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Red Tea Mediated Synthesis and Characterisation of Copper Nanoparticles

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Authors' contribution

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The synthesis of metallic nanoparticles is a lively area of education and, more importantly, "application research" in nanotechnology. A wide range of chemical and physical procedures might be used for synthesis of metallic nanoparticles. However, these methods are swarming with many problems including use of toxic solvents, generation of hazardous by-products, and high energy consumption. Accordingly, there's a vital need to develop environmentally benign procedures for synthesis of metallic nanoparticles. A promising approach to realize this objective is to take advantage of the wide array of biological resources in nature. Indeed, over the past several years, plants, algae, fungi, bacteria, and viruses have been used for production of low-cost, energy-efficient, and nontoxic metallic nanoparticles.
Aim: The aim of the current study was to synthesise and characterize the copper Nanoparticles mediated with red tea.
Materials and Methods: The green synthesis of the copper Nanoparticles was done using red tea. Morphological characters like the shape and size of the obtained copper nanoparticles were done

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by transmission electron microscopy (TEM).
Results: The results confirmed that the synthesised red tea mediated nanoparticles are eco-friendly, good and non toxic. TEM images showed that the copper nanoparticles were well dispersed, crystalline in nature. Copper nanoparticles are spherical in nature. The particles size was ranging from 40 to 90 nm, The TEM image shows that nanoparticles are not combined but are separated by equal interspace between the particles, which was confirmed by microscopy visualising under the higher resolution.
Conclusion: In this study, a simple, biological and low-cost approach was done for the preparation of copper nanoparticles using red tea extract. Thus the green synthesized copper nanoparticles can be subjected to the various other biological activities to test their biological efficiency and can be a pioneering step towards the shift to eco friendly medicine.

Keywords: Copper nanoparticles; green synthesis; innovative; nanotechnology; Red Tea.

1. INTRODUCTION

Over the past few years, considerable interest has been focused on metal nanoparticles because of their potential applica- tions in diverse fields including catalysis, magnetic recording media, or microelectronics. Various methods are now known which enable one to organize these nanoparticles with controlled size and shape, these include metal vapour deposition, electro [1-3] chemical reduction, radiolytic reduction, thermal decomposition, mechanical attrition and chemical reduction. Among these methods, the solution method is found to be simple and most versatile for metal nanoparticles.

Nanoparticles are of great scientific interest as they bridge the gap between bulk materials and atomic or molecular structures. A bulk material has constant physical properties despite its size, but at the nanoscale this is often not the case [4]. Several well-characterised bulk materials are found to possess the most interesting properties when studied within the nanoscale. There are many reasons for this including the very fact that nanoparticles possess a really high aspect ratio. Metallic nanoparticles have possible applications in diverse areas like biotechnology, cosmetics, coatings, electronics and packaging. For instance, nanoparticles are often induced to merge into a solid at relatively lower temperatures, often without melting, resulting in improved and easy-to-create coatings for electronics applications (eg: capacitors) [5,6]. Nanoparticles possess a wavelength below the critical wavelength of light. This renders them transparent, a property that creates them very useful for applications in packing, cosmetics and coatings. Metallic nanoparticles are often attached to single strands of DNA nondestructively. This exposes avenues for medical diagnostic applications. Nanoparticles can traverse through the vasculature and localize any organ. This potentially can cause novel therapeutic, imaging, and biomedical applications [7-13].

There are two alternative approaches for synthesis of metallic nanoparticles: the “bottom-up” approach and therefore the “top-down” approach. Bottom-up, or self assembly, refers to the development of a structure atom-by-atom, molecule-by-molecule, or cluster- by-cluster. In this approach, initially the nanostructured building blocks are formed and, subsequently, assembled into the ultimate material using chemical or biological procedures for synthesis [14-18]. A definite advantage of the bottom-up approach is the enhanced possibility of obtaining metallic nanoparticles with comparatively lesser defects and more homogeneous chemical compositions. In the top-down approach, an appropriate starting material is reduced in size using mechanical or chemical means. An important drawback of the top-down approach is the imperfection of the surface structure. Such defects within the surface structure can have a big impact on physical properties and surface chemistry of the metallic nanoparticles because of its high aspect ratio [19-23].

