Chemical Synthesis of Zinc Oxide Nano particles by Precipitation Method

Shambhu Sharan Kumar

Abstract— **In the area of synthesis of nano materials, research and development are mainly oriented to control the shape, size, structure and compositions of nano materials. Each of these factors is a key factor in determining the properties of nano materials that lead to different technological applications. Nano zinc oxide is a multifunctional material with its unique physical and chemical properties such as high chemical stability, high electrochemical coupling coefficient, broad range of radiation absorption and high photo-stability.**

In this research work a very simple but effective technique has been developed to synthesize zinc oxide (ZnO) nano particles using zinc nitrate and potassium hydroxide (KOH) in aqueous solution. The precipitated amalgam has been dried, calcined, grinded and characterized by UV-vis spectroscopy, transmission electron microscopy (TEM) and dynamic light scattering (DLS). The ZnO nanoparticles displayed characteristic surface plasmon resonance peak at around 372 nm. Particles-size distribution by dynamic light scattering technique showed that the particles were found in the range of 15-45 nanometer (nm) for the purpose of advance applications.

Index Terms— **ZnO nanoparticles, precipitation method, zinc nitrate, KOH.**

I. INTRODUCTION

Nanotechnology is the most recent part of science that deals with materials and structures at nano-scale ranging from 1 to 100 nano meters. It provides an innovative and effective solutions in the areas of science and technology encompassing corrosion protection, surface coatings, electronics, computer, sunscreens-protection, medicine, diagnostic techniques, drug delivery, anti-microbial bandages, disinfectants, a friendly manufacturing process (that reduces waste products as catalyst for greater efficiency in current manufacturing process by minimizing and eliminating the use of toxic and hazardous materials), to reduce pollution (e.g. by the use of water and air filters) and an alternative energy production (e.g. solar and fuel cells) etc [1,2,19,20]. Nano zinc oxide has been introduced as a multifunctional material with its distinctive physical and chemical properties such as high chemical constancy, high photo-stability, high electrochemical combination coefficient, and broad range of emission assimilation [3, 4, 5, 6].

ZnO nanoparticles are synthesized by different methods. It is confirmed that the various applications of ZnO nanoparticles depend upon the control of both physical and chemical properties such as size, shape, crystal structure, size-distribution, dispersion, surface-state, organization onto a support and expendability [5,6,7]. It has led to the development of an imposing variety of techniques for synthesizing the nano materials. Some researchers used a controlled precipitation method. The process of precipitating zinc oxide was carried out using zinc acetate: Zn $(CH_3COO)_2 \cdot H_2O$ and ammonium carbonate: $(NH_4)_2CO_3$ [6,7,8]. A simple precipitation process for the synthesis of zinc oxide was carried out. The single step process for the large scale production without unwanted impurities is desirable for the cost-effective preparation of ZnO nanoparticles [8, 9, 10, 16].

Another process of controlled precipitation of nanometric zinc oxide was being followed by precipitation from aqueous solutions of NH_4HCO_3 and $ZnSO_4 \cdot 7H_2O$ [9, 10]. ZnO particles have already been prepared by sol-gel method from zinc acetate dihydrate and oxalic acid using ethanol as solvent [10, 11, 12]. The technique of obtaining ZnO using micro emulsion was also used by Yildirim and Durucan. They attempted to modify the micro-emulsion method so as to obtain mono-disperse zinc oxide [11,12,15]. A continuous synthesis of zinc oxide nanoparticles in a micro-fluidic system for photovoltaic application has also been reported. The work was carried out to explore the synthesis and characterization of ZnO nanoparticles using numerical simulations and experimental methods. So, this paper refers the synthesis of nano ZnO particles by a simple synthesis and effective method [12,13,14].

The precipitation method and hydrothermal process both have several advantages over other growth processes such as use of simple equipment, catalyst-free growth, low cost, large surface area, uniform production, environmental friendliness and less hazards. The low reaction temperatures make this method an attractive one for microelectronics and plastic electronics [12, 14, 15, 16].

This method has also been successfully employed to prepare nanoscale ZnO and other luminescent materials. The particle's properties such as morphology and size can be controlled via precipitation method and hydrothermal process by adjusting the process parameter, i.e. the reaction temperature, time and concentration of precursors [13,16,17].

