



Biosynthesis and Characterisation of Zinc Oxide ZnO Nanoparticles

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DOI: 10.5281/zenodo.19537347

ABSTRACT

The green synthesis of metal oxide nanoparticles has gained significant attention due to its simplicity, eco-friendliness, and cost-effectiveness compared to conventional chemical and physical approaches. In the present study, zinc oxide nanoparticles (ZnO NPs) were synthesised using aqueous root extract of Echinops echinatus (Roxb.) as a natural reducing and stabilising agent. The synthesis was carried out using zinc sulfate heptahydrate (ZnSO₄·5H₂O) precursor, where a distinct color change indicated nanoparticle formation. The obtained ZnO NPs were characterized by Field Emission Scanning Electron Microscopy (FE-SEM), which confirmed the formation of predominantly spherical nanoparticles with an average size in the nanometer range (1–100 nm) and a tendency toward agglomeration. The plant-mediated synthesis route proved efficient in producing stable ZnO nanoparticles with potential applications in antimicrobial textiles, pharmaceuticals, catalysis, and environmental remediation. This eco-friendly method highlights the dual role of Echinops echinatus root extract in nanoparticle reduction and capping, making it a promising alternative for large-scale green nanotechnology applications.

Keywords:- Zinc oxide nanoparticles, Echinops echinatus, green synthesis, FE-SEM, nanotechnology, phytochemicals.

1. INTRODUCTION

A nanoparticle (or nanopowder or nanocluster or nanocrystal) is a tiny particle with at least one dimension less than 100 nm. Due to small size, these nanomaterials have novel properties and function in every field of science. The world Nanotechnology was derived from word 'nanos' means 'dwarf'. The nanometer is one billionth of a meter. Nanomaterials composed of atom, molecules, engineered nanomaterials having size range of 1 to 100 nm. The single human hair is 60,000 nm in diameter. Undetectable by the human eye, nanoparticles can exhibit significantly different physical and chemical properties to their larger material counter parts.

1.1 History of Nanotechnology

Nanoparticles and structure have been used by human in fourth century AD by the Roman, which demonstrated one of the most interesting examples of nanotechnology in the ancient world. The famous Lycurgus cup was made from dichroic glass having unusual optical properties. It appears red in transmitted light and green in reflected light. It is observed that there is presence of Ag-Au alloy nanoparticles of 50–100 nm. The gold is responsible for green reflection. Other evidence such as herbal kaja bhasman etc. are also indicators of use of nanotechnology. Kaja has been prepared since ancient times by the controlled combination of coconut oil and collecting soot on silver plate. Now it is proved that this synthesized kaja contains nanoparticles of carbon. Carbon-based nanomaterials have great importance in the field of cosmetics. They have antibacterial properties. In 1857, Michel Faraday studied preparation and properties of colloidal suspension of ruby gold. He prepared different colored gold solutions and concluded that these unusual colors are due to different size gold nanoparticles. Gustav Morin in 1908 illustrated optical properties of gold nanoparticles. The most theory is a complete mathematical-physical theory of the scattering of electromagnetic wave by homogeneous spherical nanoparticles. The concept of "nanotechnology" was first put forward by great physicist Richard Feynman. The day of nanotechnology was started from a speech of Richard Feynman entitled "There is plenty of room at the bottom" given at an American Physical Society meeting at the California Institute of Technology in 1959. He explained the possibility of manufacturing small machines and objects with atomic precision. According to him, there is possibility of all vilyames of ancyloprdia will be pin tip of pin. The concept of 'nanometer' was first proposed by Richard Zsigmondy in 1925 and got the Nobel Prize in chemistry. He used the term nanometer to measure the size of gold colloidal particles using microscope. The actual term 'nanotechnology' was first used by Japanese scientist Nario Taniguchi in 1974. "Nanotechnology" mainly consists of the processing of separation, consolidation and deformation of material by one atom or one molecule. "Nanotechnology in



agriculture practices, control of pollution has remarkable application. From year 2000 the progress of nanotechnology is rapidly spread in all over the world. We all are aware about importance of nanosized materials but the progress of nanotechnology will reach up to certain limit till the technology comes up to one atom level.