Copper is one among the most widely used materials in the world. It has an excellent significance in all industries, particularly within the electrical sector because of it’s low cost. Copper nanoparticles are synthesized and characterized by different methods [18]. Stability and reactivity are the two most important factors that impede the utilization and development of the metal cluster during a new generation of nanodevices. The copper nanoparticles have been promising in the field of medicine and dentistry due to their properties such as their interaction with pathogens, their large active surface area, and their high biological and chemical reactivity [24-26].

Our team has extensive knowledge and research experience that has translated into high quality publications [27-46]. In this context, this study was done to synthesise and characterise the copper nanoparticles using red tea extract.

2. MATERIALS AND METHODS

2.1 Preparation of Red Tea Extract

A sample of Red Tea powder is taken and measured accurately to 1g to which 100mL of distilled water is added and boiled for 15-20 minutes at 60-70 degrees and the obtained extract is cooled for sometime, then the solution is filtered by using whatman no.10 filter paper. The filtered extract was collected and stored in the refrigerator for further use.

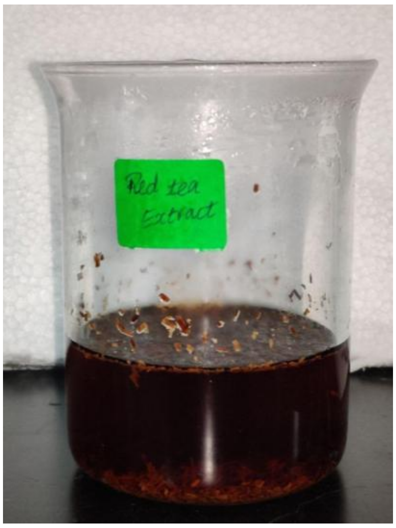

Fig. 1. Mixture of Red Tea extract in distilled water'

2.2 Synthesis of Copper Nanoparticles

Synthesis of Copper Nanoparticles is done biologically using red tea. 20mM of copper sulphate is added to the obtained extract. The colour change was observed visually and photographed. The solution is kept in a magnetic stirrer for nanoparticle synthesis. The reaction mixture of copper sulphate and red tea was centrifuged at 8,000xg for 10 minutes. The resulting pellet was washed three times with distilled water and filtered and the supernatant so formed was collected.

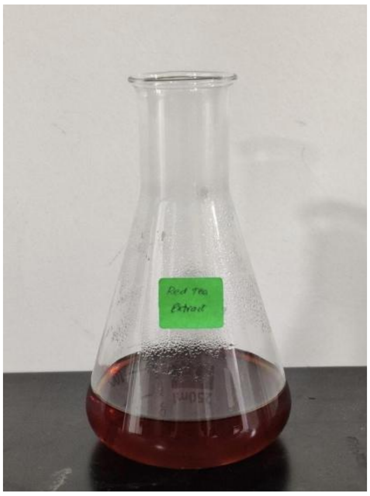

Fig. 2. Concentrated extract of Red Tea extract

Fig. 3. Mixture of Copper sulphate and Red tea

2.3 UV Spectrometric Analysis of Synthesized Nanoparticle

Spectrometric analysis was evaluated by UV-visible spectroscopy. The biologically reduced solution mixture was scanned by Shimazdu, Lambda UV mini-1240 instrument operated at a resolution of 1 nm. The UV-visible analysis was performed in the absorption wavelength of 200 to 700 nm periodically for one hour to observe rapid reduction of copper nanoparticles and the results were recorded for the graphical analysis.

2.4 Characterisation of Prepared Copper Nanoparticles

The synthesized Cu NPs were characterised using TEM (Transmission Electron Microscope).

