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Sustainable Nanotechnology- Green Synthesis Methods for Silver Nanoparticles

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ABSTRACT

Silver has a long history of being an excellent substance in its field of medicine . Because of their special qualities, they have been used for a wide range of products, including antibacterial agents, household, industrial, and healthcare-related items, coatings for medical devices, drug delivery, and eventually to increase the tumor-killing effects of anticancer drugs. By the help of nanotechnology pure silver nanoparticles is obtained. The bioreduction of metal ions into their elemental form in the size range of 1–100 nanometers (nm) is known as "green synthesis," and it requires the use of plants or plant parts. As a result, the biological activities are increased and the toxicity level is decreased when AgNPs are synthesised using a green method. Scientists and researchers from various fields are becoming more and more interested in synthesising nanoparticles, particularly silver nanoparticles. However, they are unsure of the proper procedures to follow and the safety precautions to take while synthesising AgNPs, therefore the main aim of this paper is to provide a detailed methodology for the environmentally friendly synthesis of silver nanoparticles.

Keywords: Nanotechnology, Green synthesis, silver nanoparticles, 10-100nm, procedure for synthesis.

I. INTRODUCTION

Silver has been used for many years to cure skin wounds and treat a number of disorders, including pleurodesis and cauterization. On account of its growing potential impacts, silver has historically been an excellent compound. Due to their unique properties, they have been applied for a variety of purposes, such as antibacterial agents, industrial, domestic, and healthcare-related products, consumer goods, medical device coatings, optical sensors, cosmetics, pharmaceutical and food industries, diagnostics, orthopedics, drug delivery, and ultimately to enhance the tumor-killing effects of anticancer medications. Thus, nanotechnology is being used to provide a platform for the generation of pure silver

nanoparticles. Silver nanoparticles (AgNPs) are one of the most prominent and fascinating metallic nanoparticles used in biomedical applications. This is because of their distinctive physicochemical properties, such as catalytic activity, optical properties, electrical properties, antibacterial activity, and a high fraction of surface atoms, which gives them a specific surface area and a concentrated amount of surface atoms. AgNPs have antibacterial action that is harmless, secure, and efficient against 650 different species of harmful microorganisms. The bioreduction of metal ions into their elemental form in the size range of 1–100 nanometer (nm) is known as "green synthesis," and it requires the use of plants or plant parts. As a result, the biological activities are increased and the toxicity level is decreased when AgNPs are synthesised using a green method. Green synthesis, also known as sustainable nanotechnology, is the production of nanoparticles from any living entity, including bacteria, fungi, algae, and plants. Due to their tremendous medical powers, plants have received a lot of attention in recent years during the creation of nanoparticles. Microorganisms, however, have received much less focus, and some native plants have also received less attention. Scientists and researchers from various fields are becoming more and more interested in synthesising nanoparticles, particularly silver nanoparticles. However, they are unsure of the proper procedures to follow and the safety precautions to take when synthesising AgNPs, which is why the main goal of this paper is to provide a detailed methodology for the environmentally friendly synthesis of silver nanoparticles.

II. RAW MATERIALS NEEDED

The two main basic materials required for the synthesis of AgNPs are briefly discussed below.

A .One millimolar (mM) of silver nitrate solution is the first essential raw material required for the environmentally friendly synthesis of silver nanoparticles. Silver nitrate should be purchased with a purity level of > 99%.

1) Measuring 1mM of $AgNO_3$

1M = equivalent weight of silver nitrate in grams dissolved in one litre of deionized water. That is 169.87 grams of $AgNO_3$ in one litre of deionized water.

1mM = 169.87 / 1000

= 0.16987 grams of AgNo3 dissolved in one litre of deionized water

2) Different concentrations

In some cases the concentrations of the silver nitrate need to be increases from 1mM to various levels like 2mM, 3mM, 5mM, 10mM etc. Therefore it is also important to calculate how much amount of $AgNO_3$ is needed to be taken for different concentrations.

For1mM silver nitrate is 0.16987 grams

For 2mM = 0.16987 X 2

= 0.33974 grams of $AgNO_3$ in 1000 mL of deionized water.

For 3mM = 0.16987 X 3

= 0.50961 grams of $AgNO_3$ in 1000 mL of deionized water. And it goes on.