1.2 Ethnomedicinal plant

Echinops Echinatus (Roxb) is yearly herb with branches spreading widely from the base, growing from a taproot it can reach 1 – 3 ft height, flower heads occur in solitary white spherical ball with spin which occurs in the period of December and January and grow in hot and dry stony soil. The plant is commonly harvested from the wild nature for use as a traditional medicinal herb in India and it is sold in local markets by ethno medical preachers (Vaidya) under the various vernacular names such as

Botanical Name: Echinops Echinatus (Roxb)

- English: Indian globe thistle, Camel's thistle
- Hindi: Gokhru, Uthkanta, Utakatira
- Marathi: Utkatar
- Urdu: Brahmadandi

Echinops Echinatus (Roxb) belongs to the family Asteraceae. It is one of the largest flowering plant families. Roots of Echinops Echinatus (Roxb) plant are a very useful part.

The plant Echinops Echinatus (Roxb) is well ethno – medicinal plants in Indian traditional system of medicine. The whole plants, root, stems, leaves, fruits, seeds, flower and bark are extensively used in alternative medicine system as ayurvedic, Unani and folk medicine.

A mixture of leaf powder or root extract and honey is taken in the morning to expel round worms. Ash of the whole plant is used with ghee or butter to treat leucorrhoea. Echinops Echinatus (Roxb) is a spiny annual herb growing approximately 1.0m in height which is found throughout India growing wild up to heights of 5000ft above sea level.

Its roots have been claimed to be useful in treating hoarse cough in children and fever.

2. REVIEW OF LITERATURE

Recent research trend in green/ biosynthesis of nanometals using plants extract has opened a new era in fast, non-toxic and eco friendly method for biosynthesis of metal nanoparticles. Many researchers have reported the green synthesis of metal and metal oxide based nanoparticles by using various parts of plant such as leaf, leaves, flower, stem and roots extracts and their potential applications in various filed.

Plant mediated green/biosynthesis of metal (Ag, Fe, Zn, Au and Cu) and metal oxide (AgO, FeO, ZnO, AuO and CuO) nanoparticles (NPs) is a revolution that has wide range of applications in catalysis, organic synthesis, inorganic chemistry, electrochemistry, polymer chemistry, physics, life sciences, agriculture, food industry and pharmaceutical industries for the development of medicine. Medicinal plants possess bioactive phytochemicals such as like proteins, vitamins, coenzymes based intermediates, phenols, flavonoids, steroids, terpenoid, alkaloids and carbohydrates. These bioactive phytochemicals contain hydroxyl, carbonyl, and amine functional groups that react with metal ions and reduce their size into nano range.¹⁸ These molecules not only help in bio-reduction of the ions to the nanoscale size, but they also play a vital role in the capping of the nanoparticles which is important for stability and biocompatibility. Reducing agents such as phenolic compounds, sterols and alkaloids can reduce metal ions into NPs in a single reaction. AgNPs were reported, using this plant root extract as well as their biological applications while other metal NPs such as CuO, ZnO and FeO-NPs are not reported.

3. METHODOLOGY

3.1 Collection of plants material

The roots of the plant Echinops Echinatus (Roxb) were collected from the forest of District Buldhana, in the month of March. The plant material were shade dried until all the water molecules evaporated and plants became well dried for grinding. After drying, the plants material were ground well using home electric blender into fine powder.



Fig -1 Echinops Echinatus (Roxb)

3.2 Preparation of plant extracts

Fresh roots of Echinops Echinatus (Roxb) plants were collected and shades dried and the root of the dried in natural ambient and known weight of root was taken and washed multiple times in distilled water to remove impurities. After dry were grinded to fine powder. 10g of root powder of Echinops Echinatus (Roxb) was transfer into 250 ml beaker containing 100 ml distilled water and boiled up to 2 hrs. After cooling, filtered with vacuum suction pump using whatmann filter paper No.41 and is collected in conical flask, stored in refrigerator to avoid formation of bacteria before its used for bio synthesis.



