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Synthesis of Zinc Oxide Nano Powder and its Characterization Using XRD, SEM and Antibacterial Activity Against *Staphylococcus aureus*

Medical Science

KEYWORDS : ZnO, XRD, SEM, FWHM

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ABSTRACT

Nanoparticles have attracted much attention for their distinct characteristics that are unavailable in conventional macroscopic materials. Their uniqueness arises specifically from higher surface-to-volume ratios and an increased percentage of atoms at the grain boundaries. ZnO nanoparticles in the size range 41nm have been synthesised by a wet chemical method where ZnO particles were grown in basic Zinc nitrate hexahydrate and NaOH solution. The particle size given from XRD measurements has been developed and compared to other similar relations found in the literature. SEM is used to analyze the morphological size of nanoparticle. Scanning Electron Microscopy (SEM) is used primarily for the study of surface topography of solid materials. Zinc oxide nanoparticles can enhance the antibacterial activity of Staphylococcus aureus enhancing effect of this nanomaterials concentration is dependent against test strain.

INTRODUCTION

Nanotechnology can be useful in diagnostic techniques, drug delivery, sunscreens, antimicrobial bandages, disinfectant, a friendly manufacturing process that reduce waste products (ultimately leading to atomically precise molecular manufacturing with zero waste), as catalyst for greater efficiency in current manufacturing process by minimizing or eliminating the use of toxic materials, to reduce pollution (e.g. Water and air filters) and an alternative energy production (e.g. Solar and fuel cells) **(Sobha *et al.*, 2010).** Nanoscale particles have emerged as novel antimicrobial agents owing to the high surface area to volume ratio, which is coming up as the current interest in the researchers due to the growing microbial resistances against metal ions, antibiotics and the development of resistant strains (**Ho Chan *et al.*, 2003**). The recent growth in the field of porous and nanometric materials prepared by non-conventional processes has stimulated the search of new applications of ZnO nanoparticulate (**Amekura *et al.*, 2006**).

Zinc oxide–soluble starch nano composites were synthesized using water as a solvent and soluble starch as a stabilizer and impregnated onto cotton fabrics to impart antibacterial and UV-protection functions (***Kumar et al.*, 2006).** Nanotechnology as defined by size is naturally very board, including fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics micro fabrication etc., **(Saini *et al.*, 2010*).*** Nanotechnology is being applied to or developed for application to a variety of industrial and purification processes. Purification and environmental cleanup applications include the desalination of waste water treatment, and other nano remediation . In industry, applications may include construction materials, military goods and nano machining of nano wires, nano road, few layers of grapheme used in developing countries to help treat disease and prevent health issues. The umbrella term for this kind of nanotechnology is nano medicine. Nanotechnology has produced highly effective pool liquids that antibacterial require a lesser amount of chemical in the water. This product makes swimming pools safer for people on two levels. Bacteria is controller more effectively and exposure to harsh. There are numerous application of nanotechnology. Most of the applications come as a surprise to your average person (**Dai *, et al* ., 2010) .**

In material science Zinc oxide is a wide - band gap semiconductor of II - VI semiconductor group .The native doping of the semiconductor is n -type . This semiconductor has several favorable properties, including good transparency, high electron mobility, wide band gap, and strong room-temperature luminescence. Those properties are used in emerging applications for transparent electrodes in liquid crystal displays, in energy-saving or heat-protecting windows, and in electronics as thin-film transistors and light-emitting diodes***(Saini et al ., 2010) .*** Zinc oxide is an interesting semiconductor material due to its application on solar cells, gas sensors, ceramics, catalysts, cosmetics and varistors (**Abhulimen *et al.*, 2005**). In this work, the precipitation method was used followed by controlled and freezing drying processes (**Atul Gupta *et al.*, 2006).**

Zinc oxide has high biocompatibility and fast electric transfer kinetics, such phenomena encourage the use of this material as a biomimic membrane to immobilize and modify the biomolecules (**Chitra *et al.*, 2013**). Zinc is a necessary element to our health and ZnO nano particles also have good biocompatibility to human cells (**He H *et al.*, 2011).** ZnO nanoparticales offer tremendous potential in future applications of electronic and magneto–electric devices. Also, maybe, applied for photocatalysis, gas sensing, biomedical device and sun sucreen applications. The method has a high yield and can be used for large scale synthesis of ZnO nano particles **Robina Shahid *et al.*, 2012**.

2. MATERIALS AND METHODS

2.1 Synthesis of Zinc oxide

The zinc oxide nanoparticles were synthesised by chemical solution using zinc nitrate hexahydrate and sodium hydroxide. 7.43M of Zinc nitrate hexahydrate $(Zn(No_3)_2.(6H_2O)$ salt was taken and dissolved in 50 ml distilled water . 1M of sodium hydroxide (NaOH) salt was taken and dissolved in 50 ml distilled water. The above solution was vigorous stirred at 75^o C for 2 hours. A $(zn(No_3)_2.\ 6H_2O)$ solution was slowly added drop wise into NaOH solution often hours with stirring. After sometimes the white precipitate powder formed. It was washed thrice thoroughly with distilled water. This procedure was repeated several times until the precipitate was free from any trace impurities.

The precipitate powder was calcinated at 100^o C for several hours. After that the coarse molecules were made into nanoform with the aid of pestle and mortar. The product obtained was characterized by X-ray diffraction (XRD) and scanning electron microscope (SEM) to analyse morphological size and magnification of zinc oxide nanoparticles.

