanoparticles hold potential applications in various fields, including medicine, biotechnology and environmental remediation. Further research is warranted to explore their full range of applications and to optimize the synthesis process for large-scale production while ensuring safety and environmental responsibility.

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