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Tools and Techniques for Synthesis of Zno Nanoparticle

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ABSTRACT

Nanotechnologies are based on the manipulation, control and integration of atoms and molecules to form nanomaterials, nanostructures, components, devices and systems at the nanoscale. Synthesis of nanoparticles like ZnO has received considerable interest in current research due to their nano structure and different properties such as optical, catalytic, electrical, magnetic, and thermal and in biological at molecular level. In nanobiotechnology, many discoveries has been invented so far and more will be needed for better future. Applications of nanoparticles in the field of medical such as drug delivery, target pathogens, detection of cancer, antibacterial activity, treatment of cancer, etc are showing enormous potential for benefit of mankind.

Keywords: Nanotechnology, Nanoparticle, synthesis of ZnO, Application of ZnO

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Abbreviation:

NP-	Nanoparticle	TGA	Thermal gravimetric analysis
ZnO -	Zinc Oxide	DLS	Dynamic light scattering
Ag	Silver	CFU	Colony forming unit
XRD	X- ray diffraction	CD	Circular dichroism
SEM	Scanning Electron Microscope	TEM	Transmission Electron Microscopy
EDX	Energy dispersive X-ray spectroscopy		

INTRODUCTION

Nanotechnology is an emerging field with enabling technology. Nanomedicines are recently attracting the interest of researchers in the field of clinical application such as wound healing because of its quick and efficient recovery. The origins of nanotechnology are traced back to a speech given by Richard Feynman at the California Institute of Technology in December 1959 called “There’s Plenty of Room at the Bottom” (Feynman, 1992). In this talk, Feynman spoke about the principles of miniaturization and atomic-level precision and how these concepts do not violate any known law of physics (Fritz, 2010).

Nanotechnologies are the application of nanoscience especially to industrial and commercial sector. The essence of nanotechnology is the ability to work at the atomic, molecular and macromolecular levels in order to create materials, devices and systems with fundamentally new properties and functions. Building blocks are atoms and molecules, or there assemblies such asnanoparticles, nanolayers, nanowires and nanotubues.

Nanotechnology implies the ability to manipulate the matter under control at the nanoscale and integrate manufacturing along scales. Main challenges are creation of tailored structure at the nanoscale and combination of the bottom-up and top-down approaches to generate nanostructured devices and system. Further challenges are integration of living and non-living structures, replication and eventually self replication methods at nanoscales,and development of new concepts that would allow economic scale-up for industrial production. Development of tools and techniques to measure, calibrate, manufacture and detection (Rathi, 2009).

Synthesis of different type of nanoparticles and use of nanoparticles has been seen as a viable solution to stop infectious diseases due to the antimicrobial properties drug delivery, target pathogens, detection of cancer, treatment of cancer, etc.(Fig.1) The intrinsic properties of a metal nanoparticle are mainly determined by size, shape, composition, crystallinity and morphology (Dickson and Lyon 2000).

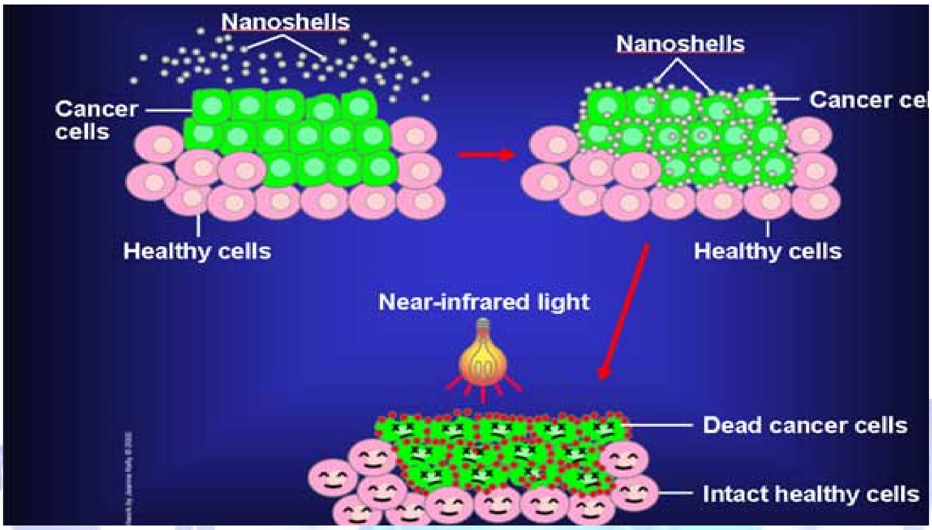


Fig.1: Nanoshell as cancer therapy- uses of nanoparticles such as AuroShell developed by Nanospectra biosciences to destroy cancer cells (www.cancer.gov/nanoshell).

