SYNTHESIS OF NANOPARTICLES AND IT'S IMPLICATIONS IN REDUCING NATURAL DISASTERS

P. K. Singh* & Akhilesh Kumar **

Department of Physics, M. L. K. P.G. College, Balrampur, U.P. India

****Department of Physics, Pt.D.D. U. Govt. Girls P.G. College Rajajipuram, Lucknow, UP, India***

ABSTRACT

Nanotechnology is a promising field of interdisciplinary research. The potential uses and benefits of nanotechnology are enormous. Nanotechnology is the technology of 21^{st} century i.e. Nanotechnology is the science of the extremely small particles holds enormous potential applications for environment. Nanotechnology is the science of materials at the molecular or subatomic level. It involves engineering of particles smaller than 100 nanometers (one nanometer is one-billionth of a meter) and the technology involves developing materials or devices within that size is invisible to the human eye and often many hundred times thinner than the width of human hair. The physics and chemistry of materials are radically different when reduced to the nanoscale; they have different strengths, conductivity and reactivity, physical, chemical, biological, thermal, electrical properties. Nanotechnology has been described as the development of clean technologies, to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products and to encourage replacement of existing products with new nano-products that are more environmentally friendly throughout their lifecycle. Most applications of Nanoparticles in reducing natural disasters can be analyzed in three main areas that are **building materials, sensors and medicine.**

Keywords: Nanotechnology, Environment Nanotechnology, Nanoproducts, Nanosensors, Nanomedicine.

1. Introduction

Nanotechnology and science of nanomaterials provide apt potential in engineering of materials and at present is the enormously growing and developing scientific technology. It is defined as the study of controlling, manipulating and creating systems based on their atomic or molecular specifications [1]. As stated by the US National Science and Technology Council, the essence of nanotechnology is the ability to manipulate matters at atomic, molecular and supra-molecular levels for creation of newer structures and devices [2]. Generally Nanotechnology deals with structures sized between 1 to 100 nanometer (nm) in at least one dimension and involves in modulation and fabrication of nanomaterials and nanodevices. It has been endured as an area of intense scientific research in various fields like optical, electronic and biomedical fields. Bacterial cells, plant cells and mammalian cells which are more than 100 nm size can easily engulf or internalize the particulates of nano-size like viruses (75-100 nm), proteins (5-50 nm), nucleic acids (2 nm width) and atoms (0.1 nm). If we compare a single human hair diameter (50 µm) to 1 nm nanofibre, hair will be 50,000 times larger than the size of 1 nm [3]. The great visionary late Nobel Physicist Richard P Feynman first designed the idea of molecular manufacturing in 1959. The legendary scientist who first suggested that devices and materials could someday have atomic specifications and that this development path cannot be avoided [4].

For years this science have engaged scientist in exploring the very unique physico-chemical properties of nanoparticles. In field of Nanotechnology due to increase in surface to volume ratio and quantum confinement, the physical, chemical, thermal, electrical, optical and biological properties of a nanomaterial are drastically changes[5].

