
*Scienxt Journal of Biotechnology & Life Sciences*
*Volume-1|| Issue-1|| Year-2023|| Jan-June || pp. 39-46*

# *Nanostructure metal oxide - synthesis and characterization*

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## Abstract:

The use of a capping agent, undoped ZnO or Ni- as well as Fe-doped ZnO nanoparticles were synthesized via chemical precipitation. The structural, optical, vibrational, and electrical properties of the samples prepared for the chemical precipitation procedure were studied using a battery of characterization techniques. Specifically, a model and mechanism were proposed to explain the notable structural transformation of Ni as well as Fe-doped ZnO nanostructures. This method exhibited numerous characteristics, including do pant type and concentration, that give rise to distinct structural transformations of transition metal doped ZnO nanoparticles, and it did so without the need for a substrate or elaborate synthesis conditions or procedures. To obtain copper oxide samples, the novel synthesis process of Exploding Wire Technique (EWT) has been used. In an initial effort, scientists utilized the EWT technique to artificially create nanoparticles with a composition consisting of Cu, $Cu_2O$, and CuO. In this case, it adjusted the current architecture to make better use of the infrastructure's components. Not only did it improve the technique, but it also paved the way for the creation of CuO pure phase nanoparticles via annealing at various temperatures.

## Keywords:

Nanoparticles, Exploding Wire Technique**,** Electronic Properties Nanomaterials, ZnO Nanomaterials

## 1. Introduction:

In this study, we report the chemical precipitation synthesis of undoped ZnO, Ni-doped ZnO, and Fe-doped ZnO nanoparticles without the need for a capping agent. Multiple characterization techniques were used to investigate the samples' overall structural, optical, vibrational, or electric properties to be used in the chemical precipitation process. The significant structural change in Ni and Fe doped Nanostructures was proposed to be explained by a model and mechanism. Several features, such as dopant and concentration, give rise to unique structural modifications of transition metal ZnO nanoparticles, and this method achieved so without the need of a substrate or complicated synthesis conditions or processes. Exploding Wire Technique (EWT), a unique synthetic procedure, has been used to generate copper oxide samples. This research utilized EWT to synthesize Cu, Cu2O, plus CuO nanoparticles in a lab. The existing architecture was modified to make greater use of the infrastructure's parts. Not only was the method enhanced, but it also paved the path for the synthesis of CuO pure phase nanomaterials by processing at different temperatures.

### 1.1. Aim:

The main aim of this research is to create a generic synthesis strategy for the tunable synthesis of metal and metal oxide nanoparticles in solution on surfaces by utilizing metal ion-dendrimer complexes.

### 1.2. Objective:

- To determine methods for synthesis or characterization of metal oxide on nanostructures.
- To create self-sustaining nanomaterials that is incredibly small in size, highly sensitive, extraordinarily multifunctional, and requires little energy to operate.
- To find out how manufactured metal oxide nonmaterial scatter.

### 1.3. Research question:

1) Why is it necessary to characterize nanoparticles?
**2)** For what applications can metal oxide nanoparticles use?
**3)** What procedures were used to create nanoparticles of metal oxide?

## 2. Literature Review:

### 2.1. The effects of nanoscale:

A nanometre is a one-billionth of meter. The diameter of the red blood cell was about 7,000 nm, while the diameter of a water molecule was nearly 0.3 nm. The nanoscale interest since it is hypothesized that material properties will vary significantly between the micro- and macro-scales. When compared to their nanostructure counterparts, the characteristics of bulk materials might display notable variation (nzlbusiness, 2022). Despite the limitations of current models, the strength of composites including ceramic or metallic particles can unexpectedly spike (U.S. Department of Energy, 2016). For example: compared to their regular equivalents with grain sizes within hundreds of nanometres, metals with a grain size around 10nm approximately are nearly and about seven times harder as well as tougher. Quantum physics laws are the root of many unexpected shifts. Materials' aggregate characteristics are the total of all quantum processes influencing their constituent atoms.