REVIEW

Ashe (2011) reported that study on the synthesis and characterization of ZnO and Ag nanoparticles and their application on biological system. Antibacterial efficacy of the ZnO and Ag nanoparticles against four different bacteria like *Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Streptococcus pneumonia* has been performed. *In vivo* biological activity of expressed β-glucosidase enzyme in *E.coli* was measured in the presence of various concentrations of ZnO and silver nanoparticles and resulted that ZnO and Ag nanoparticles were synthesized successfully by chemical reduction and green synthesis methods (From *Citrus sinensis*), respectively.

Yousef and Danial (2012) reported and suggests that, the antimicrobial activity of ZnO and nano-ZnO may be influenced by preparation method as well as by particle size. The difference in MIC results against the test microorganisms might be due to the strains used and nano-ZnO inhibited the growth and multiplication of all the tested microorganisms like *Bacillus subtilus* NRRL B-543, *Bacillus megaterium* ATCC 25848, *Staphylococcus aureus*; NRRL B-313, *Sarcina lutea* ATCC27853, *Escherichia coli*; NRRL B-210, *Pseudomonas aeruginosa* NRRL B23 27853, *Klebsiella pneumoniae* ATCC 27736, *proteus vulgaris* NRRL B-123, *Candida albicans* NRRL Y-477 and *Aspergillus niger* NRRL-3. Nano-ZnO exhibit a good bacteriostatic effect but poor bactericidal effect towards all pathogens tested. Nano-ZnO can be a potential antimicrobial agent due to its low cost of production and high effectiveness in antimicrobial properties.

Commonly used method for synthesis of nanoparticles:

Table 1: Showing different methods of synthesizing nanoparticles

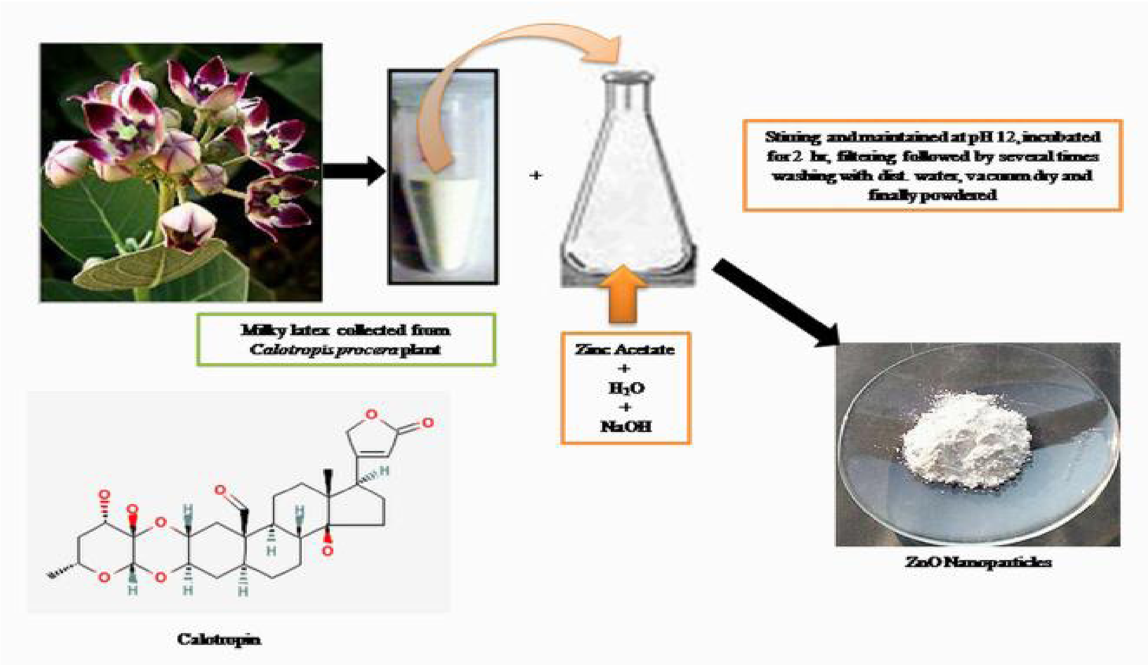
Physical methods	Chemical methods	Biological methods
(i)Methods based on evaporation	i. Colloidal Rout method	i. Biomembranes
•Resistivity heating	ii. Langmuir Blodgett (L.B.) method	ii. DNA
•Electron beam heating	iii. Sol-Gel Method	iii. Enzymes
•Laser heating	iv. Inverse micelles	iv. Micro Organisms
•Sputtering	v. Electro chemical	
(ii) Ion implantation	vi. Chemical Vapour Deposition	
(a) Nano structure by low energy ions		
(b) Nano structure by low energy ions		
(iii) Molecular beam epitaxy		

