ABSTRACT

The research work takes a green approach to metal nanoparticle synthesis. During the investigation, several physicochemical and spectroscopic techniques were used.

The goal of green nanomaterial synthesis is to generate as little waste as possible while also starting a sustainable process. The increasing demand for "green" and cost-effective metal nanoparticle synthesis systems has prompted scientists to investigate the use of microorganisms, plant extracts, and other biomaterials such as fruit waste, vegetable waste, agricultural waste, and so on. However, there are some drawbacks to using microorganisms, such as the inability to control the size and shape of synthesized nanoparticles and the slow synthesis rate. There is also the possibility of contamination. The constraints increase the possibility of using plants as precursor materials in nanoparticle synthesis. This study will also try to make nanoparticles out of leaves and fruit peel. In this study, pure and copper-doped zinc oxide nanoparticles were synthesized from neem leaf extract. Nickel Oxide was also produced by extracting lemon and sweet lemon peel. Fe_2O_3 nanoparticles were created using lemon peel extract.

The study also focused on the chemical synthesis of nanoparticles. To make ZnO nanoparticles from sodium hydroxide, the precipitation method was used. Green synthesized nanoparticles may have outperformed chemically synthesized nanoparticles in any application.

In general, there are two approaches to nanoparticle synthesis: top-down synthesis and bottom-up synthesis. For green synthesis, the bottom-up approach is used. Top-down approaches are used to separate bulk materials into nanoparticles. Some of the techniques used include laser ablation, etching, sputtering, milling, and electro-explosion. The surface structure of the top-down approach has a significant flaw. The bottom-up approach, on the other hand, has the potential to generate less waste and thus be more cost-effective.

Pure and copper-doped zinc nanoparticles were synthesized in this study. They possess intriguing physical, chemical, optical, and electrical properties. Doping has been found to be useful in fine-tuning their optical properties, antibacterial, antifungal, and seed germination properties. The synthesized nanoparticles were characterized using a variety of techniques, including UV-Vis spectroscopy, Infrared spectroscopy, dynamic light scattering methods, Field emission scanning electron spectroscopy, Zeta potential, Powder X-ray diffractometer,

and energy dispersive X-ray spectroscopy. The nanoparticles were also subjected to spore germination, seed germination, and computational studies.

The interaction of nickel Oxide nanoparticles with calf thymus deoxyribonucleic acid (CT-DNA) was carefully examined using UV-Visible spectroscopy in this study. The mode of binding and the strength of binding were the most important aspects of interaction studies. Equations were used to compute the various parameters.

The catalytic efficiency of hematite nanoparticles against methylene blue dye was investigated. At neutral pH, it demonstrated ultrafast Fenton-like reactions. Catalytic activity was evaluated using a variety of parameters such as rate constant, catalyst amount, reaction order, and degradation efficiency. The Zone of Inhibition was used to evaluate the antibacterial activity of synthesized nanoparticles.

The seed germination properties of fabricated nanoparticles were evaluated using the seed vigour Index, germination Index, germination percentage, mean germination time, the Coefficient velocity of germination, Promptness index, and root-shoot length. Antifungal activity was determined using the poison food assay. This study also looked into the biochemical properties of wheat seeds treated with nanoparticles.

The findings of this study should shed new light on the field of metal oxide nanoparticles. The findings indicate that the nanoparticles produced can be used in biomedical applications as well as catalysis.

Summary of work done:

Chapter I: This chapter includes the opportunity, objectives, and applications of the research. It explains why metal salts were chosen and how they can be used.

Chapter II: This chapter contains a review of previous literature on nanoparticle synthesis and applications. This chapter describes in detail how equations and different studies were used in this research project. PXRD, FESEM, FTIR, DLS, EDX, SEM, UV-Vis, and Zeta Potential were among the techniques used.

Chapter III: It contains an experimental section. It also includes the name, structure, physical properties, and applications of the used metal salts. It describes the operating principles of the instruments used.

