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GREEN PREPARATION OF COPPER NANOPARTICLES FROM PLANT SEEDS EXTRACT: A REVIEW

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ABSTRACT

One of the biggest health and economic issues facing the world today is heavy metal contamination of waterways. As a result, the environmentally friendly production of Cu2+ nanoparticles from avocado seed extract may offer a simple, safe, and least expensive way to adsorb these heavy metals. In this work, several quantities (5%, 6%, 8%, and 10%) of Nigella sativa seed extracts were used to create the copper nanoparticles. The easy synthesis of environmentally safe copper nanoparticles (CuNPs) utilizing Cuminum cyminum (Cumin) seed extract is reported in this study. In a single step of green synthesis, the metal ions can be reduced to nanoparticles using biomolecules found in the seed extracts. Using aqueous wheat seed extract, a simple innovative green technology is provided for the manufacture of very stable and well-dispersed copper oxide nanoparticles. The electron-rich biomolecules produced from wheat seed extract served as a capping/stabilizing and reducing agent under ideal reaction circumstances. The production of copper oxide

nanoparticles was verified by the UV-visible absorption peak at 300 nm. The green chemistry technique is an easy, non-toxic, economical, ecologically beneficial, and biological process. The seed extract of Phoenix dactylifera has been applied as a capping and reducing agent in the environmentally friendly synthesis of copper oxide nanoparticles. This strategy had anticipated interest in studying natural waste products to boost the use of complementary and alternative medicine for infectious disorders. This study found that date fruit (Phoenix dactylifera L.) seeds may be used to produce biogenic copper oxide nanoparticles in an environmentally friendly and sustainable manner. Research in the fields of industry and health has focused on the cost-effective, non-toxic, and environmentally acceptable green synthesis of copper nanoparticles, or Cu NPs. A distinct class of multiphase, nanobiotechnology has emerged as a field of study in modern science and a paradigm change in the study of materials. The discovery of new natural resources for the biological production of metal nanoparticles is one of the two main issues facing the field of nanomaterial synthesis. The other issue is the lack of knowledge regarding the chemical composition of the bio-source needed for synthesis and the chemical process or mechanism behind the production of metal nanoparticles. Here, a natural extract from Tribulus terrestris seeds was used to create template-free, green synthesized copper oxide nanoparticles without the need for an isolation procedure. Wild birds prefer to eat black oil sunflower seeds (Helianthus annuus L.) because of their thin hulls and high-calorie content. However, in hot, humid regions, the oils can rapidly deteriorate and waste away. Our theory is that we can use sunflower seeds as a reducing agent to create copper nanoparticles (CuNPs). A copper sulfate solution, a black oil sunflower seed extract, and starch as a capping agent were the ingredients in the procedure. Visual inspection revealed that CuNPs were formed when the color changed from bright blue to light brown and reddish-brown precipitates formed when heated. When Cuprotesmo test sheets were used to test a portion of the precipitate, they became pink, indicating the presence of metallic copper. We created the copper nanoparticles for this study utilizing a green, environmentally acceptable manner. This study describes an easier and more environmentally friendly method for the production of copper nanoparticles utilizing seed extract from Persea americana. Copper nanoparticles were made from an aqueous extract of the shade-dried portions of Asparagus aethiopicus L. UV-visible spectroscopy was used to evaluate the Cu NP production process. The range of 310–360 nm had the maximum absorbance, indicating the production of Cu NPs. Compared to alternative synthesis methods, the biosynthesis of nanoparticles using medicinal plants has several advantages. Many bioactive substances found in plants can contribute to the reduction and capping of

nanoparticles. The advantages of plant-mediated synthesis are low cost, environmental friendliness, and long-term availability. The present study uses the medicinally valued herb Silybum marianum, which has a high silymarin concentration, as a stabilizing and reducing agent throughout the nanoparticle creation process. In this work, chia seed extract was used to create copper oxide nanoparticles (CuO NPs) in an easy, quick, and environmentally responsible way. Because of their many benefits and applications in industry, research, and health, copper nanoparticles are becoming more and more popular. Copper nanoparticles are green synthesized using an extract from the seeds of Foeniculum vulgare. The objective of this work is to use coffee arabica extract and straightforward techniques to create copper nanoparticles (CuNPs) at room temperature. Green synthesis was used to create CuO nanoparticles using an extract from the seeds of the Calotropis procera plant in an aqueous media. Ammonia was used as a stabilizing agent and copper acetate monohydrate as a precursor in the chemical reduction procedure to create CuO nanoparticles.