## 2.2. Metal oxides nonmaterial:

Given the extensive literature on material science, one may conclude that the subject of bulk metal-oxides in general as well as nanophase metal-oxides semiconductors in particular, always has captivated the research (Singh, Neti, Sinha, and Srivastava, 2007). Its significance could be determined by varied applications which root down to its important features.

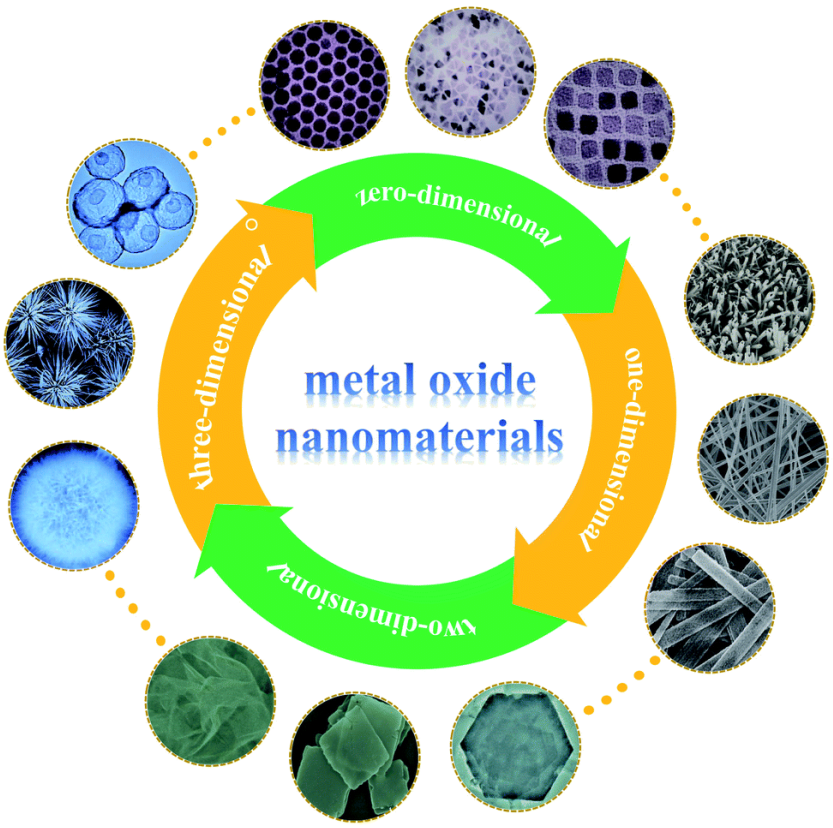


***Figure. 1: Metal Oxide of Nano Material (source: Chen, Liu, Guo, and Huang, 2020)***

Owing to their small size nanostructures offer different physio-chemical or even transport properties, differing from those of bulk materials and hence, could be employed to manufacture novel or superior optical, electrical, and sensing technologies (Apostolov, Apostolova, and Wesselinowa, 2014). Particularly, the synthesis of inorganic metal-oxide nanomaterials at reliable low cost, and very well morphology has gained substantial attention due to the ease of production and possible applications. Tuning their size and shape of nanoparticles in different forms including nanowires, microfibrils, rectangle, and seed-like, belt-like as well as sheet-like nanostructures have been intensively explored to date. Below figure 1 shows the metal oxide of nanomaterials.

## 2.3. Thermal properties:

Using thermal expansion coefficients for both in-plane and out-of-plane situations, we may quantify the temperature dependence of the lattice properties of any semiconductor (Goswami and Sharma, 2010). Using capacitive techniques, we were able to calculate that the usual room temperature values for the lattice constants defined from thermal expansion coefficients in hexagonal ZnO are a/a=4.75106 K -1 and c/c=2.9106 K -1. These characteristics are highly sensitive to the temperature as well as growth frequency under which the thin films were formed on the substrates during the synthesis process (Goswami and Sharma, 2010). Metal oxides and ZnO in particular may be crucial for high-temperature applications due to the importance of lattice characteristics including thermal expansion coefficients on substrates both for nanscale.

