ECE1006

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY

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Slot: C1

PROJECT REPORT

GREEN SYNTHESIS OF SILVER NANOPARTICLES

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1. Introduction

Nanoparticles are referred to as materials which have at least one dimension in the nanoscale (1-100nm). The word nanotechnology is derived from the Greek work ‘nano’ which means ‘dwarf or miniature’. The field of nanotechnology is known to be one of the most active areas of research in modern material sciences.

Nanotechnology provides the ability to engineer the properties of materials by controlling their size, and this has been driven research towards a multitude of potential uses for nanomaterials [1]

One of the major fields in which nanotechnology finds extensive applications is nanomedicine which is considered to be an emerging new field and an outcome of fusion of nanotechnology and medicine.

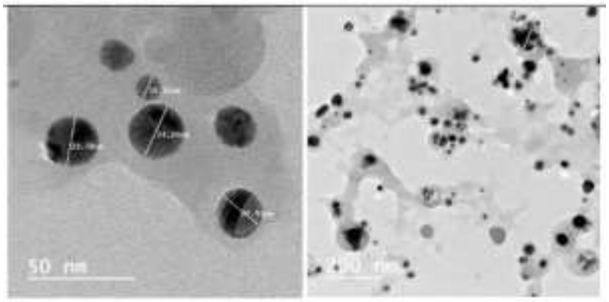
1.1 Need for Green Synthesis

The need for biosynthesis of nanoparticles rose as the physical and chemical processes were costly [10]. The biosynthesis of nanoparticles by green technique which represents a connection between biotechnology and nanotechnology, has received increasing consideration due to the growing need to develop environmentally benign technologies for material syntheses [8].

Green synthesis has advantages over chemical and physical methods as it is more cost effective, environment friendly, and easy to scale up for large scale synthesis. There is also no need for high pressures, temperatures, or toxic chemicals.

1.2 Silver Nanoparticles

Silver Nanoparticles are of particular interest due to their optical, magnetic and electrical properties which have been found to have extensive use in antimicrobial application. Nanosilver particles are mostly smaller than 100 nm and consist of about 20-15,000 silver atoms [21]. Antimicrobial capability of silver nanoparticles allows them to be suitably employed in numerous household products such as textiles, food storage containers, home appliances, and medical devices [22]. Silver is an effective antimicrobial agent which exhibits low toxicity [23].



2. Methods Of Synthesis

2.1 Using Pterocarpus Marsupium Roxb

The plant extract has been used in the production of silver nanoparticles. It has become popular because it is rapid, eco-friendly, non-pathogenic and provides a single step technique for the biosynthetic processes.
It is credited as a medicinal plant widely distributed in India.
Also known as Indian kino, Bijasal, Vijaysar, it belongs to the family Leguminosae.
The heart wood, leaves, flowers and bark have useful medical properties. The, plant is traditionally used to treat various disease like diabetics, angina, cancer.

Fig. 2.1

2.1.1 Material Collection:
Bark and wood of the Pterocarpus marsupium Roxb are collected. It is then cleaned properly with water.

2.1.2 Authentication:
The authentication and identification of the plant species is done by the Botanical survey of India.

2.1.3 Drying and Pulverizing
Shade drying if bark and wood takes place. This is done at a temperature not exceeding 40°C. Using a mixer, it is ground into fine powder and made to pass through the sieve number 16. It is stored in a dry place in a container well closed.

Fig. 2.2

2.1.4 Preparation of aqueous extract:
The Cold maceration method is employed in the production of the aqueous extract of the Pterocarpus marsupium Roxb. This is done through the accurate measurement and reaction of 50g air dried powder of *Pterocarpus marsupium* Roxb macerated with 500 ml of distilled water used as solvent. It is then allowed to stand for 24 hours followed by filtering it rapidly through muslin cloth. This filtrate is used as a test solution.
The filtrate is evaporated to dryness at a temperature of a maximum of 40^{o}C
for around 2 hours.
The extract is then photochemically screened.

About 1mg of Pterocarpus marsupium Roxb bark and wood extract powder is taken in a test tube and its solubility in ethanol, water, chloroform and diethyl ether are checked.