KEYWORDS: Adsorption process, Facile synthesis, Biosynthesis, seeds extract.

INTRODUCTION

Owing to their nano-size (1–100 nm), where one nanometer is equivalent to a billionth of a meter, nanoparticles possess unique characteristics. The structure of the nanoparticles produced, which show distinctive electrical, catalytic, antibacterial, and antimicrobial capabilities in addition to promoting environmental conservation, has drawn attention to the synthesis of nanoparticles using green methods in recent years.[1] Gold, nickel oxide, and silver nanoparticles are the most commonly used in biological applications as well as the quickly emerging fields of nano-biotechnology, resonance imaging, amplified voltammetric, detection chronocoulometry, and Raman spectroscopy. Furthermore, in chronic lymphoid leukemia (B cell-chronic lymphocytic leukemia), copper can trigger apoptosis. Researchers have been interested in it because of its many applications in integrated circuits, bio-labeling, sensors, filters, cell electrodes, antimicrobial deodorant fibers, and antimicrobials.[2] With the help of microbes, plant, and seed extracts, researchers are discovering new and inexpensive methods for the creation of nanoparticles. The process of creating nanoparticles by biosynthesis may be able to reduce toxicity and increase biocompatibility. The utilization of seed extracts has benefits over other biosynthetic methods, including being readily available, safe to handle, and easily scaled up for the green route's large-scale synthesis of nanoparticles.[3] Since they have a higher surface area and a smaller particle size than bulk materials, nanoparticles exhibit unique material properties that have led to their increased demand and widespread use in a variety of applications in recent years. Many physical and chemical methods have been developed recently to create different kinds of nanoscale particles with varying sizes and shapes. Their benefits are limited because, despite their widespread use, they are expensive and frequently contain hazardous ingredients (such as solvents, reducing agents, acid, and base reagents) that represent a major risk to public health. In contrast, biological processes have a simple methodology, great atom economy, are non-toxic, and—most importantly—are environmentally friendly.[4] Nowadays, a fascinating field in nanotechnology and nanoscience is the environmentally friendly creation of metal nanoparticles. A key component of green chemistry is the bio-fabrication of metal oxide nanoparticles utilizing living things. The green synthesis route is an alternate, straightforward, one-step, environmentally friendly, economical, effective, non-toxic, and reasonably repeatable method for producing nanomaterials with the required qualities. For the creation of diverse inorganic metal and metal oxide nanomaterials, the discipline of nanotechnology offers a variety of chemical and physical procedures, including photochemical reduction techniques, ultraviolet irradiation, laser ablation, lithography, aerosol technologies, and laser ablation.[5] The reduction of alkaloids, tannins, balsams, phenolic, and flavonoid metabolites in plants containing noble metal ions, including copper, is known as the "green synthesis" of nanoparticles. Cu metal has garnered interest because of its affordability, accessibility, and medicinal qualities that are comparable to those of silver and gold. Cu NPs give tissues stability and balance and have positive effects on living things.[6] Consequently, an enormous quantity of unwanted man-made waste is thrown into the environment, leading to major problems with pollution and ecological balance. Consequently, scientists are searching for novel materials to create a better atmosphere these days. The new material must meet several essential requirements, including being non-toxic, safe for the environment, and having a straightforward, eco-friendly processing process. Because less harsh chemicals are used in the green synthesis process, it is safer and more environmentally friendly.[7] CuNPs can be produced chemically, physically, or biologically. Adding a reducing agent and a capping/stabilizing agent to a copper salt solution results in its reduction by chemical means. Nanoparticles are produced as a result of the reduction process. An electrochemical reaction involving two electrodes divided by an electrolytic solution of copper sulfate and sulfuric acid is the subject of another well-liked chemical process.[8] Green metallic nanoparticle synthesis has been a novel and fascinating field of research in recent years. The utilization of green synthesis techniques to create nanoparticles (NPs) has gained popularity in recent times due to its several advantages, such as low cost, high stability, speed of production, absence of hazardous by-products, and ability to be scaled up for large-scale synthesis. Chemical synthesis methods result in the presence of hazardous chemical species absorbed on the surface of NPs, which is why green synthesis to manufacture diverse metal and metal oxide NPs has garnered interest. When made with green synthesis techniques, these metal NPs have been demonstrated to be more trustworthy and efficient.