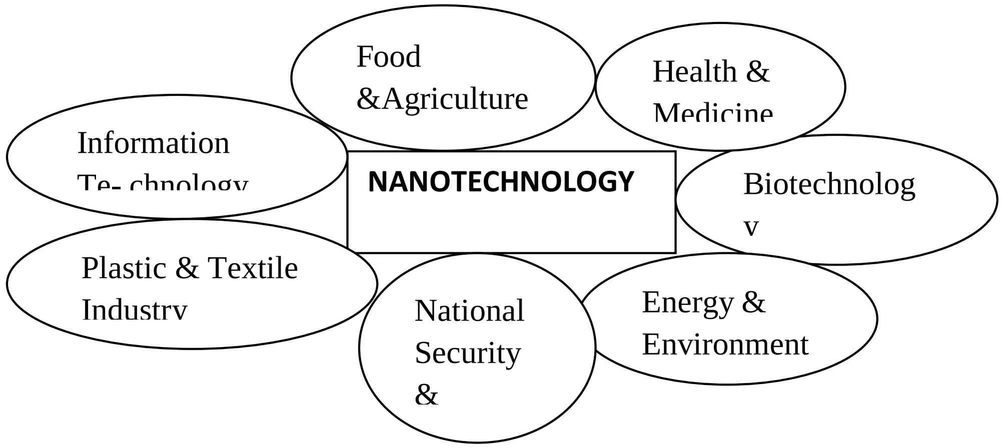

Figure 1: Various Research Fields of Nanotechnology

2. Methodology

Nanotechnology is an interdisciplinary research field, several methods are used in fabrication of nanomaterials such as **Physical** (mechanical and vapor deposition techniques), **Chemical** (Colloids, Sol-gel, L-B films etc.), **Biological** (Biomembranes, DNA etc) and **Hybrid** (Electrochemical, CVD etc). **The guiding principle for the technique, to be employed for synthesis, depends largely upon**, (a) material of interest, (b) type of nanostructure (oD, 1D, 2D, 3D), and (c) size and quantity etc .There are two basic approaches for manufacturing nanomaterials, (i) Top down approach (ii) Bottom up approach. In top-down approach, we reduce the size of material upto nano size, where as in bottom up approach, we start from atomic size and collecting atoms to nano size.

Among various methods for fabrication of nanomaterials the **'WET CHEMICAL METHOD** is the simplest one because of following considerations---------

(a) Inexpensive, least instrumentation required as compared to Physical Methods,

(b) Moderate temperature ($< 350^0$ C) is required for most of nanomaterials,

(c) Dopant can be easily inserted during synthesis process,

(d) Nanomaterials of different size and shapes are possible. Materials so obtained can be dried to obtain powder and thin films.

2.1. Preparation of ZnS Nanoparticles

Although various methods are available for the synthesis of ZnS nanoparticles, chemical precipitation is widely being used for the preparation of colloidal nanoparticles as the possibility of cluster formation is very less in this method when compared to the other methods. Here, 0.27 g of $ZnCl_2$ (1/10 M, 20ml) solution and 0.1M Na_2S solution were prepared in distilled water and were first refluxed for an hour separately. 50 ml Na_2S solution was then added to the mercaptoethanol solution of 0.25 ml (10^{-2} M) and then 20 ml $ZnCl_2$, which was continuously refluxed to get a colloidal form of ZnS. The colloidal sample was refluxed for another 20 min at 80°C for uniform distribution of the particles. Then this was filtered out and washed with distilled water and ethanol for removing the additional impurities formed during the preparation process. The filtrate was dried at room temperature, which yields high-quality ZnS nanocrystals.

The X-ray diffraction of the sample at room temperature is taken by a powder X-ray diffratometer (Rigaku Miniflex-II). The transmission electron micrograph of the sample is taken by a transmission electron microscope (Jeol JEM-100cx). The absorption and luminescence spectra for ZnS nanoparticles were recorded using UV-Visible spectrophotometer (Shimadzu UV-2450) and spectrofluorometer (Shimadzu RF-5310) respectively.

3. RESULTS AND DISCUSSION

Fig. 2 shows the X-ray diffraction pattern of the sample taken at room temperature. The broadening of the diffraction peaks is primarily due to the finite size of the nanocrystallites and is quantitatively analyzed by the Debye–Scherrer formula

$$L = \frac{0.94\lambda}{B\cos\theta} \qquad (1)$$

where L is the average size of the particle, λ is the wavelength of X-ray radiation, B is the full width at half maximum (FWHM) and θ is the diffraction angle. According to the data in Fig. 1and given formula, the average particle size of the material is found to be 45 nm. The transmission electron micrograph of the ZnS is shown in the inset of Fig. 1. The average grain size of the nanoclusters of ZnS is found to be 50 nm. Particle size analyzed by XRD and TEM are in good agreement.