The present study gives focus on the precipitation method in place of hydrothermal synthesis of ZnO nanopowders alongwith the study of the effect of reaction temperature, concentration of the precursor and time of growth and other properties. Both the processes i.e. precipitation method and hydrothermal synthesis of ZnO nano particles have extra advantages to get the actual size at nanometer scale, can be obtained by these methods [2,3,4]. The reaction is carried out under moderate conditions to get required powders with

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different morphologies by adjusting the reaction conditions. The as-prepared powders have different properties from that of the bulk particles [1, 3, 14, 16].

Nanotechnology recompenses the solution to medicine because it has the ability to find materials in nanoscale diameter that have an enhanced bioactivity for dieses-curing [21,22]. Nanoparticles are introduced as vital element of nanotechnology that draw a special interest from scientists and researchers of different fields. The main reason for this importance is the increased specific surface area of these nanoparticles in comparison to their volume, which enables their interaction with bio-organics present on the viable cells surface [20,21,22]. Nanoparticles provided many applications in high-density magnetic recording media and biomedical activities such as magnetic resonance imaging (MRI), cell and DNA separation, drug delivery, gene cloning, and hyperthermia for cancer therapy, etc [17,18, 21].

Today, for the purpose of increasing demand of antimicrobial products that can solve the problem of resistant strains instead of existing antimicrobial drugs; metallic nanoparticles which have a great attention by many researchers to study these nano particles, and is obtained many important results in this field [20,23]. Metal oxides nano particles such as ZnO, MgO, TiO_2, SiO_2, CuO and CoO play a vital role as anti corrosion additives, UV blocking agents, anti aging agents, antimicrobial agents etc.

In other words, these metal nanoparticles can be used as antimicrobial activity because of their effectiveness on resistant strains of microbial pathogens, less toxicity and heat resistance. In addition, they provide mineral elements essential to human cells. In this work, zinc nitrate $\{Zn(NO_3)_2.6H_2O\}$ has been employed as a primary reagent and potassium hydroxide (KOH) as a precipitating agent. Precipitation method is a promising alternative synthetic method because of the low process temperature and was very easy to control the particles-size [18,19,21,22].

II. MATERIALS AND METHODS

Materials

To carry out the synthesis work, zinc nitrate as the precursor and potassium hydroxide (KOH) as a precipitating agent to synthesize the ZnO nanoparticles were procured from Sigma-Aldrich Company Limited.

Preparation methods

In this work, the aqueous solution (0.2 M) of zinc nitrate $\{Zn(NO_3)_2.6H_2O\}$ and the solution (0.4 M) of KOH were prepared with deionized water. The KOH solution was slowly added into zinc nitrate solution at room temperature under vigorous stirring, which resulted in the formation of a white suspension. The white product was centrifuged at 5000 rpm for 20 minutes and washed three times with double distilled water, and then washed with absolute alcohol at last. The obtained product was dried and calcined at 500°C in air atmosphere for 3 hours.

The method by which, nano particles have been synthesized has a special interest. This is because, it has many factors that cooperate to adjust the size, morphology, stability and properties (chemical and physical) of the metal nanoparticles, some of these factors are the experimental conditions, the kinetics of interaction of metal ions with reducing agents, and adsorption processes of stabilizing agent with metal nanoparticles [21,22,23].

There are many ways to produce nanoparticles, which are: electrochemical method, thermal decomposition, laser ablation, microwave irradiation and chemical synthesis. One of these methods is chemical reduction method; this method has many advantages, such as simple equipment, short process and easy industrial production [13,18,21,23]. ZnO nanoparticles were synthesized by direct precipitation method using zinc nitrate and KOH as precursors.

Characterization of nanoparticles

For characterization purpose, Uv-vis spectroscopy was used to prove the existence of nanoparticles. The morphology and size was determined by the transmission electron microscopy (TEM), and Dynamic light scattering (DLS) study.

III. RESULTS AND DISCUSSION

For analytical study of the prepared sample, the amount of absorption within wave length of 300–550 nm was observed by uv-vis-spectroscopy.