[9] With a wide range of applications, from engineering to medical, nanotechnology is one of the most inventive and exciting areas of science and technology. These nanoscale materials have been created via a variety of techniques, including chemical, physical, and green pathways, but these techniques have many disadvantages. Since a few decades ago, green technologies have gained popularity as the preferred way to fabricate nanoparticles (NPs) due to their biocompatibility, safety, low toxicity, and affordability compared to alternative options. The small size and large surface area of metallic nanoparticles allow for a wide range of applications. Copper oxide nanoparticles (CuO-NPs), among other metallic nanoparticles, have found applications in a variety of fields, such as biomedical, textile, catalysis, and sensing. Additionally, CuO is less expensive than silver, mixes readily with polymers, and has relatively stable chemical and physical properties. CuO-NPs are being produced using a variety of natural sources, such as fungi, bacteria, and plants. A range of biomolecules and metabolites, including vitamins, carbohydrates, phenolics, and flavonoids, are present in plant extract and can function as reducing and stabilizing agents as well as convert Cu2+ ions into CuO-NPs.[10] Since nanoscale materials (sizes ranging from 1 to 100 nm) have unique chemical, mechanical, and electrochemical characteristics that set them apart from large-molecule materials, they have found extensive use in a wide variety of applications in the last few decades. TiO2, ZnO, NiO, Fe2O3, and CuO are examples of metal oxide nanoparticles (MONPs) that have been used in biological, medicinal, and environmental domains. As a result, several physical and chemical preparation techniques have been created. However, because these synthetic processes are costly and time-consuming, and because they discharge hazardous chemicals into the environment, they have created additional hurdles for scientific communities.[11] Although there are many different types of nanoparticles depending on the material used for synthesis, the process, and other factors, metallic nanoparticles are the most desirable. Of all the metals, copper nanoparticles have long attracted attention because of their potential medical applications. Their fascinating qualities and widespread applicability in nearly every sphere of human endeavor established the foundation for today's tech-savvy society. They have a significant role in bioengineering, agricultural productivity, and environmental degradation. For many years, copper has been known to have biocidal properties.[12] In contemporary science and technology, nanomaterials are now regarded as a new field. Nanotechnology, on the other hand, has drawn a lot of interest because of its many uses in the majority of human endeavors, such as in agricultural fertilizers, nanoelectronics, and nanomedicine. Fundamentally, nanomaterials are produced by two methods of producing nanoparticles: breakdown and accumulation. The physical, chemical, and biological creation of nanoparticles frequently handles these methods. While the breakdown method is employed in physical production, the bottom-up strategy is frequently used in chemical and biological synthesis. Physical approaches have limitations because of their high cost, toxicity to the environment, difficulty in use, etc. While the synthesis of nanoparticles by plants and microorganisms is thought to be clean, eco-friendly, simple, low-energy, and inexpensive, the use of toxic chemicals is bad for the environment. As a result, more botanical herbals are chosen to create nanoparticles. The three stages of the build-up process for bio-mediated nanoparticles are stabilization, reduction, and reaction medium selection. Phytochemical substances include vitamins, proteins, amino acids, terpenoids, flavones, polyphenols, polysaccharides, alkaloids, tannins, and saponins function as capping, reducing, and antioxidant agents to help form nanoparticles.[13] Because of its many uses, including the creation of organic-inorganic nanostructure composites, high-Tc superconductors, sensors, optical, electrical, and gas sensors, and solar energy conversion, copper oxide nanostructures have garnered a lot of interest. Chemical synthesis techniques result in the surface absorption of some hazardous chemicals that could have negative impacts on medicinal applications. Typically, a nanoparticle's size is within the range of 1 and 100 nm. Particularly, metal oxide nanoparticles differ from bulk metals in their physical and chemical characteristics (such as having higher specific surface areas, lower melting points, and unique optical, magnetic, catalytic, and medicinal properties) that may be useful in a variety of industrial applications. Nanocrystalline copper oxide has been produced using a wide range of physical and chemical techniques, including vapor deposition, microemulsion, precipitation pyrolysis, sol-gel technique, one-step solid-state reaction method, and electrolysis method.[14] Recent studies have focused on metallic nanoparticles (NPs) due to their significant applications in the disciplines of material science, life science, agriculture, and pharmaceutics. NPs have special characteristics such as high yield strength, high surface-to-volume ratio, stiffness, flexibility, particular magnetization, and quantum size, which set them apart from bulk materials with the same chemical composition.[15] The present study focuses on the review of the preparation of copper nanoparticles from various seeds of different plants.