2.1.5 Green Synthesis:
Stock Solution: 1 mg of aqueous extract is weighed and diluted to 10 ml with distilled water.
To make 1mM silver Nitrate aqueous solution, 0.017g of silver nitrate is dissolved in 100ml distilled water and stored in an amber coloured bottle (to keep from reaction) until further use.

2.1.6 Silver Nanoparticle Production
The aqueous extract is taken in a
beaker and paced on a magnetic stirrer with hot plate. To this we add 50ml of 1mM silver nitrate solution earlier prepared drop wise with constant stirring at 120 rpm. The change in colour of the solution is to be monitored.

2.1.7 Separation of Silver Nanoparticles
The synthesised Pterocarpus marsupium Roxb silver nanoparticles are separated by centrifugation at 5000 rpm for 15 minutes.
The supernatant liquid is discarded. The pellets that we collect and store are the silver nanoparticles.

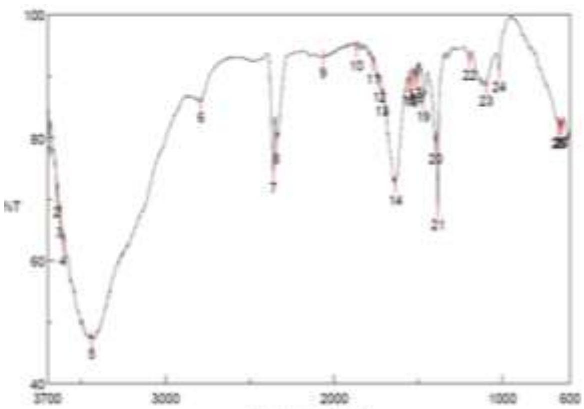


Fig. 2.3 FTIR Spectrum of Silver nanoparticles

2.2 Using Zingiberaceae Plants

Zingiberaceae family has around 52 plant genera and more than 1300 plant species, Of these plants, some were reported for their therapeutic usage. Among those, Curcuma longa (turmeric) and Zingiber officinale (ginger) are the most important and possess a variety of medicinal values.

Curcuma longa, commonly known as turmeric is an aromatic plant. In Ayurveda, it has come into use to treat wounds, acne, common cold, parasitic infections, urinary tract infection, and even liver diseases. This plant also possesses various important medicinal properties like antioxidant, anti-inflammatory, antibacterial, anti-human immunodeficiency virus properties. Importantly, it has potential anti-cancer property against liver, pancreatic, colon, cervical, lung, brain, breast, and bone cancers.

Another important medicinal plant is *Zingiber officinale*, generally called Ginger. The rhizome of this plant is widely used as a nutraceutical and in folk medicine. In Ayurvedic and Chinese traditional medicinal systems, it has been used to treat indigestion, arthritis, rheumatism, fever, and microbial infections. It has been found to possess antioxidant, anti-inflammatory, antihyperglycemic, anti-cancer, immunomodulatory, and cardioprotective properties.

a) b)

Fig. 2.4 a) Turmeric b) Ginger

2.2.1 Material Collection:

The rhizome of Zingiber officinale and Curcuma longa is collected. Soil and other surface contaminants present on fresh rhizome are removed using tap water followed by distilled water. Air-drying and maceration makes it into a fine powder.

2.2.2 *Extract generation:*

Then 5 g of mixed rhizome powder of both the Zingiber officinale and Curcuma longa are added to 250mL of distilled water and boiled for 30min. After cooling to room temperature, the extract is centrifuged at 5000 rpm, and filtered using number 1 filter paper (20–24 μm).

Filtered extract is further used for green synthesis of Silver nanoparticles.

2.2.3 Silver Nanoparticle generation

The prepared extract is used for the synthesis of silver nanoparticles.
Add 20 mL of 1 M $AgNO_3$ solution into 80 mL of rhizome extract. Then extract along with optimized silver nanoparticles is incubated until the colourless solution turns into a brownish colour, which indicates the reduction of Ag+ into Ag0 nanoparticle.