Sol Gel Methods: Sol- Gel methods involve two types of materials or components sol and gel. Sol Gel formation process is usually a low temperature process, which consumes less energy and pollution is less. It is used in nuclear fuel synthesis. Sol-Gel methods generates highly pure, well controlled ceramics. Sols are solid particles in liquid and subclass of colloids. Gels are nothing but a continuous network of particles with pores filled with liquid. A Sol Gel process involves formation of sols in a liquid and then connecting the sol particles to form a network. By drying the liquid, it is possible to obtain powders, thin films or even monolithic solid. Sol Gel method is used to synthesize ceramics or metal oxides although sulphides bromides and nitrides are also possible (Ashe B. 2011).

Bhanage et. al. also reported greener approach to produce nanoparticles with uniform shape and size without using templates or capping the synthesis of verity of nanoparticles such as one step synthesis of Cu/CuO_2 /1,4-butandiol and Ag/ AgCl nanoparticles using sugarcane juice as a greener solvents.

Singh et al. reported a novel simple and cost-effective biological approach for the synthesis of ZnO NPs has a promising application in biosensing, electronics and photonics for the formation of zinc oxide (ZnO) nanoparticles using Maddar (*Calotropis procera*) latex at room temperature. TEM, XRD, SEM, UV-Vis absorption shows characteristic absorption peak of ZnO nanoparticles.

Fig.2: Diagrammatic representation of one of the method for the synthesis of ZnO nanoparticles (Singh et al. 2011).



Wet Chemical Method: Patil and Talekar reported **s**ynthesis of ZnO nanoparticles were prepared by wet chemical method using zinc nitrate and sodium hydroxides precursors and soluble starch as stabilizing agent. Soluble starch (0.5%) was dissolved in 500 ml of distilled water and treated in microwave oven for complete solubilization. Zinc nitrate, 0.1M, was added in the above solution and the solution was kept under constant stirring at room temperature using magnetic stirrer for one hour. After complete dissolution of zinc nitrate, 300ml 0.2 M of sodium hydroxide solution was added under constant stirring, drop by drop touching the walls of the vessel. The reaction was allowed to proceed for 2 h after complete addition of Sodium hydroxide. After the completion of reaction, the solution was allowed to settle for overnight and the supernatant solution was then discarded carefully. The remaining solution was centrifuged at 10,000rpm for 10 min and the supernatant was discarded. While produced nanoparticles were washed three times using distilled water and ethanol. Washing was carried out to remove the byproducts and the excessive starch that were bound with the nanoparticles. After washing, the nanoparticles were dried at 80°C for overnight. During drying, complete conversion of Zn (OH)2 into ZnO takes place (Rajendran et al. 2010).

Parthasarathi & Thilagavathi (2011) also reported two different media for Zinc oxide nano particle synthesis,as follows

- Zinc oxide nano particle synthesis in Water medium
- Zinc oxide nano particle synthesis in 1,2 Ethanediol (Ethylene glycol) medium

Zinc oxide nano particle synthesis in water medium: 5.5gms of the zinc chloride was dissolved in 100ml of distilled water in a beaker. This solution was kept under constant magnetic stirring till zinc chloride totally dissolved in the distilled water. The temperature of the beaker was raised to 90˚C by electric hot plate heating. Meanwhile 20gms of sodium hydroxide was dissolved in 100ml of distilled water in a separate vessel. From the prepared sodium hydroxide solution, 16 ml of sodium hydroxide is added to the beaker with constant stirring, drop by drop touching the walls of the beaker. The aqueous solution turned into a milky white colloid without any precipitation. The reaction was allowed to proceed for 2 hrs after complete addition of sodium hydroxide. After the complete reaction, the solution was allowed to settle and the supernatant solution was removed by washing with distilled water for 5 times. After complete washing, the zinc nano was dried at 100˚C for 30 min and then it changed into powder form.

Zinc oxide nano particle synthesis in 1, 2 Ethanediol medium: 5.5gms of the zinc chloride was dissolved in 200ml of 1, 2 Ethanediol in a beaker. This solution was kept under constant magnetic stirring till zinc chloride totally dissolved in 1, 2 Ethanediol. The temperature of the beaker was raised to 150˚C by electric hot plate heating. Meanwhile 20gms of sodium hydroxide was dissolved in 100ml of distilled water in a separate vessel. From the prepared sodium hydroxide solution, 16 ml of sodium hydroxide is added to the beaker under constant stirring, drop by drop touching the walls of the beaker. The aqueous solution turned into a white colloid without any precipitation. The reaction was allowed to proceed for 30 minutes after complete addition of sodium hydroxide. After the complete reaction, the solution was allowed to settle and the supernatant solution was removed by washing with distilled water for 5 times. After complete washing, the zinc oxide nano particles were dried at 160˚C for 20 minutes and then it changed into powder form (Parthasarathi and Thilagavathi ,2011).

