SYNTHESIS AND CHARACTERIZATION OF FUNCTIONALIZED NANOPARTICLES FOR ENVIRONMENTAL APPLICATIONS

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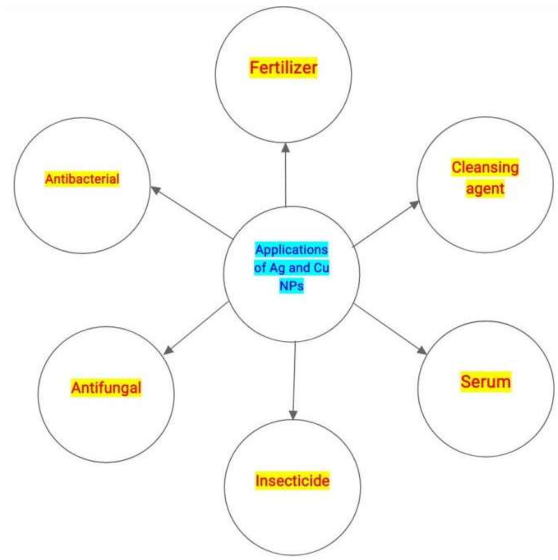
Abstract

Due to their improved performance over their parent materials and their adaptable properties, nanoparticles (NPs) are significant in the progress of technology. These are frequently it is made using hazardous reducing chemicals to convert metal ions into uncharged NPs. On the other hand, a number of initiatives to create green technologies that favor the use of natural resources over hazardous chemicals have been underway recently. Biological processes are used in green synthesis to synthesize natural products because they are easy to use, affordable, safe, clean, and highly productive. The green synthesis of uses a wide range of biological organisms, including as actinomycetes, bacteria, yeast, fungi, and plants. This study will also go through their properties, synthesis techniques, use, and possible applications. A material's characteristics change when it approaches the atomic scale. This is because, when the surface area to volume ratio rises, the atoms at the material's surface begin to control its behavior. Compared to bulk materials like powders, plates, and sheets, they have a significantly higher surface area to volume ratio because to their smaller size. This characteristic makes it possible to exhibit surprising visual, chemical, and physical qualities. This is because they may trap electrons and produce quantum effects because of their small size. are found in many parts of nature and are the subject of research in several scientific fields, including biology, chemistry, geology, and physics. Their state of transition between bulk materials and atomic or molecular structures sometimes results in them exhibiting features not observed at any larger size.

Keywords: Copper sulphate ($CuSO_4$) Nps, silver nitrate ($AgNO_3$) Nps, green synthesis, nanotechnology, UV-Visible spectroscopy.

Introduction

This field's interdisciplinary scope includes the management and applications of materials smaller than 100 nm. Numerous sectors use NPs, including wastewater treatment, environmental monitoring, food additives, antimicrobial agents, agriculture, food, biotechnology, biomedicine, and pharmaceuticals. Their nature, biocompatibility, antibacterial and anti-inflammatory properties, effective drug administration, bioactivity, bioavailability, tumor targeting, and bioabsorption are examples of their modern attributes. These attributes have led to an increase in NPs applications in biotechnology and applied microbiology. NPs is the general term for matter particles of dimensions between one and one hundred nanometers (nm). Since NPs are so small and have such a large surface area, they frequently display certain size-dependent properties [1]. The periodic boundary conditions of a crystalline particle are destroyed when it approaches the nanoscale because its normal length scale approaches or is less than the de Broglie wavelength, or wavelength of light.This leads to a variety of unique uses for NPs because many of their physical properties are very different from those of bulk materials [2].



Experimental section

Chemicals, solution preparation and synthesis

The synthesis of NPs can be done in two ways: either top-down, where the NPs are extracted or crushed from large-sized materials or bulk without atomic control, or bottom-up, where the NPs are created by assembling and mixing the nanosized precursors. Physical chemical, and biological processes can be used to broadly categorize the described methods for the production of nanomaterials. Chemical reduction in aqueous or nonaqueous solutions, micro-emulsions, etc., is used to accomplish these transformations [3].