METHODOLOGY AVOCADO SEED

Preparation of the aqueous avocado seed extract: After removing any impurities with deionized water, we dried the avocado seeds at 50˚C in an oven to remove any remaining moisture. Next, we used a blender to grind the avocado seeds into a fine powder. Next, we created the brown extract solution by combining 500 mL of deionized water with 5 g of avocado powder. After that, the mixture was stirred and heated to 60 ˚C for 30 minutes. After filtering the brown solution, we were left with a pure liquid that could be used to manufacture metal nanoparticles. This liquid was then examined using FTIR and UV-VIS technology.

Preparation of copper avocado nanoparticles: A 200 mL beaker containing 80 mL of a blue solution containing 1 M copper sulfate was filled dropwise with 20 mL of brown seed extract. At 25 ˚C, the resulting solution was swirled for two hours. After fifteen minutes, the solution's color gradually transitioned from green to brown. This demonstrated that Cu nanoparticles were being produced. After the mixture was separated by centrifuging it for approximately 10 minutes at 6000 rpm, unreacted material was filtered out, it was calcined for 6 hours at 650 ˚C, and the Cu nanoparticles were collected.

Nigella sativa seed

Extraction of plant extract: The aqueous solvent extraction procedure (1:10) was utilized to extract Nigella sativa seeds. First, a 5 g sample was dissolved in an aqueous solvent after the Nigella sativa seeds had been ground. Subsequently, the liquid extract was treated by placing it on a hot plate at 30 °C for 40 minutes and letting it cool to room temperature. The extract mixture was then filtered using Whatman filter paper no. 1, and centrifugation was carried out for 10 minutes at 5000 rpm. For later usage, the supernatant was gathered and kept in glass bottles.

Synthesis of copper nanoparticles (CuNPs) using plant extract: A 100 mL conical flask containing a 0.05 M solution of copper sulfate (i.e., 1.25 g) was heated to 80 °C on a hot plate. Then, 25 mL of seed extract was added dropwise using a micropipette while being continuously stirred at 150 rpm using a magnetic stirrer. The reduction of copper sulfate was observed, and the hue transitioned from blue to green, indicating the completion of the reaction. Plant-stabilized copper nanoparticles (CuNPs) were optimized by using varying amounts of seed extract (5%, 6%, 8%, and 10%) while maintaining a constant quantity of copper sulfate (25 mL). The presence of flavones, phenols, polysaccharides, and terpenoids caused the size of copper ions to decrease, and this was observed using varying concentrations of herbal extract.

Cuminum cyminum seeds

Aqueous Cuminum cyminum seed extract preparation: 15 g of freshly harvested Cuminum cyminum seeds were surface cleansed with milli-Q water to get rid of any dirt, and they were then allowed to dry naturally to get rid of any moisture. Then, using a household blender, a fine powder of Cuminum cyminum seeds was made. After weighing and adding 10 g of seed powder to 100 ml of milli-Q water, the mixture was heated for 10 minutes. The seed extract was then filtered using Whatman's No. 1 filter paper. Lastly, to protect the sample from external factors, the filtered extract was stored for upcoming research.

Synthesis of copper nanoparticles: 50 milliliters of room temperature milli-Q water were used to create an aqueous 0.001 M copper acetate solution. After that, 10 milliliters of seed extract was added to the solution above, which was left at room temperature and stirred magnetically for 15 minutes at 1000 rpm. The quick bio-reduction of copper ions causes the blue color solution to turn pale bluish-green after about five minutes, indicating the synthesis of CuNPs. There is no more color change. The resultant CuNPs were further refined by centrifuging the pellet for 10 minutes at 10,000 rpm while significantly redispersing it in Milli-Q water. The synthesized CuNPs were then preserved for additional examination in a pristine amber bottle.