The morphological analysis of the particle was done with TEM. A sample of Cu NPs was loaded on a carbon-coated copper grid, followed by solvent evaporation at room temperature for an hour. The TEM micrograph images were recorded on Zeiss- EM10C instrument on carbon coated copper grids with an accelerating voltage of 80 KV. The clear microscopic views were observed and documented in different ranges of magnifications.

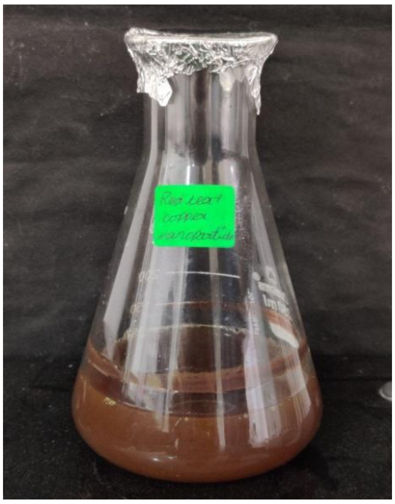

Fig. 4. The final reaction with red tea mediated CUSO4 Nanoparticles

3. RESULTS

Nanoparticle synthesis was predicted through visual observation of solution color change from light brown to brownish black and also nanoparticle synthesis were later confirmed using UV–Visible spectroscopy.

Copper nanoparticles were successfully synthesized using red tea extract after being subjected to continuous heat and stirring. The reddish brown reaction mixture slowly changed to a thick brown suspension after several minutes of reaction. The development of intense brown colour owing to the surface plasmon resonance confirmed the synthesis of the copper nanoparticles. Colour changes of the reaction mixture 240 minutes after the bioreduction process, which were recorded by UV-visible spectrophotometer. UV–Visible readings were recorded in the wavelength range of 200 - 600nm. The absorption formed in the reaction media has an absorbance peak at 350 nm. The surface plasmon resonance absorbance was very sensitive to size and shape of the particles. It was observed that the SPR bands are located at the range 357 nm which is the characteristic absorption peak for copper nanoparticles in this study. (Fig. 5).

The centrifuged substrate was then subjected to the TEM analysis for the characterisation so as to determine the size, shape and distribution of nanoparticles. TEM images show that particles are well dispersed, crystalline in nature is shown in the figure below, Copper nanoparticles were spherical in nature. The particles size was ranging from 40 to 90 nm, The TEM image showed that nanoparticles are not combined but are separated by equal interspace between the particles, which was confirmed by microscopy visualizing under the higher resolution. This image explains that the copper nanoparticles are bounded with the phytochemicals of the plant extract (Fig. 6).

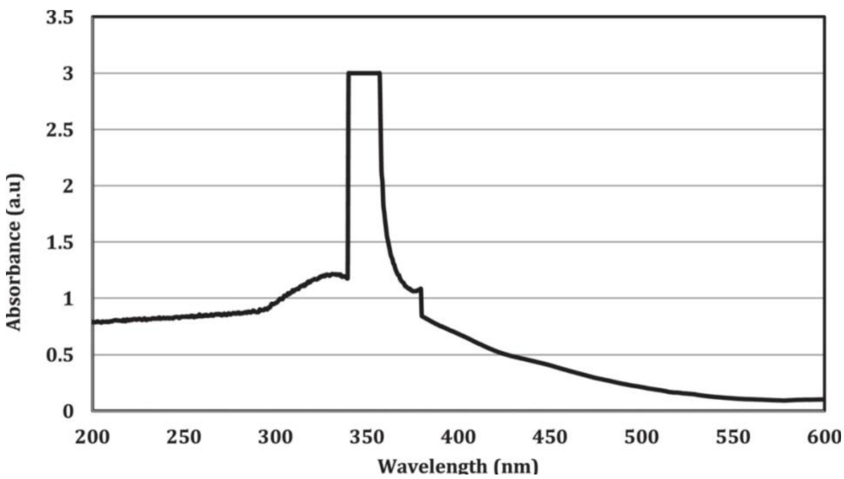

Fig. 5. UV-Vis spectroscopy of copper nanoparticles synthesised using red tea extract. The X-axis shows the wavelength (nm) and the Y axis shows the absorbance(Abs). UV-visible spectra of the copper nanoparticles showed the peak at 350 nm