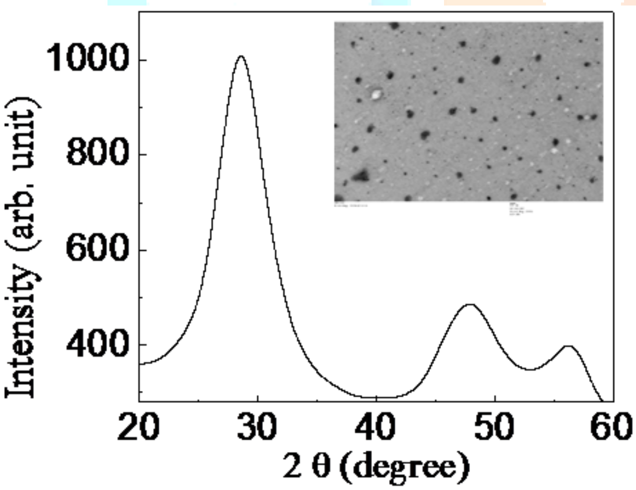

Fig. 2. The XRD (TEM micrograph shown in the inset) for ZnS.

The inset of Fig. 3 shows the UV – visible spectra of ZnS nanoparticles in the absorbance range of 200-350 nm. The absorbance peak at 277 nm is blue shifted compared to the bulk ZnS for which absorption peak is at 345 nm. The blue-shifted absorption edge is due to the quantum confinement of the excitons present in the sample, resulting in a more discrete energy spectrum of the individual nanoparticles. The broadening of the absorption spectrum is mainly due to the quantum confinement of the ZnS nanoparticles. The effect of the quantum confinement on impurity critically depends on the size of the host crystal. As the host decreases, the degree of confinement and its effect increases. The band gap energy is increased (~4.1 eV) compared to that (~3.6 eV) of bulk ZnS shown in the Fig. 2, the enlargement of the band gap can be attributed to the quantum confinement effect of the ZnS nanoparticles.

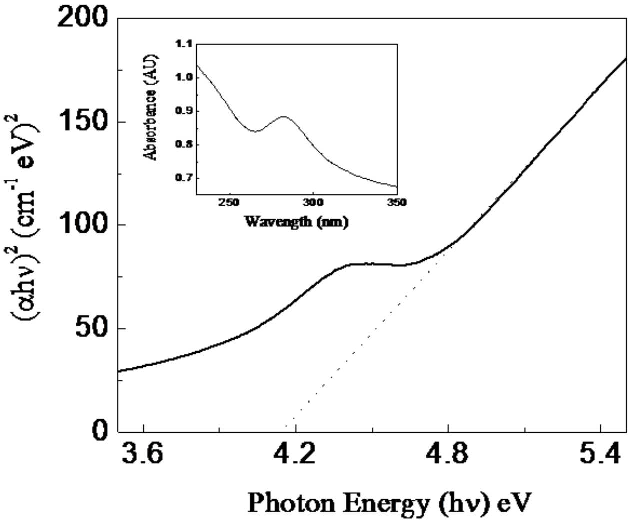

Fig. 3. Energy band gap determination of ZnS nanoparticles. The UV-visible absorption spectra of the ZnS nanoparticles shown in the inset.

4 Applications of Nanotechnology in Building Materials

(a)Applications of Nanotechnology in Building Materials

Nanomaterials have great potential to create new types of strong, lightweight materials such as composites, or they can be used to strengthen existing materials such as concrete. Concrete is the most commonly used building material in the world [16], and as such improving the way that concrete is engineered would vastly improve the durability and resiliency of civil engineering works and architectural design. It is believed that using nanomaterials in concrete would increase its durability from 50 years to 500 years and would increase the compressive strength thereby reducing the amount of reinforced steel needed by as much as 50% [17]. Future research directions for nanostructured concretes include [16]:

• Engineered materials using nanotechnology that will maximize the use of local materials, thereby allowing rapid construction and repair of building following largescale disaster;

• Designing concrete mix that is resistant to the freeze-thaw cycle, corrosion, and other environmental factors; and

• Developing specialty products with blast resistant properties and advanced sensing technologies.