A. Chemical method

AgNPs are prepared using $AgNO_3$ and tri sodium citrate ($C_6H_5Na_3O_7 \cdot 2H_2O$). Typically, 50 mL of 0.01 M $AgNO_3$ is heated, and then 5 mL of 1% TSC is added drop by drop to this solution. The two solutions are thoroughly combined and heated to a temperature of around 50 °C, at which point their color changes to a pale yellow [4]. It is then taken out of the hot bath and swirled until it cools to room temperature. The following could be used to express the mechanism of reaction:

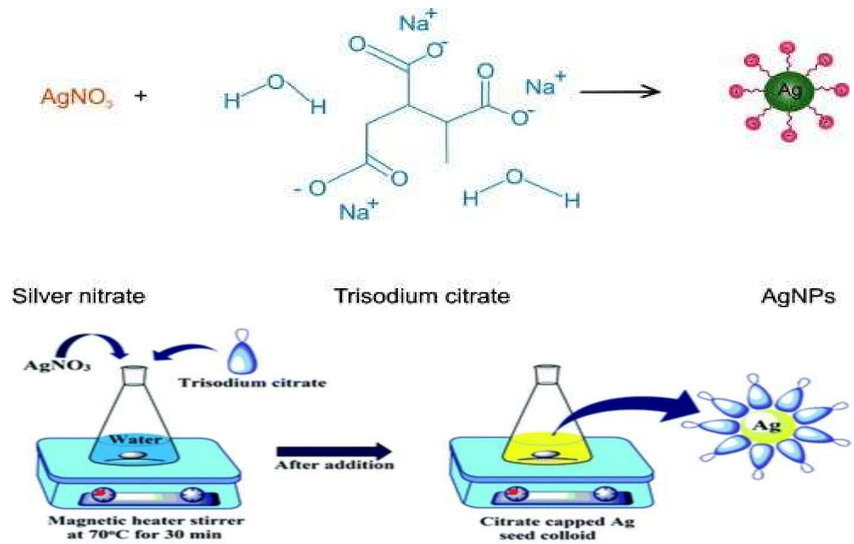


Figure 1. Synthesis of AgNPs

B. Biological method

By using plant leaf extracts as a reducing agent on an aqueous solution of $CuSO_4•5H_2O$, stable CuNPs were produced. Stable CuNPs were created by treating 1 mM aqueous solutions of $CuSO_4•5H_2O$ with leaf extract; the solution's color change verified the creation of stable NPs [5].

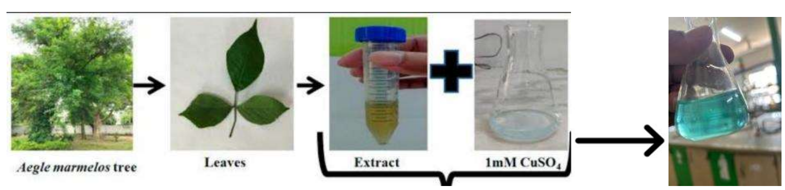


Figure 2. Synthesis of $CuSO_4$ NPs by leaf extract

Instrumentation and Characterization

Spectroscopic Analysis (UV-Visible Spectroscopy)

UV-Visible spectroscopy is a method for measuring the amount of light that a substance absorbs and scatters. This quantity, which is also referred to as the extinction, is calculated by adding the entire amount of light that is absorbed and scattered. In essence, the intensity of a visible light beam is measured both before and after it passes through a sample, which is positioned between a light source and a photodetector [6]. The wavelength-dependent extinction spectrum of the sample is measured through a comparison of these results at each wavelength. A common way to display the data is as extinction vs wavelength. To ensure that the sample extinction spectrum is devoid of any spectral characteristics from the buffer, every spectrum is background corrected using a buffer. [7].

Figure 3. UV-Visible Spectroscopy

Figure 4. Ag and Cu NPs solution

Applications

(a) Cleaning liquid: By mixing CuNPs and lemon juice, we can use antimicrobials to clean the microbes present in places like doors, glasses, floor, refrigerator, kitchen slab etc. It's use in antimicrobial.

(b) Dishwashing liquid: By mixing orange peel powder in CuNPs and lemon and soda in it, we can easily clean the stains on utensils, besin etc.