Wheat seeds

Preparation of the aqueous wheat seed extract: A simple soaking extraction procedure was used to obtain the wheat seed aqueous extract. Triticum aestivum, or healthy wheat grains, were typically harvested at the appropriate time from the nearby wheat field in Ahwaz, Iran (31°19'8.44"N, 48°41'3.12"E). The surfaces of the T. aestivum seeds were properly rinsed many times with distilled water to remove any potential unwanted pollutants, such as plant detritus, waste, or debris of any type, to obtain flawless powder. Harvested wheat grain specimens were dried at 60°C for two days to lower the moisture content of the seeds. A micro flour mill was then used to grind the grain into a fine powder. To get a suitable liquid extract, 5 g of sterilized seed powder was then steeped in 300 mL of sterile distilled water. The solution was gradually heated for ten minutes to a comfortable temperature of 80°C. After filtering and centrifuging the product at 5000 rpm, the liquid supernatant was kept chilled at 5°C in preparation for additional experimental testing.

Green synthesis of CuO NPs: 90 mL of a 0.01 M aqueous solution of copper (II) sulfate was mixed with 10 mL of liquid T. aestivum extract in an Erlenmeyer flask, following the standard protocol for the biological production of CuO NPs using wheat seeds. The mixture was continuously agitated for one hour at room temperature (25°C) to achieve a uniform composition. After that, the mixture was heated gradually to 70°C for 20 minutes and sonicated for 10 minutes. As a first visual inspection of the bioreduction of copper ions to CuO NPs, a constant color variation from dark blue to dark brown in solution was observed after the final heating process lasted for 10 minutes. The resulting material was dried in a furnace at 95°C for 120 minutes, centrifuged for 10 minutes at 12,000 rpm, and the precipitate of CuO nanopowder was collected. By adjusting the concentrations of wheat seed extract, pH, the concentration of salt precursor, and duration of contact, the reaction was thereby optimized.

Date fruit's seeds: Phoenix dactylifera seed extract preparation: After being cleaned, the Phoenix dactylifera seeds were ground in a grinder, and the resulting powder was gathered. After the process of segregation, the fine powder was obtained. Two hours were spent boiling the 2 g of seed powder in 100 mL of deionized water at 80°C in a water bath. Whatman filter papers were then used to filter the mixture. For further examination, the aqueous extract of Phoenix dactylifera seed extract was preserved and kept in a cool room.

Copper oxide nanomaterials synthesis: Co-precipitation and green chemistry were used to create copper oxide nanoparticles. At 80°C, with continuous stirring, 100 mL of 2% seed extract was combined with 0.1 M copper sulfate. The pH was kept at nine. The brownish-black pellet was the result of the process. The hot air oven was used to dry the pellet. Ultimately, the powder in black color was gathered and preserved in sterile, well-cleaned bottles in preparation for characterization examination.

Pipinella anisum seed extract

Preparation of seed extract: P. anisum seeds were identified after being purchased at a nearby market. To get rid of dust particles, P. anisum was washed in tap water first, and then in distilled water. Room temperature was used to allow the seeds to dry. The electric mill was used to grind the dry seeds into a powder. The 10 g of seed powder was added to a beaker with 250 mL of distilled water, and it was heated for 10 minutes at 60°C while being stirred. After allowing it to cool to room temperature, Whatman's filter paper was used to filter it. After centrifuging the filtered seed extract for five minutes at 5,000 rpm, the supernatants were removed and kept at +4 °C for further research on biosynthesis.

Synthesis of plant-mediated Cu nanoparticles: A 250 mL beaker was filled with 100 mL of

1 mM copper sulfate solution and 10 mL of anise seed extract, which was added through distillation. It was allowed to react at room temperature for a whole day. After the solution was put into Eppendorf tubes, it was centrifuged for ten minutes at 10,000 rpm. Twice, distilled water was used to wash the resulting Cu NPs. After that, it was dried for 48 hours at 50°C in an oven.

Tribulus Terrestris seeds

Preparation of powder of T.terrestris seeds: Using a mortar and pestle, 20 g of T. terrestris seed was ground into a powder.

Synthesis of copper nanoparticles: 50 ml of a 0.2 M CuSO4 solution was combined with around 2 g of T. terrestris seed powder, agitated for 10 minutes, and heated for 1 hour on a hot plate at 60 °C. The change in color to a dark brown hue indicates the development of CuO–NPs. After decanting the produced solution and washing the residue with 50% alcohol and water to remove any grossness, it was dried in a hot air oven at 80°C.