Aside from concrete, nanomaterials can be integrated with other materials and could improve the performance of road structural layers [18], increasing the integrity of road systems, reducing the amount of potholes, and minimizing required maintenance. Other advanced uses for nanotechnology in construction and building materials would include [19]:

• Production of inexpensive corrosion free steel;

• An increase by a factor of 10 for thermal insulation materials;

• Production of coats and films with self-cleansing abilities.

Other than infrastructure and buildings, nanotechnology could be used to improve the resiliency of vehicles, especially aircraft. Advances include a superior strength-the-weight ratio, a reduction in aircraft icing, and lightning protection [20]. Better constructed aircraft reduce the risk of crashes from natural phenomena. Finally, new types of nano-engineered flame retardant coatings are being developed that limit the flammability and combustibility of existing polymers used in vehicles and buildings [21].

Table -1: Nanomaterials used in construction materials

Area	Nanoparticles Type	Major Applications
Concrete	Silica nanoparticles	•Reinforcement in mechanical strength • Rapid hydration
Concrete	Titania nanoparticles	• Increased degree of hydration • Self-cleaning
Concrete	Carbon nanotubes	• Mechanical durability • Crack prevention •High mechanical Strength
Asphalt concrete	Aluminium oxide nanoparticles	• Increased serviceability
Timber		• Increased compressive strength
Bricks mortar	Clay nanoparticles	• Increased compressive strength • Increased surface roughness
Steel resistance	Silica Nanoparticles	•Higher Weldability & Higher Corrosion
Asphalt concrete	Zycosoil	•Increased Fatigue life & Higher Compaction

(b)Role of Nanoparticles in Preventing CORONAVirus infection

- Nanoparticles coated mask and Personnel Protective Equipment (PPE) kits are more efficient to prevent the infection of CORONA virus.
- Nanoparticles are also useful in making CORONA virus vaccines.
- It is possible to develop nanostructures, that could attach with COVID-19 and disrupting its structure with a combination of infrared light treatment and not affecting other parts of the body.
- Magnetic Nanoparticles can be directed with magnetic field to target the specific organ such as lungs to take care of virus infections.

(C)**Sensors**

Using nanotechnology we can create tiny sensors that fulfill a variety of roles and creates a tool called a nanosensor. Nanosensors have the potential to detect a variety of threats, including chemical and biological agents.

Nanosensors can be used as an indicator of Natural Disasters.

(i) Nanosensors as Early Land Slide Indicator

Nanoparticles based Sensors used in association with geotextiles can also be used to monitor rainstorm, landfill leakage, NPS Pollution and water run-off. Nanoparticles based sensors can also be used as a land slide indicator.

Fig. 4: Nanosensor as land Slide Indicator

(ii) Nanosensor as Natural Disaster Indicator

Nanosensors can also be used as a Natural Disaster Indicator.