(c) Insecticide: By making copper carbonate ($CuCO_3$) from CuNPs, we can make insecticide to kill small insects.

$$2NaHCO_3 + CuSO_4 \longrightarrow 2\ CuCO_3 + Na_2SO_4 + CO_2 + H_2O$$

(d) Fertilizer: By mixing calcium oxide (CaO) with NPs of $CuSO_4$, we can obtain fertilizer in the form of copper oxide which can also be used in leguminous fungi in plants.

$$CuSO_4 + CaO \longrightarrow CuO + CaSO_4$$

(e) Cleansing agent (Pitambri Powder): When sodium bicarbonate ($NaHCO_3$) is mixed with CuNPs, sodium sulphate (Na_2SO_4) is obtained in which we can mix tamarind and use it in the form of Pitambari, such as in cleaning metal utensils etc.

$$2NaHCO_3 + CuSO_4 \longrightarrow CuCO_3 + Na_2SO_4 + CO_2 + H_2O$$

(f) Serum: By mixing aloe vera gel and lemon juice with CuNPs, we can make a serum which cures pimples on the face.

(g) Antifungal: By adding 2 to 3 drops of AgNPs to aloe vera gel, we can make an antifungal cream and clean the stains on the screen, remove warts or skin tags.

(h) Antibacterial: We can make anti-fungal cream by adding 1 to 2 drops of $AgNO_3$ to neem powder. We can use it as anti-dandruff, anti-fungal and antibacterial in hair.

(i) Compost: By making homemade compost, we can get a good fertilizer by drying it and mixing two to four times $AgNO_3$ in it.

Applications of Cu and Ag NPs		
 **(a)Cleaning liquid**	 **(b)Dishwashing liquid**	 **(c)$CuCO_3$ solution and killed insect**
 **(d)CaO solution**	 **(e)Cleansing agent**	 **(f)$CuSO_4$ NPs serum**
 **(g)AgNPs alovera gel**	 **(h)AgNPs Neem paste**	 **(i)AgNPs compost**

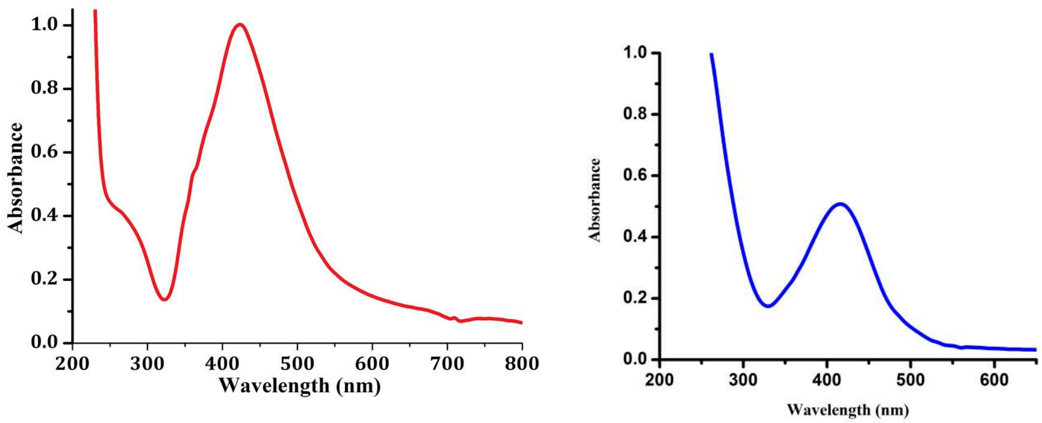
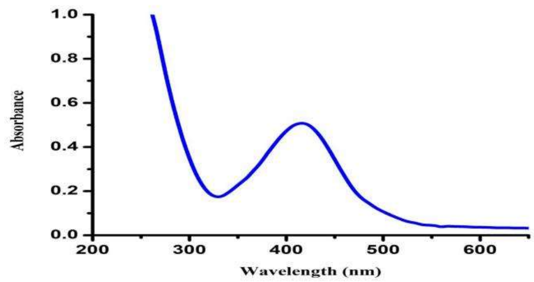


Figure: UV-Visible spectra of AgNPs and CuNPs

Graph1- Graph of absorbance



Graph 2- Graph of absorbance.

Results and Discussion

This Visible spectrum for Ag has λ_{max} = 420 nm and Cu has λ_{max} = 410 nm.