Black oil sunflower seeds

Preparation of Plant Extract : To get rid of contaminants, black oil sunflower seeds were cleaned in deionized water. Next, the seeds were pulverized in a grinder. A mixture of 5 g of pulverized seeds and 100 mL of water was brought to a boil at 100˚C for 10 minutes. The mixture was filtered through Whatman filter paper number 1 following a full day of setting the extract.

Preparation of copper nanoparticles: Five grams of copper sulfate were dissolved in eighty milliliters of deionized water. After adding 1 g of starch and 20 mL of the seed extract, the mixture was swirled. The seed extract was left out of the second solution that was made. For one hour, both flasks were submerged in a bath of boiling water. To reduce oxidation, they were sealed, put in a dark cabinet, and left to stand for 36 hours. The flask containing the seed extract underwent a color change and precipitate formation. To prepare for TEM and EDS analyses, a portion of the solution was poured into amber glass vials. On the remaining solution, tests were conducted both chemically and visually. The flask without the seed extract, on the other hand, did not change color or produce any precipitates. On this solution, no more analysis was done. Asparagus aethiopicus L seeds

Preparation of A.aethiopicus seed extract: Fruits of A. aethiopicus were gathered from the garden at St. Joseph's College Campus (SJCC) and allowed to dry in the shade for two weeks.

The fruits were carefully cleaned with deionized water after being rinsed under running tap water. To extract the seeds from the fruit pulp, the cleaned fruits were further crushed. The pulp and separated seeds were kept in separate containers for storage. After carefully washing the seeds to get rid of extra fruit pulp, they were dried on blotting sheets. We used a mortar and pestle to grind the seeds. After boiling the one-gram seed powder in 100 milliliters of deionized water for five minutes, it was allowed to cool to room temperature. After passing the extract combination through the Whatman No. 1 filter paper, it was kept at room temperature.

Green synthesis of CuO NPs from A.aethiopicus seed extract: For 6-7 hours, 20 mL of aqueous seed extract and 80 mL of CuSO4.5H2O were continuously stirred with a magnetic stirrer at 45–50°C. This procedure produced a brownish-black result at the end.

Silybum marianum seeds

Seed collection and preparation of seed extract: Seeds of Silybum marianum were obtained from the Plant Cell and Tissue Culture Lab (Herbarium code: PSM 04), Quaid-i-Azam University Islamabad's Department of Biotechnology. After twice being cleaned with distilled water, the seeds were dried and ground into a fine powder. To make an aqueous extract, 20 grams of seed powder and 200 milliliters of distilled water were combined in a flask and agitated at 6000 rpm for three hours at 50 degrees Celsius. The extract was run through nylon fabric as a filter to get rid of any solid residue. Three passes with Whatman filter paper further refine the filtrate. To prepare it for more research, the extracted material was kept at 4 °C.

CuO-NPs biosynthesis: CuO-NPs were biosynthesized by mixing aqueous seed extract with copper acetate monohydrate. In summary, 100 mL of produced extract was mixed with 10 grams of salt (copper acetate monohydrate) and allowed to agitate for two hours at 50 °C. CuO-NPs in the form of pellets were recovered after the reaction was finished by centrifuging the solution for ten minutes at 10,000 rpm to settle down the dissolved precipitate. The pellet was centrifuged twice with ethanol and three times with distilled water to further purify it. It was then let to dry for twenty-four hours at forty degrees Celsius. To produce a crystalline structure and eliminate additional impurities, the resulting CuO-NPs were calcined for three hours at 500°C.

Chia Seeds

Preparation of Seed Extracts: After buying chia seeds (Salvia hispanica L.) from a nearby market, we gave them a quick wash with tap water. After that, they were cleaned to get rid of contaminants and dust using double-distilled water. After that, they were left to dry for three days in the open. To make the seed extract, combine 5 g of dried seeds with 100 mL of double-distilled water, then bring to a boil at 50 °C for 20 minutes. After filtering, the seed extract was saved for use in additional studies.