Fig -2 Decantation Process



Fig.3 Filtration of extract

3.3 Green Synthesis of ZnO NPs

According to Vijayakumar et al (2018) the parts i.e leaves, stem, and root were studied separately for the synthesis of Zinc Nanoparticles. The zinc oxide nanoparticles were prepared by using 10 ml of 0.1 M of $ZnSO_4 \cdot 5H_2O$ solution was prepared in 250 ml round bottom flask; 80 ml of root extract was added to the zinc sulphate solution with 30:10(V/V) using separating funnel at $60^{\circ}C$ for 2 hrs with continuous stirrer using magnetic stirrer for accelerative bio reduction of ZnO-NPs. The reddish brown color indicated the formation of ZnO-NPs. The fully reduced ZnO-NPs solution was centrifuge at 6000 rpm for 20 min. and Washed with distilled water followed by Methanol to remove the unwanted impurities. Finally the residues was collected in crucible.

Fig.4 $ZnSO_4 \cdot 5H_2O$ solution before adding in plant aq. Extract



adding plant extract

Fig.5 $ZnSO_4 \cdot 5H_2O$ solution after





Fig.6 Centrifuge process for preparing nanoparticles

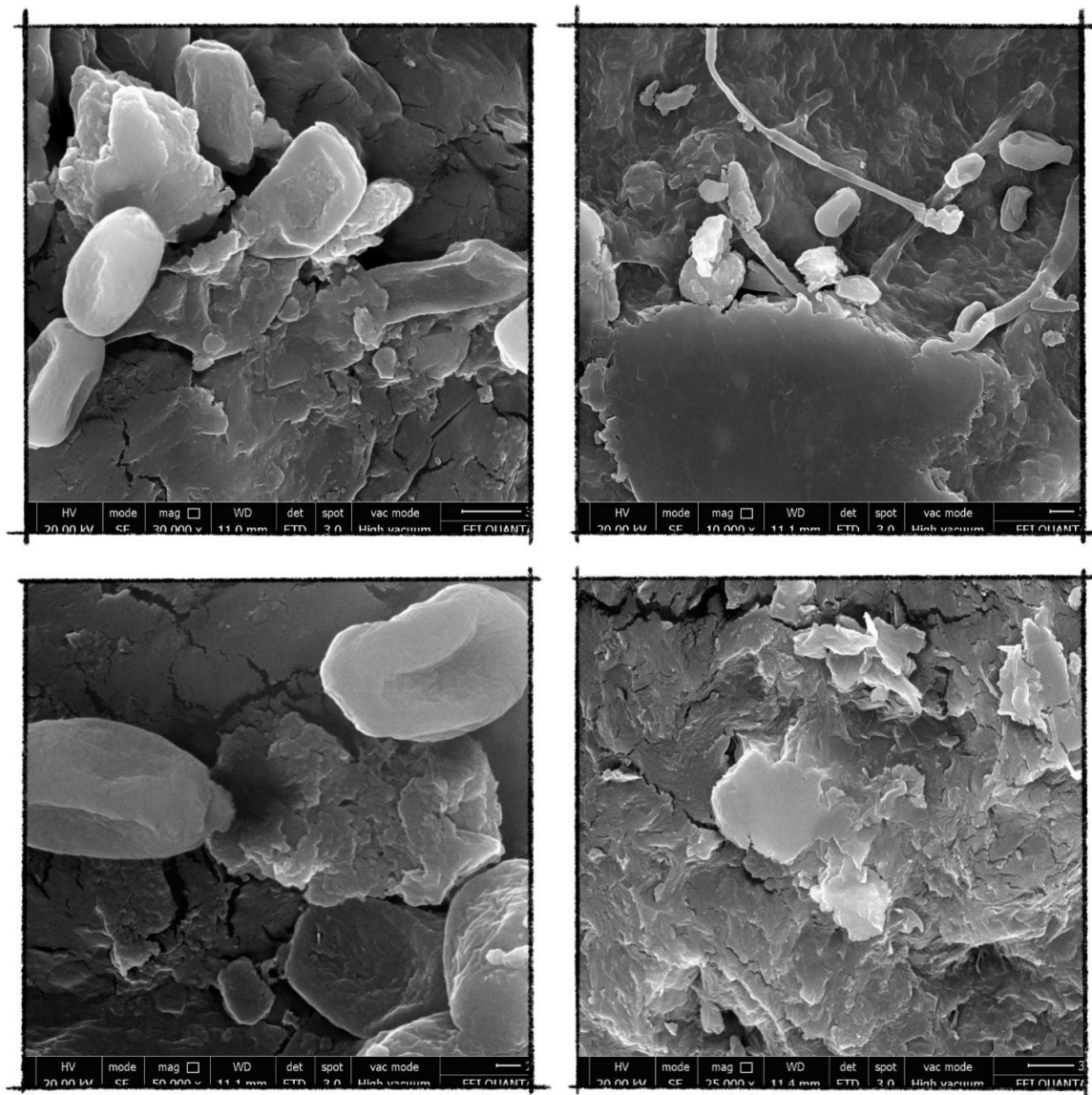
4. RESULTS AND DISCUSSION

This method of green synthesis ZuO-NPs beings by mixing the plant root extracts (natural) with $ZnSO_4 \cdot 5H_2O$ solution with biochemical reduction of cupric sulphate salt color change is observed in the solution indicating synthesis of ZuO-NPs. In the present work, we develop an eco-friendly, clean, non-toxic, facile chemically preparative method, for the synthesis of ZuO-NPs using the extract of Echinops Echinatus (Roxb). Project investigation indicates that the extract of Echinops Echinatus (Roxb) is one of the new approaches in the field of nanosynthesis. To date, there is no report on the green synthesis of ZuO-NPs by utilizing the root extract of Echinops Echinatus (Roxb).

While performing our project we took (3.4gm of $ZnSO_4 \cdot 5H_2O$) and obtain yield of nanoparticles is 0.50gm. result shows that the obtain nanoparticles are crystalline in nature having a black color. Nanoparticles have low particle momentum and very high mobility. Due to the small size of nanoparticles they allow for free movement and therefore heat treatment is necessary in furnace which transfers heat. Synthesized CuO-NPs shows magnetic properties.

4.1 SEM Results