2.2 Characterisation Technique - XRD

Characterization of the nano particles was done by three tests such as X-ray Diffraction Method (XRD), Scanning Electrom Microscopy and Abtibacterial Activity. To get the phase and the also the size of the particles X-ray diffraction, XRD, have been used in National Institute of Technology in Department of Physsics, Thiruchiraapalli. It is clearly seen that ZnO is highly crystalline and all diffraction peaks are well indexed to the diffraction pattern of ZnO. The measurements have been done on a Siemens D5000 Diffractometer using parallel beam geometry with x-ray mirror and a parallel plate collimator of 0.4o . All measurements have been done on films on glass substrates in order to be able to directly correlate optical properties with XRD-data. The angle of incidence has been 0.5o and the scan has been performed from 10º to 90º. For a first set of samples the step size has been 0.02o and the integration time 11 seconds, and for a later set of samples the step size has been 0.1o and the integration time 54 seconds. This means that the sampling time typically is around 12 hours for each sample, which is necessary to get good statistics. Phase purity and grain size were determined by X-diffraction analysis recorded on a siefert X-ray diffractometer usig the radiation CuK_{α} (α = 0.1541nm) at 60 KeV over the range of 2α = 20-80 α ***(*****Mariappan Premanatham, 2010*****)*.**

2.3 Scanning Electron Microscopy (SEM)
Scanning electron microscopy (SEM) is used primarity for the study of surface topography of solid materials, which was done in Annamalai University, Department of Physics, Chidambaram. It permits a depth of field for greater than optical or transmission microscopy. The resolution of the scanning electron microscope is about 3 nm (30) approximately two orders of magnitude greater than that of the optical microscope and one order of magnitude less than that of the transmission electron. Scanning electron microscopy (SEM) is used primarily for the study of surface topography of solid materials. It permits a depth of field fothan optical or greater transmission microscopy. The resolution of the scanning electron microscope is about 3 nm (30) microscope.

2.4 Antibacterial activity of ZnO Nano Powder
The stock cultures of bacteria purchased on nutrient agar slants at 4°C. Inoculums was prepared by suspending a loop full of bacterial cultures into 10 ml of nutrient broth and was incubated at 37°C ± 2°C for 24 to 48 hours. Agar well-diffusion method was followed to determine the antibacterial activity. Nutrient agar (NA) plates were swabbed (sterile cotton swabs) with 24 hours cultures of *Staphylococcus* bacteria. Agar wells (5mm diameter) were made in each of these plates using sterile cork borer. About different concentration (0.1, 0.2 and 0.3 μl) of zinc oxide powder insert into the respective wells and plates were left for 1 hour to allow a period of preincubation diffusion in order to minimize the effects of variation in time between the applications of different solutions. The plates were incubated in an upright position at 37°C ± 2°C for 24 h for. The diameters of the zones were measured using diameter measurement scale. Triplicates were maintained and the average values were recorded for antibacterial activity (**Perezet *et al.*, 1990).**

3. RESULTS AND DISCUSSION

2θ	FWHM	D value
36.28	0.21	41.6

Table:1 Variation of peak height and FWHM

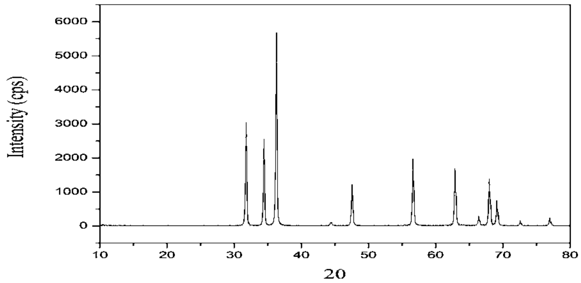

Figure: 1 X-ray diffraction of Zinc oxide Nanopowder

The average grain size of the ZnO Nanopowder is D = 41.6 particle size determined by using Debyes-scherres (DS) equation with increasing calcination temperature. The peak height in increased and FWHM (Full Width Half Maximum) decreased as diffraction peaks become stronger and sharper.

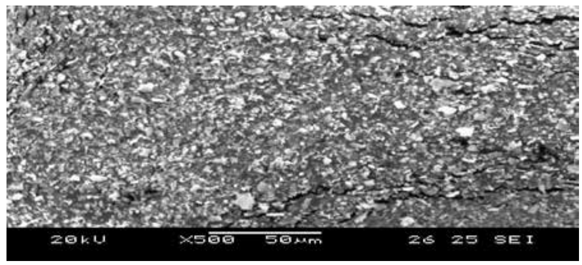

Figure 2: SEM Image of Zinc oxide Nanopowder in 50μm

S.No	Organism	Zone of inhibition (mm)		
		0.1 μl	0.2 μl	0.3 μl
1	Staphylococcus aureus	10	13	11

Table: 2 Antibacterial activity of Zinc oxide Nano powder *on Staphylococcus aureus*

Figure: 3 Antibacterial activity of Zinc Oxide Nano Powder (*Staphylococcus aureus*)

4. CONCLUSION
In this study, the ZnO nanoparticles were successfully synthesized by direct precipitation method using zinc nitrate as zinc source and NaOH as precipitating agent in aqueous solution. The size and range of the generated ZnO powder was approximately 41.6 nm. In summary successfully designed a facile and fast synthesis route to produce ZnO nanoparticles and finally ZnO nanoparticles were characterized by XRD and SEM. Zinc oxide nanopowder exhibited impressive antibacterial properties against an important food borne pathogen, *Staphylococcus aureus* and the inhibited effect is increased at the concentrations level of 0.2 μl. Infection is generally associated with breakages in

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the skin or mucosal membranes due to surgery, injury, or use of intravascular devices such as catheters, hemodialysis machines, or injected drugs.

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