2.3 Using Leaf Extract Of Azadirachta Indica

Silver nanoparticles can also be manufactured using the leaf extract of Azadirachta indica (neem) which is a member of the Meliaceae family. It is a medicinal plant and is used for the treatment of bacterial, fungal, viral and many types of skin ailments since ancient times.

The aqueous neem extract is also be used in the synthesis of various other nanoparticles such as gold and zinc oxide.

Aqueous neem leaf extract reduces silver salt to silver nitrate, this capped nanoparticle with neem extract exhibit antibacterial activity.

Fig. 2.5 Neem

2.3.1 Preparation Of Neem Leaf Extract:

Chop Neem leaves finely and add that to double-distilled water. Boil concoction for around 10min. Cool and filter the extract and store for later usage.

2.3.2 Silver Nanoparticle Synthesis:

Use Silver nitrate in order to prepare 100ml of 1 mM solution of silver nitrate.

Then 1, 2, 3, 4 and 5 ml of neem extract was added separately to 5 ml of silver nitrate solution. Incubate this setup in a dark chamber in order to minimize photo-activation of silver nitrate at room temperature.

The colour change from colourless to brown in colour can confirms the reduction of silver ions.

2.4 ***Using Leaf Extracts Of Clitoria Ternatea And*** Leaf extracts of clitoria ternatea and solanum nigrum can be used to generate silver nanoparticles.

a) *b)*

Fig. 2.6

2.4.1 Collection of Material:

Fresh leaves of two different plants, Clitoria ternatea and Solanum nigrum, leaves that are free from diseases are collected and then washed thoroughly 2-3 times with tap water and then once with sterile water.

2.4.2 Preparation:

Chop finely 20 g of fresh leaves and add to 100 mL of distilled water. Stir at 60^{o}C for 1 hour.

After boiling, cool the mixture and filter it through filter paper number 1. Collect and store filterate.

2.4.3 Synthesis of Silver Nanoparticles

0.1 M of aqueous solution of silver nitrate is prepared and used for the synthesis of silver nanoparticles. 5 mL of leaf extract of Clitoria ternatea and Solanum nigrum is added to 45 mL of 0.1 M AgNO3 solution for bio-reduction process at room temperature.

3. Silver Nanoparticle Applications

Antibacterial activity of the silver containing materials is used in medicine to reduce infections in burn treatment [14] and arthroplasty [15], as well as prevent bacteria colonization on prostheses [16], catheters [17], vascular grafts, dental materials [18], stainless steel materials [19], and human skin [20]

Medicinal plants based synthesis of nanoparticles has various biological benefits. Plant-based synthesized silver nanoparticles have strong antimicrobial activity and they are widely used as an ingredient in the pharmaceutical.

The biological and medicinal properties of NPs are mostly determined by various physical properties like particle size, structure, and crystallinity composition.

Silver Nanoparticles are interacting with cells and regulate active and passive cellular responses. without toxicity, especially no genotoxicity effects on human cells.

3.1 Agriculture:

In plants, Ag nanoparticles are transported through intercellular spaces referred to as short-distance transport and through vascular tissue also called long-distance transport.

Nanoparticles penetrate cell walls of the plants and plasma membranes of the epidermal layers in roots. It then enters the vascular tissues Xylem, followed by the stele. Xylem acts like a vehicle for distribution and translocation of nanoparticles. Through xylem, Silver nanoparticles can be taken up and sent to the leaves and all over the plant.