it is type of electron microscopy that produce images of sample by scanning it with a beam of electron the electrons interact with electrons in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. The SEM images of four different ratios are as follows



Displays the SEM image of ZnO NPs synthesized using RE. The synthesized nanoparticles are aggregated in a spherical shape and showed an average size between 1 and 100 nm. The characterization results obtained in this study were found to be similar to the earlier reports on the biosynthesis of ZnO NPs from algal and other plant extracts.

5. CONCLUSION

Green synthesized ZnO NPs have several advantages including cost-effectiveness, ease of production, environmental safety, and biocompatibility. Through the use of plant components, such as leaf, stem, root, fruit, and seed, we have evaluated current trends and understandings of green synthesized ZnO NPs and their medicinal applications in this review. In a related study, researchers described comprehensive scientific data on recent advancements in the methods used to synthesize and characterize ZnO nanoparticles from plant sources. Another study by Akbar et al. gives a summary of numerous investigations on the creation of zinc oxide nanoparticles by plants and their use as antimicrobial agents. On the other hand, a similar study conducted by an investigation and characterization techniques used for the environmentally friendly production of ZnO NPs from various biological sources. Although the widespread involvement of polyphenolic compounds in the plant commonwealth could be used to explain how extracts from various plant species are capable of producing NPs, a precise understanding of the green synthesis process is required to realize the full potential of this process in medical and industrial applications. Obtaining homogeneously dispersed NP is extremely difficult despite the



straightforward synthesis of NPs using a green method Because many factors, such as temperature, the pH of the system, the type of capping agent Used, the concentration of active compounds, etc., may be crucial in determining the size morphology. It is crucial to compare ZnO NPs produced using medicinal plant extracts to their chemically or physically manufactured equivalents in order to ascertain whether the bioactivities observed may be related to the presence of capping agents in the ZnO NPs

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