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A review on the characterization, synthesis of Zno nanoparticles and their application

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Abstract: Nanotechnology is a technique to change the size of the materials particle so that the properties of nano size particle changes drastically or to create some new properties in that material as we wish by reducing the size of material particle. This technology operates in the length scale of 1 – 100nm. This review article provides a comprehensive overview of the synthesis methods and characterization techniques used for the production and analysis of nanomaterials.

Keywords: Nanotechnology; size, nanomaterials and ZnO

1. Introduction

On December 20, 1959, lecture Plenty of Room at Bottom, Richard. P. Feynman the physicist talked of the hypothesis linked with the nascent field of nanotechnology, vision the revolution that was to come decades latter. Today, Feynman's ambition is assuredly being recognized on a global scale and grand. In twenty first century we are poised to make use of it for atomic-level manipulation of matter or engineering at the atomic level for the well-being of mankind [1].

Nanotechnology means the "Engineering of functional systems at the molecular scale." It can be defined as "interlinked field is nanotechnology combining principals of physics and chemistry with the principals of structural analysis, electrical engineering, mechanical design as well as system engineering. The product which is produced has improvement in toughness, strength, speed and efficiency had low cost and high quality. Nanotechnology is field of preference to make everything light, cheap and small [2].

Nanotechnology is the study as well as system design at the nanometer scale [0.0000000001(10^{-9}) meter] which is the scale of molecules and atoms. The man has ability to manipulate materials at the nanoscale and made as nature does. The field of NSST is very broad from nanocluster, Nanoparticle and macroscopic to individual molecules, atoms and there self-assembly in the prescribed structure such as biomolecules and nanowires.

Nanotechnology is field in which there is broader between disciplines like chemistry, biology, and physics no longer detectable and interesting synergies arise e.g. the equipments developed in the subject of physics gives the sensitivity and precision to perform particular molecular experiments in biology [3].

To remove pollutants from environment and to deactivate chemical ware fare agents for this purpose nanometer scale traps will be constructed. Computers with the capacities of current workstations shall be the size of small particles or grains of sand and able to work for decades with equivalent of battery of single wristwatch. To explore the solar systems as well as very nearest star the Robotic Spacecrafts which is having weight few pounds will be sent. The nature of each and every man made subject will be changed by Nanotechnology. The total combined influences that the medical imaging, manmade polymers, computers aided engineering and silicon integrated circuits is less than the total societal influence of nanotechnology and it is expected to greater. The remarkable improvements in performances as well as changes of the production of paradigms will lead to thousand industrial revolutions in 21^{st} century. One billionth of meter is nanometer. 80000nm is the width of human hair. Approximately 70000nm is the width of RBC and 0.3 nm is the water drop.

ZnO is wide band gap material possessing many interesting properties and probably the richest family of nanostructure. Zinc oxide (ZnO) is metal oxide semiconductor with quartzite structure under ambient conditions. The wurtzite structure has hexagonal unit cell as shown in fig. In this crystals structure, two interpenetrating hexagonal-close-pack (hcp) sub lattices are alternatively stacks along c-axis [4].

One sub lattice consists of four Zn atoms and the other sub lattice consists of four Oxygen atoms in one unit cell; every atoms of one kind is surrounded by four atoms of the other kind and forms a tetrahedron structure.

CRYSTALINE STRUCTURE OF ZnO

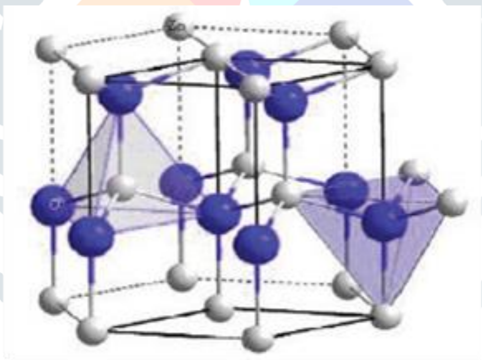


Fig 1. Hexagonal wurtzite structure of ZnO

ZnO commonly consists of polar and non-polar surfaces. The surface energy of the polar surface is higher than the non-polar surfaces and therefore the preferential growth direction of ZnO NR is along the <0001>.