Chapter IV: This chapter describes the environmentally friendly synthesis of pure and nickel-doped zinc oxide nanoparticles. During the synthesis process, the phytochemicals in neem leaf extract act as reducing and stabilizing agents. To obtain doped samples, the molar concentrations of zinc nitrate and nickel nitrate were varied. XRD analysis confirmed the hexagonal wurtzite structure. FTIR analysis demonstrates that phytochemicals are important in the synthesis process, and the shifting of the Zn-O stretching vibration with doping demonstrates that nickel is doped on the ZnO matrix. The hydrodynamic size of nanoparticles is greater than the particle size, according to DLS. It is caused by water molecules, capping agents, and stabilizing agents found on the nanoparticle's periphery. SEM analysis reveals the spherical shape. Antifungal and seed germination properties were used to assess bioactivity. The antifungal properties of nanomaterials against *A. flavus* grown in PDA media were determined using colony diameter.The created nanoparticles were to be used to study the growth of wheat seeds under both light and dark conditions.

Chapter V: This chapter compares the antibacterial activity of green and chemically synthesized ZnO nanoparticles. Their morphology, as well as antibacterial activity, were studied. Because it contains Quercetin, tannins, saponins, flavonoids, and steroids, *Azadirachta indica* is used as a precursor agent for bioinspired ZnO nanoparticles, whereas sodium hydroxide is used as a precursor agent for chemically synthesized ZnO nanoparticles. Density functional theory was used to further establish the formation of bio-synthesized nanoparticles. UV-Vis spectroscopy, FTIR, DLS, SEM, PXRD, and EDX were used to characterize the samples. These measurements confirmed that the synthesized materials were in the nanometer range. *Staphylococcus aureus*, *Bacillus subtilis*, *Shigella sp.*, and *E. coli* were tested for antibacterial activity.

Chapter VI: The green synthesis of pure and copper doped ZnO nanoparticles using *Azadirachta Indica* (Neem) Leaf Extract for optical, structural, morphological, and antifungal applications is the focus of this chapter. The nanometer size of the synthesized nanoparticles is confirmed by DLS, which is also confirmed by XRD. The shape and size distribution of nanoparticles were determined using SEM analysis. Copper doping on the ZnO matrix is successfully demonstrated using EDX. *Rhizopus*, dangerous fungi, was studied for its antifungal activity. Antifungal activity was determined using the Spore Germination Inhibition assay. Doped materials outperformed pure nanomaterials in terms of antifungal activity.

Chapter VII: A bioinspired synthesis of hematite nanoparticles from lemon peel extract is described in this chapter. Phytochemicals such as flavonoids, carbohydrates, proteins, phenol, tannin, and saponin all play important roles in the synthesis process. Phytochemical screening was used to detect the presence of phytochemicals. The nanoparticle characterization, in this case, indicates that they are cubical-shaped nanoparticles. Under ideal conditions, these nanocubes exhibit Fenton-like reactions. The degradation was rapid and followed first-order kinetics. The most intriguing discovery was that they produce a Fenton-like reaction in neutral pH under dark conditions. Plant growth was observed in the treated wastewater. *Bacillus megaterium*, *Bacillus Subtilis*, *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella typhimurium* were tested for antibacterial activity, while *Fusarium solani* was tested for antifungal activity. Free radical scavenging activity was dose-dependent.

Chapter VIII: The green synthesis of nickel oxide nanoparticles from citrus fruit peel extract is discussed in this chapter. It's a comparison study. The extract's phytochemicals act as a stabilizing and reducing agent. The pH of the solution is kept near 11 during the synthesis process. According to XRD, SEM, and DLS, the nanoparticles produced have a size range of 4-10 nm. The presence of nickel and oxygen in the nano samples was confirmed by EDX spectra. Antibacterial activity of synthesized nanoparticles against *Bacillus sp.*, *Klebsiella sp.*, and *E. coli* causing urinary tract infections was tested. In every case, lemon peel extract mediated nanoparticles outperformed sweet lemon peel extract mediated nanoparticles. Antifungal activity was determined using a poison food assay against *Rhizopus*, and antioxidant activity was dose-dependent.

Chapter IX: This chapter concludes with a look back at the work done during this research journey.