Green Synthesis of the CuO NPs: In a flask, 10 g of CuCl2.2H2O was dissolved in 100 mL of double-distilled water. After that, the mixture was heated to 30 °C for five minutes on a hot plate. Following a vigorous stirring motion, 20 mL of the seed extract was added to the salt solution. During the reaction, the color of the solution changed from light green to dark brownish, signifying the creation of CuO NPs. After that, the mixture was centrifuged for 20 minutes at 15000 rpm. The synthesized CuO NPs were dried in an oven at 80 °C for 12 hours after being repeatedly cleaned with double-distilled water. To produce stable CuO NPs, the dried NPs were next annealed for three hours at 300 °C in a muffle furnace. To be characterized, the synthesized CuO NPs were lastly kept in a glass vial.

Fennel seeds

Preparation of Plant Extract: To prepare the fennel seed extract, the seeds were properly washed two or three times with tap water, and then again with distilled water to remove any remaining dirt or impurities. Following the washing process, 500ml of distilled water and 7g of fennel seeds were cooked for 20 minutes at 80˚C. Afterward, 125 mm-pore Whatman filter paper was used to get the filtrate. The filtrate was kept for subsequent analysis in a biological experiment at 4 ˚C.

Biosynthesis of CuNPs: The stock solution was used to prepare various quantities of copper nitrate salt, which were subsequently combined with the fennel seed extract. The solution combination was made in the following ratios:1:1,1:3,1:5, and 1:9. Following the creation of the reaction mixture including various ratios, they were incubated at 37 ˚C for 24 hours before being stored at room temperature in preparation for additional biomedical tests.

Coffee Arabica seeds

Preparation of Extract: The high-quality coffee arabica seeds were imported from Yemen's Taiz farms. Twenty grams of ground coffee arabica powder were then weighed and added to a 100 mL flask filled with distilled water. The mixture was heated to 80 ˚C for thirty minutes using a magnetic stirrer on a hot plate before being refrigerated. Whatman filter paper No. 11 was used to separate the mixture using a vacuum pump after 24 hours. For later testing, the transparent brown extract solution was refrigerated.

Synthesis of CuNPs: Subsequently, 40 mM of copper sulfate pentahydrate (CuSO4.5H2O) solution was mixed with the filtered coffee extract and allowed to stand at room temperature for the entire night. Rinsing the centrifuge three times with distilled water, CuNPs were recovered using a centrifuge (HERMLE Z 366 K1) at 12,000 rpm for 15 minutes at 4 ˚C. To create powdered copper nanoparticles, the pellet was suspended in deionized water and dried for eighteen hours at 80˚C in an oven.

Calotropis procera seeds

Preparation of seed Extract: In tropical regions, C. procera is a shrub that grows to a height of two to three meters. The plant seeds were gathered from Thanjavur, India, campus of Tamil University.50 grams of C. procera seeds were cleaned, dried, and ground before being added to 100 milliliters of deionized water and boiling for 60 minutes. The seeds were then sun-dried to eliminate any remaining moisture. The seed extract was obtained by filtering the aqueous solution.

Synthesis of Copper oxide nanoparticles: Copper ions were chemically reduced in an aqueous solution at room temperature to create copper oxide nanoparticles. A mixture of 0.05 mM copper acetate monohydrate and 0.001 mM ascorbic acid was used to dissolve 50 ml of C. procera seed extract, which was then continuously stirred with a magnetic stirrer. The solution was mixed with ammonia water until the pH reached 10. After adding 0.1 mM of hydrazine hydrate, the liquid was rapidly agitated for one hour. Following a 24-hour incubation period, the deep blue solution progressively turned yellow and then transformed slowly to brown coloring. For fifteen minutes, the fluid was centrifuged at 11,000 rpm. A tiny quantity of brown-colored copper nanoparticles formed at the tube's bottom after centrifugation, and with a little shake, they quickly scattered throughout the solution once more. To achieve an adequate amount of copper nanoparticles, the solution was aged for three hours at 40°C in an inert environment. After settling and being cleaned of any unreacted reactants with ethanol, the henna-colored copper nanoparticles were vacuum-dried.

Fenugreek seeds

Seed extract preparation: Twenty-five grams of fenugreek seeds were carefully cleaned in distilled water then dried and ground. The powder was also utilized to make an aqueous seed extract (5g/100ml). To get a homogenized solution, the extract was heated for about 30 minutes at 80–90˚C, shaken, and then filtered. The Whatman filter paper was used to filter the resulting extract, which was then refrigerated for later use.