The enormous interest of using ZnO in optoelectronic devices is due to its excellent Optical properties. The direct wide band gap of ZnO~3.4eV is suitable for short wavelength optoelectronic applications, while the high exciton binding energy ~60 MeV allows efficient excitation emission at room temperature. Moreover ZnO, in addition to the ultraviolet (UV) emission, emits covering the whole visible region i.e. containing green, yellow and red emission peaks. The emission in the visible region is associated with deep level defects [5].

Generally, oxygen vacancies (vo), zinc vacancies (VaZn), zinc interstitials (Zni), and the incorporation of hydroxyl (OH) groups in the lattice during the growth of ZnO are most common sources of the defects related emission. ZnO naturally exhibits n-types semiconductor polarity due to native defects such as oxygen vacancies and zinc interstitials. P-type doping of ZnO is still a challenging problem that is hindering the possibility of a p-n homo junction ZnO devices.

Furthermore, the remarkable properties of ZnO like being bio-safe, bio-compatible, having high-electron transfer rates and enhanced analytical performances are suitable for intra extra-cellular sensing applications [6].

Table 1: Properties of ZnO

Property	Value
Lattice parameter	a=b= 3.25A, c=5.21 Å
Crystal structure	Wurtzite
Density	5.606gm/cm^3
Melting point	1975℃
Dielectric constant	8.66
Refractive index	2.008
Energy gap	3.4eV
Exciton binding energy	60 MeV
Effective Mass	0.24 m_o/0.59 m_o
Electron Mobility	100-200 cm^2/Vs
Hole mobility	5-50 cm^2/Vs
Bulk youngs modulus	111.2± 4.5 Gpa

The synthesis significance of this technology and dealing with such nano size is that the behavior of matter is very different from what is similar generally understood and commonly accepted. Laws relating to physical, chemical, biological, electrical, magnetic and other properties at the nano scale are different from those that apply to macro meter. Quite understandably, research in this technology began with novel characteristics at the nano scale. Attempts to achieve control over conductivity, opacity, strength, ductility, reactivity, etc. in different combinations of matters are among the earliest research forays in this field.

This had led to radical changes and departure in the fundamental understanding of matter. For instance, it is clear that metals could become harder, ceramics, could become softer, alloys could be engineered to become harder, ceramics could become softer, alloys could be engineered to become either harder or softer, and the mixture with sufficiently designed properties can be fashioned. As a result, a whole new world is opening up, in which things that are made are not only just smaller, but stronger, or faster or cheaper or better in terms of so many features that were unthinkable, leading creation of whole new capabilities, new products and new markets and not merely the extensions of existing capabilities, products or markets [7].

Other important dimension is that the domain of nanotechnology is not restricted to only the realm of the materials and the applications but extends even to life science. It is now possible to replicate living organism to perform engineered tasks. Besides, as a number of technological strides are being made information technology, development in nanotechnology, which makes the technology multi-disciplinary, as it is becoming increasingly difficult to demarcate the different disciplines at the nano scale when the definition of nano technology itself is broad enough to permit their inclusion within realms?