3) Precautions

The selection of water is crucial for the synthesis of silver nanoparticles; for a more sustainable process, deionized water is always recommended. All the glassware must first be thoroughly cleaned with deionized water and laboratory cleaning solution, followed by a rinse with a solution of 1 mM silver nitrate. When silver nitrate is added, the solution should be clear and colourless; if it is turbid and white in colour, the cleaning step has been done incorrectly. The main cause of the water's turbidity and white colour is the presence of chloride ions, hence deionized water should be used for washing. In this situation, the entire process must be done again.

Figure 1 : Precautions to be take while preparing silver nitrate solution- (A) Turbid and white colour solution (B) clear and colourless solution.

B. The second raw material needed for the synthesis of AgNps is the plant sample or microbes

1) Plant samples

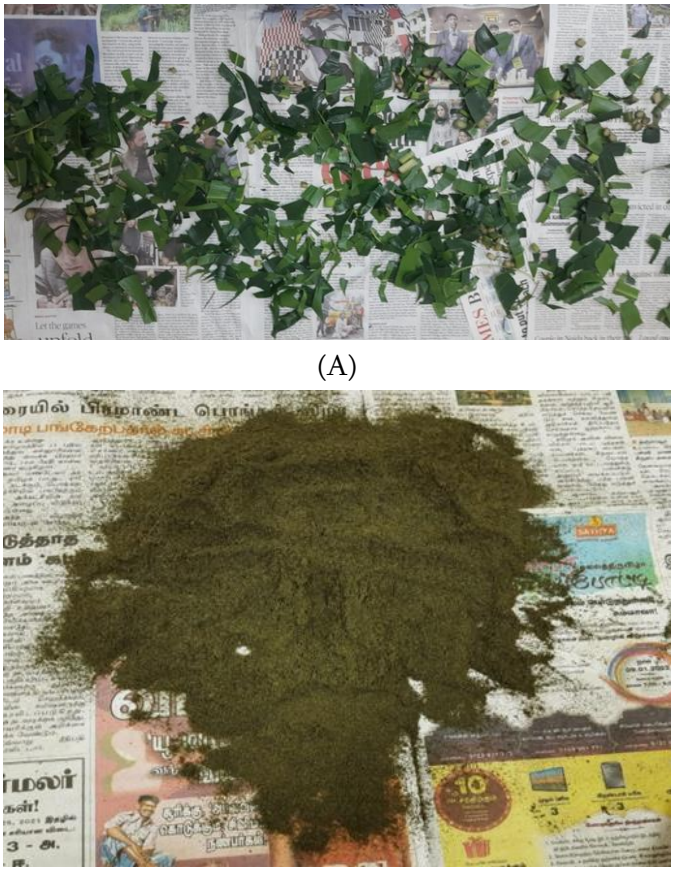
Any portion of the plant can be used as a source for the plant sample, which must be freshly picked and well cleaned with distilled water to get rid of all dust particles. The sample is then kept in a filter paper for room-temperature drying. Following their drying, the samples are finely chopped and shade dried for 10 days at room temperature. Sundry should be avoided because it may cause some of the plant's important chemicals to evaporate. The dried plant sample is pulverized into powder after ten days and kept in a sterile, clean container for future use.

2) Microbial samples

In case of microbes cell free supernatant need to be prepared for the synthesis. The selected microbe is inoculated in 1000mL of its growth medium(nutrient medium for bacteria and potato dextrose medium for fungus) and kept in a shaker at 121 rpm at 37 degree Celsius for 5 -7 days. After the incubation period the broth containing the microbes is sonicated in an ultra sonicator for 15 minutes then centrifuged at 13,500 rpm for 15 minutes. After the centrifugation process the supernatant is collected separately and used for the AgNPs synthesis.

Precautions

For microbial mediated synthesis it is always recommended to use salt free medium, because when silver nitrate is added to the cell free supernatant it reacts with the salt present in the medium and produces chloride ions produces white precipitate, therefore it is advisable to use only salt free medium.



(A)

(B)

Figure 2 : Plant sample (A) shade dry process (B) Pulverized and powdered sample.