Green synthesis of Cu NPs: A 0.2M aqueous solution of Cu (NO3)2.3H2O was made and kept. 200 milliliters of a 0.2M copper nitrate solution (1:2) was gradually dropped into 100 milliliters of extract while being continuously stirred. The combination has been incubated for a full day at room temperature. Visual evidence of the creation of CuNPs is the color shift from yellow to sea green. It was centrifuged for 15 minutes at 1000 rpm after that. To prepare the collected NPs for further examination, they were cleaned with deionized water, let to dry, and then ground.

CONCLUSION

To address important environmental and health issues, this study demonstrated the green preparation of copper2+ nanoparticles as surface adsorbent surface using avocado seed extract, which has medicinal properties, and a solution of CuSO4•5H2O. It also demonstrated the use of the adsorption process to remove heavy metals (Cd2+) from contaminated water. For the first time, Nigella sativa seed extract at four different concentrations (5%, 6%, 8%, and 10%) was successfully used to create green copper nanoparticles (CuNPs). These methods demonstrated several advantages, including easy availability, eco-friendliness, non-toxicity, and economic feasibility. The suggested strategy for the green synthesis process demonstrated great promise for various industrial uses. In this work, seed extract from Cuminum cyminum was used to create copper nanoparticles in an environmentally acceptable manner. Numerous benefits come with this method for synthesizing CuNPs, including its simplicity and the potential to scale up the process economically. It was successfully possible to biosynthesize very stable copper nanoparticles using aqueous wheat seed extract using a straightforward, green atom-economy method. In this experiment, the Triticum aestivum aqueous wheat seed extract demonstrated a dual role as a capping/stabilizing agent and a reducer for the bio-fabrication of new CuO nanoparticles. The ideal reaction conditions of neutral pH and a brief duration of 25 minutes at 70°C were met to produce copper oxide nanoparticles. Every common method, such as UV-VIS, FTIR, XRD, SEM, and TEM, verified that evenly distributed CuO nanoparticles had formed. The green chemical method was used to create the copper oxide nanoparticles. It's an easy, non-toxic, economical, ecologically friendly, and biological method. The seed extract of Phoenix dactylifera has been applied as a capping and reducing agent in the environmentally friendly synthesis of copper oxide nanoparticles. This study shows that P.

anisum seed extract can successfully promote the fast production of Cu NPs. In conclusion, T. terrestris seed natural extract with an average size of 58 nm was utilized to create CuO NPs employing the greener approach. One common waste product of the bird feed industry is black oil sunflower seeds. We predicted that sunflower seed extract would work well as a reducing agent in the CuNP production process because of its anti-oxidative qualities. We made a solution of copper (II) sulfate and seed extract to test this. CuNP precipitates developed, and TEM and EDS studies were carried out. Thus, we can say that by employing black oil sunflower seed extracts to create bigger, spherical CuNPs, we were able to successfully demonstrate a novel, ecologically friendly strategy in this experiment. Moreover, waste materials function as reducing agents in this way, supporting recycling initiatives. The method is inexpensive and devoid of harmful ingredients. It was determined that A. aethiopicus seed aqueous extracts can yield CU NPs that are fairly stable in solution. CuO-NPs were created in the current study employing a green method that involved Silybum marianum seed extract. The biosynthesis of CuO-NPs is less harmful to the environment, inexpensive, and simple. The biosynthesized CuO-NPs had a modest size of 15 nm, spherical shape, and clearly defined physiochemical properties. In this study, chia seed extract was used in an environmentally friendly manner to successfully synthesize CuO NPs. Our investigation revealed that there are numerous biological uses for copper nanoparticles derived from Foeniculum vulgare. The successful green production of copper nanoparticles using coffee bean extraction has been noteworthy. The ratio of one volume of coffee extract to one volume of 40 mM copper sulfate pentahydrate was the ideal concentration for the synthesis of CuNPs. To create a significantly active antibacterial material, the current study shows how to easily use Calotropis procera extract for the effective production of CuO Nanoparticles using a green synthesis approach. CuO nanoparticles have been successfully synthesized from seed extracts of C. procera plants in an aqueous solution utilizing the chemical reduction process. Utilizing the benefit of seed extract's inherent reducing and capping properties, this work demonstrates a simple, environmentally responsible, green synthesis of CuNPs.

Conflict of Interest

There are no conflicts of interest in this review study, the authors guarantee.

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