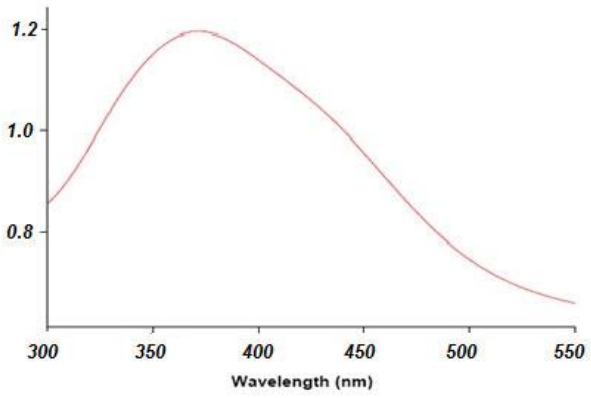

Fig.1. UV–vis spectra of ZnO nanoparticles solution

It is known that an absorption band at about 370 nm due to surface plasmon resonance in ZnO nanoparticles. Figure 1 shows the UV-vis spectra of ZnO nanoparticles recorded between 300 and 550 nm. As illustrated, the SPR band cantered 372 nm confirms the formation of ZnO nanoparticles

in the solution. Dynamic light scattering is a widely used technique for the determination of particles-size in colloidal solution. As is seen in figure 2, average size of nanoparticle synthesized is 30 nm. The distribution of ZnO nanoparticles is about 20 nm which indicates moderate distribution of the nanoparticles.

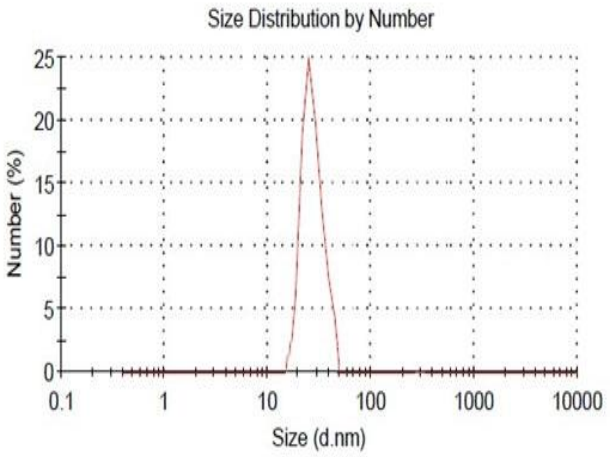

Fig.2. The size distribution of ZnO nanoparticles by number

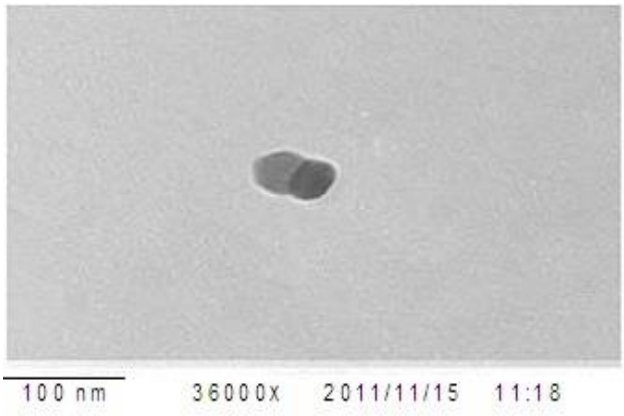

Figure 3. TEM image of ZnO nano particles

Synthesized ZnO nanoparticles were studied also by transmission electron microscope (TEM) and the image shows the confirmation of the fabrication of ZnO nanoparticles in the range of nano-sizes. TEM images of the produced nanoparticles have been shown in figure 3.

Typical physical properties of ZnO

- Chemical Formula: ZnO
- Color: White powder
- Bulk Density, g/cc: 0.25
- True Density, g/cc: 5.6
- Crystal Phase: Zincite (hexagonal)
- Morphology: Elongated
- Purity: 99+%

Zinc oxide nanoparticles have been available as coated dry powders wherein the material is treated to impart specific surface functionality to the particles, such as hydrophobicity of surfaces.

The technology has been designed for individual nanoparticle coating and as such prevents the formation of irreversible agglomerates. The coating can also be tailored to accommodate a range of surface functionality as well as reactivity, thereby providing the optimum compatibility with individual applications.

IV. Conclusion

Zinc oxide nanoparticles were effectively synthesized by direct precipitation method in this chemical synthesis using zinc nitrate as primary zinc source and KOH as precipitating agent in aqueous solution. The effects of concentration of the precursor, temperature and time of growth on the structure, and grain size were investigated. The sizes-range of the produced nano ZnO particles was approximately 15-45 nm. The particle size increases with growth temperature and decreases with increasing concentration of the precursors. By summing up successfully designed a simplistic and fast synthesis route to produce ZnO nanoparticles and ended with characterization of ZnO nanoparticles by UV-visible, TEM and DLS analysis.

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