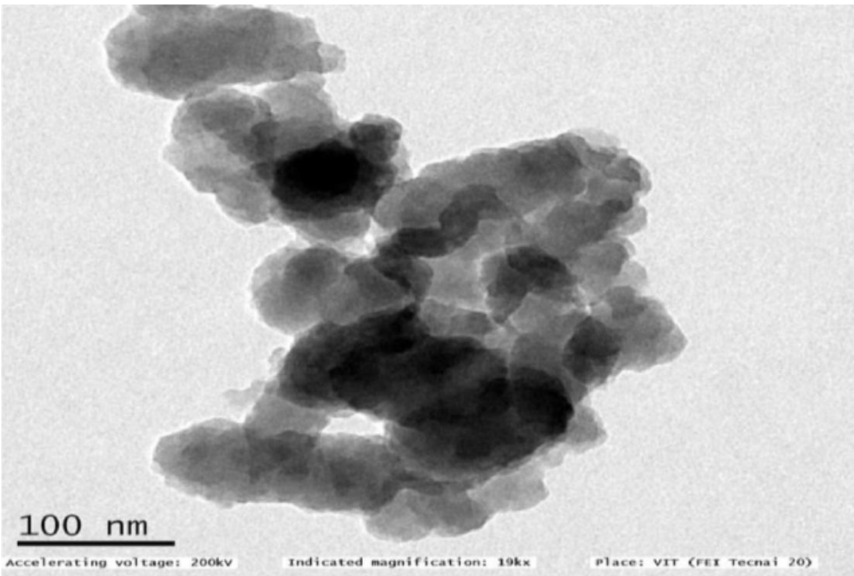

Fig. 6. Image showing the Copper Nanoparticles under TEM. The copper nanoparticles under TEM are spherical and are clustered

4. DISCUSSION

The current study was undertaken to synthesize and characterise copper nanoparticles mediated through red tea extract. So as to analyse its biologic properties to be used as adjunct in medical and dental fields.

Nandhini JT et al in 2021 synthesised copper nanoparticles using sea weed and their morphological features were characterised. The UV-visible analysis was performed in the absorption wavelength of 200-700 nm periodically for one hour to observe rapid reduction of zinc oxide nanoparticles by action of grape seed extracts after which the nanoparticles were subjected to TEM analysis. The TEM analysis in this study confirmed the spherical shape of the zinc oxide nanoparticles with their size ranging between 20 to 30 microns and were seen as clusters in the transmission electron microscope [12].

Also in another study, titanium nanoparticles were synthesized using grape seed extract and their morphological characteristics were evaluated using transmission electron microscope. The TEM analysis revealed the spherical shape of titanium nanoparticles of size 15 to 30 nm synthesised using grape seed extract [47].

Similarly, Periera et al., synthesised selenium nanoparticles using aqueous extract of clove and cinnamon and characterised the morphological features with transmission electron microscopy. In this study, the absorbance peak was noted at 355 nm. The TEM analysis confirmed the spherical and square shape of the titanium nanoparticles with the particle size ranging between 40 to 90 nm [47,48].

The current study was conducted similar to the previous studies discussed and their characterisation done using transmission electron microscope revealed similar results to the articles mentioned above. However, extensive research needs to be conducted to study the antibacterial, antifungal, antioxidant and cytotoxic activities of the synthesized nanoparticles for therapeutic purposes.

5. CONCLUSION

In this study, a simple, biological and low-cost approach was used for the preparation of copper Nanoparticles using Red Tea [49-62]. The green synthesized copper Nanoparticles can be subjected to the various other biological activities such as antibacterial, antifungal, cytotoxic evaluation to know the efficiency of these nanoparticles do that they can be used as a substitute for conventional chemical products thereby reducing the cytotoxicity.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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