By breaking down the compound of $CuSO_4$ and $AgNO_3$ into NPs, we can obtain a large solution in a minimum form which we can use in various ways and can use a large number of processes in a small solution. This allows us to produce chemical products at a much cheaper rate economically. Lemon contains vitamin C which becomes stronger when it mixes with nano particles of $CuSO_4$. It contains vitamin C which works very well as an antimicrobial and kills small microorganisms and germs.

Orange peel is an antioxidant because of which it cleans utensils and basins very well and we can use it not only as a liquid but also as washing soda by making soap from it.

In the NPs of $CuSO_4$. We can make $CuCO_3$ with $NaHCO_3$ and kill small insects like small cockroaches in the kitchen. We can easily use it on oily places. Its important advantage is that it does not cause much harm and neither does it cause any harm to humans. It also does not have any smell, due to which children cannot be harmed.

By mixing calcium oxide in the CuNPs, we can get a very good fertilizer in the form of CaO and it does not cause any harm to the plants. It also easily cleans the fungus that is present in the plants. Its advantage is that we can make a solution of a small number of NPs in a lot of water and we get a very good fertilizer.

When we get $CuCO_3$ similarly we get sodium sulphate in its ppt, which we can use in the form of Pitambari. Sulphur is a good drying agent and we also use tamarind, which we can use in the form of Pitambari. By using it, we can clean metal utensils thoroughly.

We can make a serum by adding lemon juice to the NPs of copper sulphate as lemon contains vitamin C. We can also apply lemon juice directly instead of vitamin C capsules. It can easily kill the microbes stuck in the pimples and also fulfills the lack of hydration in the face, which makes the face glow and brighten.

Aloe vera gel can be very gentle on genital skin, and there is even evidence that it can help heal genital lesions from the herpes simplex virus. However, this is typically done through prescription treatments for best results. We can make it stronger by adding two to three drops of AgNPs. Two to three drops are not harmful and combined with aloe vera makes a very good antioxidant and antimicrobial.

Neem actively cleanses and strengthens hair follicles. Neem has a lot of benefits for hair. By increasing blood circulation in your scalp, you get strong and healthy roots, hence shiny, strong and healthy hair. If you add two-three drops of $AgNO_3$ in it, it will become an even better antioxidant agent and it destroys dandruff etc. We cannot use it on the skin because it turns black, so we can use it on the head.

Compost is a type of manure which is obtained from the decomposition and recycling of organic matter. It is an important component of organic farming. The simplest way of making compost is to make a heap of moist organic matter (like leaves, leftover food, etc.) and wait for some time so that it decomposes. This is a very easy method. We can get a good manure by drying it a little and adding two or three drops of $AgNO_3$ in it. The most important advantage of homemade compost is that it produces a lot of worm growth which is very good for the fertility of plants. We make chemical compost by adding a few drops of $AgNO_3$.

Living cells have been known to produce NPs; aspergillus fumigatus, a fungus, produces AgNPs extracellularly as one example. Au and AgNPs can also be produced by a wide variety of bacterial species and other fungi.

Conclusion

The creation of NPs with specific properties is one application of nanotechnology. Compared to normal chemicals, which only need chemical composition and concentration as acceptable metrics, NPs require various analytical requirements. Measurements of the NPs size, shape, surface properties, crystallinity and dispersion state are required for a thorough explanation [8]. Additionally, sampling and laboratory procedures that change the dispersion state of other variables can skew their distribution. An additional issue in environmental contexts is that many methods are unable to detect low concentrations of NPs that may still be hazardous [9].

In certain uses, nanoparticles can become immobilized in intricate matrices including blood, water, dirt, food, polymers, inks, or complicated mixes of organic liquids like makeup [10]. Spectrophotometry can be used to characterize the concentration, size, and shape of certain types of nanoparticles. It measures how electromagnetic radiation interacts with particles as a function of wavelength [11]. X-ray, UV-visible, infrared, and nuclear magnetic resonance spectroscopy can all be used on NPs. Using laser light, X-rays, or neutron scattering, light-scattering techniques are used to estimate particle size [12]. A different spectrum of particle sizes and compositions can be used with each approach. NPs have the potential to harm both the environment and human health [13].

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