ZnO Nano particles: ZnO is one of the most important materials used in various products. Zinc white is used as a colour in paints, coating for paper, etc. Some of aspects of ZnO include its radiation hardness, biocompatibility and its high transparency in visible region; it is one dimensional ZnO nanostructures which have attracted special attention because of their unique properties and diverse hierarchical nanostructures (Fig. 3). It is used as direct wideband gap semiconductors in optoelectronics devises, gas sensor and as heat mirrors in solar collectors (Deshmukh 2009).

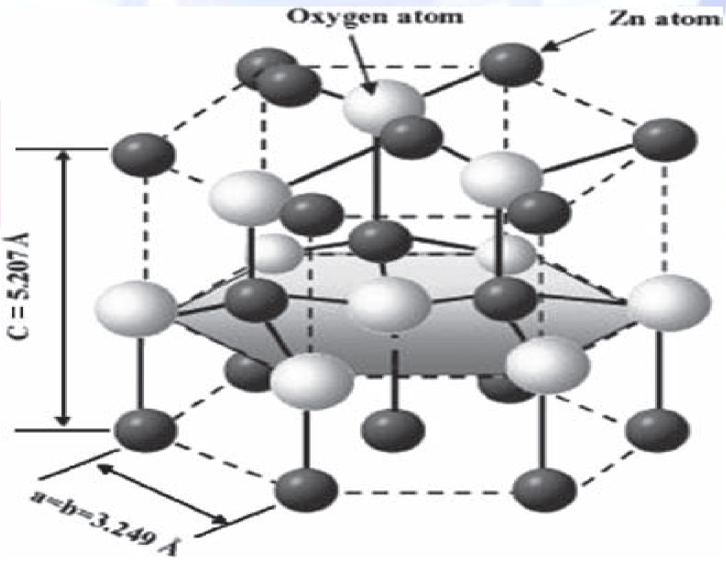


Fig.3: The hexagonal wurtzite structure model of ZnO (Vaseem et al., 2010).

It usually appears as a white powder and is nearly insoluble in water. The powder is widely used as an additive for numerous materials and products including plastics, ceramics, glass, cement, rubber (e.g. car tyres), lubricants, paints, ointments, adhesives, sealants, pigments, foods (source of Zn nutrient), batteries, ferrites, fire retardants, etc. ZnO nanoparticles are effectively to kill cancerous cell compared to the existing technique, which affects the normal cell also. ZnO is nontoxic and is compatible with human skin making it a suitable additive for textiles and surfaces that come in contact with human body (Ashe B. 2011). ZnO nanoparticles (Fig. 4) can be novel alternatives to cancer chemotherapy and radiation therapy as well as new approaches for the treatment of autoimmunity.

Fig. 4: Schematic illustration to show the structure of ZnO aggregates formed by closely packed nanocrystallites. Zhang, et al. (2008).

Different methods for characterization of Nano particles: The resultant experimental conditions greatly affect the size and shape of the particles, prepared with the different condition and also vary due to different methods involves in synthesis of nano particles. In fact, increasing the reaction temperature, results in a significant lowering of the nano particles size and their agglomeration number; The particle size of nano particles characterized and determined by using different techniques such as XRD, AFM, EDS, TEM, FEG -SEM,FT-IR UV- reflectance, Particle size analyzer, and DSC-TGA

CONCLUSIONS

Application of ZnO nanoparticles in the life science domain requires potential in different solution at neutral pH and physiological temperature, because biomolecules are very sensitive to changes in temperature pH and other physiological changes. ZnO nanoparticles used in biological applications such as in drug delivery, also involve non-photocatalytic activity, which can be hindered by the homogeneous surface covering of ZnO nanoparticles by different chemicals or other molecules, and also non-toxic to the human. In addition, comparatively nano size, easy to transport within cell, ability to cross cell membrane and feasible targeting of biologically active molecules will make potential applications of nanoparticles in the field of biology and life science. For microbial control, the overarching goal is to develop antimicrobial systems that sense and selectively target waterborne pathogens for safer water disinfection, diagnosis of pathogenic disease, and improvement of biocorrosion in a manner that is eco-responsible, broadly accessible, and practical (Mankar and Kashmiri, 2014).

Above said tools and techniques provide the instrumentation needed to examine and characterize devices and effects during the research phase, the production techniques will allow the large scale production of nanotechnology products, and the necessary supports for quality control.

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