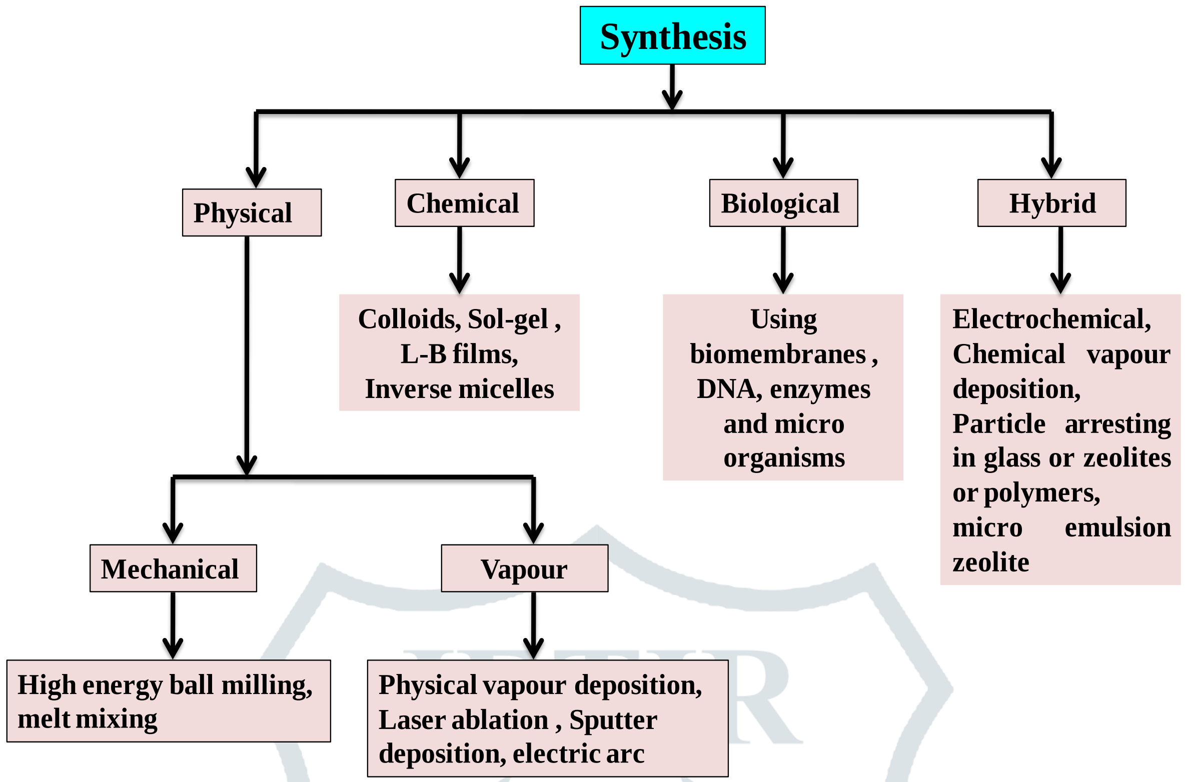
Metal oxide nanoparticle, including zinc oxide, is versatile platforms for biomedical applications and therapeutic intervention. There is an urgent need to develop new classes of anticancer agents, and recent studies demonstrate that ZnO Nanomaterial hold considerable promise.

2. Applications of Zinc Oxide Nanoparticles [8]

The applications of Zinc Oxide powder are numerous, and the principal's ones are summarized below. Most applications exploit the reactivity of the oxide as precursors to other zinc compounds. For material science applications, zinc compounds. For material science applications, zinc oxide has high refractive index, high thermal conductivity, binding, antibacterial and UV-protection properties. Consequently, it is added into material and products including plastics, ceramics, glass, cement, rubber, lubricants, paints, ointments, adhesive, sealants, pigment, foods, batteries, ferrites, fire retardants, etc.

- **Rubber manufacture**
- **Concrete industry**
- **Medicine**
- **Cigarette filters**
- **Food additive**
- **Paint Coatings**
- **Corrosion prevention in nuclear reactor**
- **Potential application**
  - ✓ Electronics
  - ✓ Zinc oxide nanorod sensor
  - ✓ Safety

3. Synthesis method



4. Characterization techniques

- ✓ **X-ray diffraction (XRD)**
- ✓ **Scanning electron microscopy (SEM)**
- ✓ **Transmission electron microscopy (TEM)**
- ✓ **Energy dispersive spectrometer (EDS)**
- ✓ **Fourier transforms infrared spectroscopy (FTIR)**

5. Conclusion:

As per ISO and ASTM standards, nanoparticles are particles of sizes ranging from 1nm to 100 nm with one or more dimensions. The nanoparticles are commonly classified into the organic, inorganic and carbon based particles in nanometric scale that has improved properties compared to larger sizes of respective materials. The nanoparticles illustrate enhanced properties such as strength, surface area, sensitivity and stability, etc. because of their small size. The nanoparticles are synthesized by various methods like physical, chemical, biological and mechanical processes. Nanotechnology provides a clean environment by providing safer air and water, and clean renewable energy for a sustainable future. The nanotechnology has a great future due to its efficiency and environmentally friendly property.

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