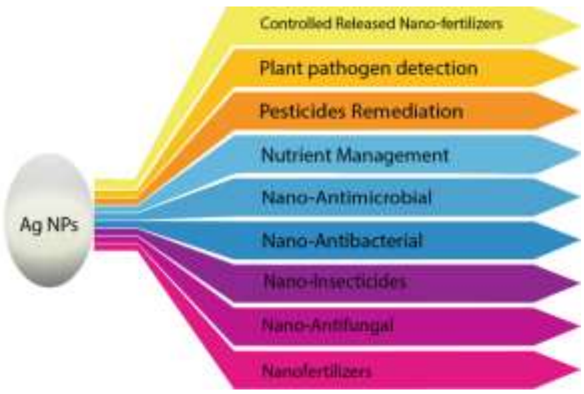


Fig. 3.1 Application of silver nanoparticles in Agriculture

Significant changes are observed when a plant is exposed to silver nanoparticles. Growth potential, seed germination, biomass, and leaf surface area are the commonly used parameters for assessing the phytotoxicity of Ag nanoparticles in plants. It has been found that Ag nanoparticles exposure could lead to inhibition of seed germination and root growth, and reduce biomass and leaf area. It is speculated that by reducing chlorophyll and nutrient uptake, respiration rate will decline, and hormones will get altered. Ag nanoparticles can disrupt the synthesis of chlorophyll in leaves and affect the photosynthetic system of the plant.

3.2 Anti-microbial activity:

Silver nanoparticles constitute a very promising approach for the development of new antimicrobial systems. Nanoparticulate objects have specific effects such as an adsorption at bacterial surfaces and can hence help in improving antibacterial activity.

However, the mechanism of action is essentially driven by the oxidative dissolution of the nanoparticles, as indicated by recent direct observations. The role of Ag+ release in the action mechanism was also indirectly observed in numerous studies, and explains the sensitivity of the antimicrobial activity to the presence of some chemical species, notably halides and sulfides which form insoluble salts with Ag+. As such, surface properties of Ag nanoparticles have a crucial impact on their potency, as they influence both physical and chemical phenomena. Here, we review the main parameters that will affect the surface state of Ag nanoparticles and their influence on antimicrobial efficacy. We also provide an analysis of several works on Ag nanoparticles activity, observed through the scope of an oxidative Ag+ release.

3.3 Optical Applications:

When silver nanoparticles are exposed to a selected wavelength of sunshine, the oscillating electromagnetic field of the sunshine induces a collective coherent oscillation of the free electrons, which causes a charge separation, forming a dipole oscillation along the direction of the electrical field of the sunshine. The amplitude of the oscillation reaches maximum at a selected frequency, called surface plasmon resonance (SPR).

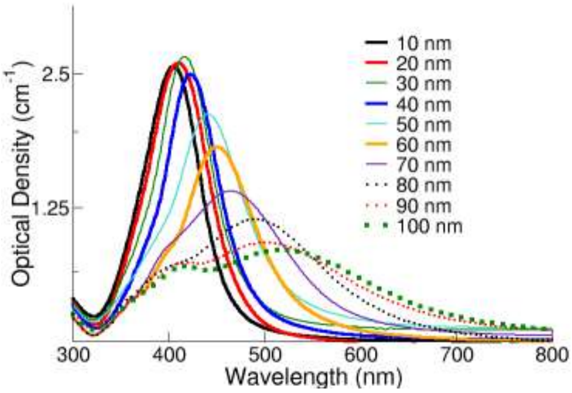


Fig. 3.2 Silver Nanoparticle absorbtion spectra.

The absorption and scattering properties of silver nanoparticles are dependent on the particle size, shape and refractive index near the particle surface. Smaller nanoparticles tend to absorb light and have peaks near 400nm, while larger nanoparticles show an increase in scattering and have peaks that broaden and shift towards longer wavelengths. The optical properties of silver nanoparticles can also change when particles aggregate and hence the conduction electrons near each particle surface become delocalized.

Silver nanoparticles have wide use as probes for surface-enhanced Raman scattering (SERS) and metal-enhanced fluorescence (MEF). Due to their higher extinction coefficients, sharper extinction bands, and high field enhancements as compared to other metals.

3.4 Catalyst

The chemical environment of the nanoparticle plays an important role in their catalytic properties. Silver nanoparticles are demonstrated to present catalytic redox properties for biological agents like dyes, also as chemical agents like benzene.

Catalysis takes place by adsorption of the reactant onto the substrate. When polymers, complex ligands, or surfactants (compounds that reduce surface tension between fluids) are used as the stabilizer or to prevent coalescence of the nanoparticles, the adsorption ability is decreased, causing catalytic action to also decrease.

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