A. There are two different process which can be followed for the AgNPs synthesis

1) Twenty Five grams of the freshly collected plant sample is added with 150 mL of deionized water and boiled at 100 degree Celsius for 15 minutes. Stirring is done for every five minutes. At the end, the solution is allowed to cool down at room temperature and filtered using whatmann No1 filter paper. 90mL of 1mM of silver nitrate solution is taken is an clean

conical flask and to it 10 mL of the filtered solution is added and kept in dark condition for 15minutes, the colour changes form pale yellow to brown indicated the presence of silver nanoparticles, this method is known as rapid synthesis.

2) Two grams of the powdered plant sample is taken in a clean beaker, to this 18 mL of deionized water is added and boiled at 100 degree Celsius for 15 minutes. Stirring is done for every five minutes. At the end the solution is allowed to cool down at room temperature and filtered using whatmann No1 filter paper. 90mL of 1mM of silver nitrate solution is taken is an clean conical flask and to it 10 mL of the filtered solution is added and kept in dark condition for 24 hours, the colour changes form pale yellow to brown indicated the presence of silver nanoparticles.

B. Microbial mediated synthesis

In a clean beaker 100 mL of cell free supernatant is taken to that 100 mL of 1mM of silver nitrate solution is added and kept in a shaker at 121 rpm for 24 hours at room temperature in dark condition. For microbial mediated synthesis incubation period may take around 24 to 72 hours and moreover various concentrations need to be analysed before going for the mass synthesis of AgNps.

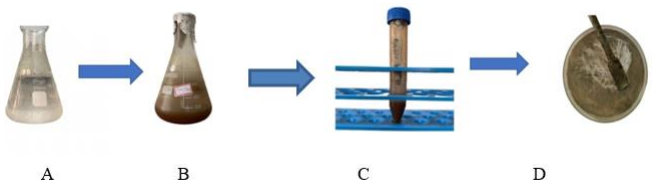


Figure 3: (A) silver nitrate solution (B) Production of nanoparticles after incubation (C) Colloidal solution of liquid nanoparticles after centrifuge (D) scrapping of crystal nanoparticles from petri plate.

C .Colour change

When the extract containing silver nitrate is incubated at a room temperature and in the dark for 24 hours, the colour of the silver ions begins to change to brown, indicating the creation of silver nanoparticles.

D. Ag Nanoparticles as liquid and crystal forms

1) Liquid form:

After 24 hours of incubation in dark, colour changed colloidal solution is centrifuged at 13,500 rpm for 15 minutes. After the centrifugation process all the nanoparticles settle down as pellets, therefor majority of the supernatant is discarded and the pellets is mixed with the little supernatant and stored in the refrigerator. This liquefied nanoparticles are used for various biological applications like Anti-oxidant, Anti-inflammatory, Anti-cancer assay, In vitro wound healing assay etc. the refrigerated liquefied nanoparticles can be used up to one month after that freshly new set of nanoparticles need to be synthesized.

2) Crystal form:

After the centrifugation process, majority of the supernatant is discarded and the pellets is mixed with the little supernatant and poured into a clean glass petri dish and kept undisturbed for 24 hours. After 24 hours the dried pellets are scraped and stored it in a clean test-tube. This pellet or crystal form of nanoparticles can be used as many days as possible. Avoid using plastic petri dish because it will be difficult while scrapping the nanoparticles from them.

Figure 4: silver nanoparticle synthesis (A) before 24 hours (B) after 24 hours. Colour change from pale yellow to brown indicates the presence of silver nanoparticles.

E. Characterization of synthesized silver nanoparticles
Once the synthesis part is done it is very important for conform the presence the AgNps based on its shape, size and morphology. Some of the standard and commonly used characterization techniques are listed below

1) UV-Visible spectrophotometer
2) FT IR (Fourier Transformed Infrared Spectroscopy)
3) X-Ray Diffraction
4) SEM and TEM
5) Particle size analysis
6) Dynamic light scattering etc.

III. CONCLUSION

Silver is used in the field of medicine for many centuries, thus by the help of nanotechnology pure silver nanoparticles can be obtained and used for various biological application. Products like AgNps Mouth washes, AgNPs coated soaps, suture materials are developed and patented. But still there is a gap which need to be filled and that is the role of Silver nanoparticles in the green synthesis and its various biological and medicinal applications .

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