# 3. Methodology:

## 3.1. Data collection:

The secondary data is collected from newspapers, journals, Articles, and websites. To get copper oxide samples, we used a method that involved the manufacture as well as characterization of Metal Oxide Nanostructure. Purified CuO nanoparticles' structural, optical, electrical, or vibrational properties were analyzed after optimizing the conditions necessary to produce them. Synthesis and characterization of Metal Oxide Nanostructures were determined using Fourier Transform Infrared (FTIR) Spectroscopy Analysis as well as Micro-Raman Spectroscopy Analysis.

## 3.2. Data analysis:

### 3.2.1. Fourier Transform Infrared (FTIR) Spectroscopy Analysis:

Nonmaterial surface physics is of great use because atoms and molecules show higher adsorption mostly on the surface of nanoscale materials relative to their index. In This research, we used Fourier transform infrared (FTIR) spectroscopy of a prepared nanostructure material to rapidly establish the same absence or presence of various vibrational modes through undoped as well as Ni-doped ZnO nanostructures and to subsequently detect a possible alteration inside the vibrational modes at the various stages of structural transformation. Exploring various vibration modes related to Zn-O bonding in undoped and Ni-doped ZnO nanorods is crucial for accurately identifying the differences within infrared spectra caused by Ni doping. To discover infrared active bonding between inorganic elements, scientists typically look at band frequencies around 1000cm.

## 3.3. Micro-Raman Spectroscopy (μrs) Analysis:

To understand how Ni doping levels affect nickel-doped ZnO nano-structured evolution, used in micro-Raman spectroscopy to probe nickel-doped ZnO's vibrational modes at various points in the material's evolution. Crystallization, structural disorder, and flaws in micro and nanostructures can all be detected by analyzing their Raman spectra. Wurtzite crystals, of which ZnO is a member, are noted for having the simplest uniaxial structures and, as a result, represent a significant group of materials amenable to analysis by Raman spectroscopy when starting with elementary physics.

Glass functional groups are typically associated with the Raman band about 930cm-1. The peak at 931cm-1 in esperite's Raman spectra is ascribed to the asymmetric stretching of Si-O bonds. This mode appears in all of our Raman spectra since the materials were mounted on a glass substrate before characterization. Not only does Raman's analysis verify the presence of the wurtzite phase for nickel-doped ZnO nanostructures, but it also provides evidence of the beginning of structural alteration.

## 4. Discussion:

The most typical vibrational spectroscopic analyses, infrared and Raman, can be used to learn about the synthesis and characteristics of Metal Oxide Nanostructure. Each analysis has its value, as vibrational transitions are typically chosen according to distinct criteria. The vibrational frequencies of nanostructures are altered by their interactions with the ions and

molecules of surfaces, as contrasted to those of isolated molecules and pure nanostructures. To better understand the behavior and strength of contacts, which is essential for exploiting applications of nanostructures, one can use the frequency changes recorded in FTIR spectra to investigate the interactions between the surface molecules or the nanostructures.

Since their unique features allow them to be produced on a nanoscale, they have the potential to be used in a broad variety of cutting-edge fields, including optical, mechanics, electrical devices, reactivity, biomedicine, and many more. Accomplishing the aforementioned uses is contingent on accurate measurement and complete control over attributes at the nano-scale, which is still a difficulty and the primary motivation to study custom-made nanomaterials. Size dependency, energy shift, or broadening of a Raman peak profile will be used to infer important properties of a nano-crystalline system.

Profile broadening and Raman frequency shifts may also be caused by other factors, such as the size and shape distribution of nanostructures, bond strain, temperature, surface enhancement, etc.

## 5. Conclusion:

An analysis of the synthesis as well as characterization patterns using the Nanostructures method reveals the presence of Cu and $Cu_2O$ nanostructures in a pure substance. Emission of fundamental level in nanostructure building blocks, supporting the existence of mixed phases or oxygen deficit in the lattice. Finally, magnetic analysis shows that the produced $Cu/Cu_2O/CuO$ nanoparticles exhibit low-temperature anti-ferromagnetic ordering due to the mixed phases formed by the non-stoichiometry of $O_2$ atoms.

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