Fig5: Nanosensors as a Natural Disaster Indicator

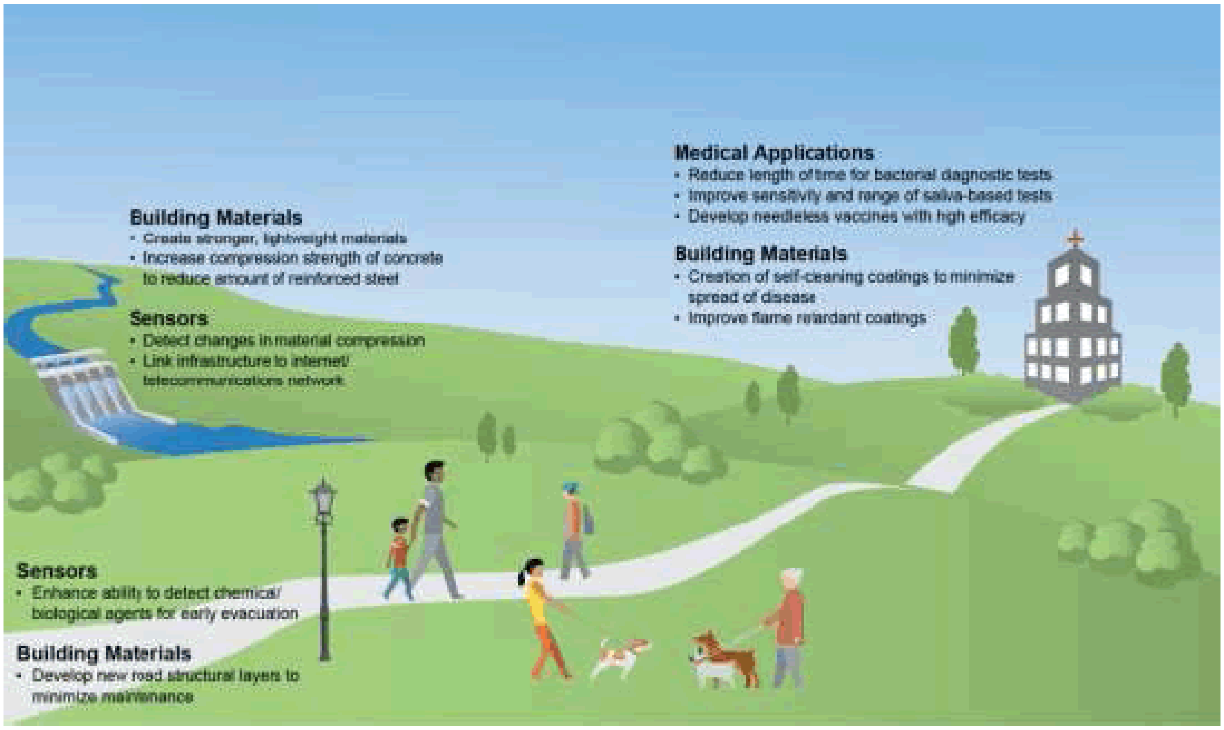

Fig. 6: Applications of Nanotechnology for improving community resilience

5. Conclusion

Nanotechnology will change the way to diagnose, treat and prevent cancer to meet the goal of eliminating suffering and death from cancer. Nanotechnology can provide the technical power and tools that enables development of new diagnostics, therapeutics and preventives. With Nanomedicine, we will be able to stop cancer even before it develops. Nanomedicine has the ability to improve health care by leaps and bounds. It has positive impact to people from all walks of life. Nanotechnology improves cancer treatment in terms of efficiency and quality and also helps in the process of understanding cancer as a disease process. Nanomedicine is a powerful and revolutionary development that has significant impact on society, the economy and life in general. Nanotechnology is avery important tool for medical sciences. Nanomaterials can be used as better building materials, which are stronger, lighter, and more resistant against natural disaster. Nanosensors can be used as natural disaster indicator.

6. References

1. Feynman R. There's plenty of room at the bottom. *Science.* 1991;**254**:1300–1301.

2. R Tripathi, A Kumarand T P Sinha , *Pramana J. Phys*. Vol. 72, No.6, June 2009, pp. 969-978.

3. Ramna Tripathi, Akhilesh Kumar, ChandrahasBhati and T. P. Sinha, *J. Current Appl. Phys.*, Vol. 10 ,2010, pp. 676-681.

4. Stirling '*Opportunities for Industry in the Application of Nanotechnology; Institute of*

Nanotechnology': 2000.

5. K.E.Drexler, 1991, MIT, USA, Ph.D. Thesis entitled '*Nanosystems: Molecular Machinery, Manufacturing and Computation'*.

6. K.E. Drexler, 1992, Nanosystems : Molecular Machinaery, Manufacturing and Computation, John Wiley.

7. Robert A. Freitas Jr., *Introduction to Nanomedicine*, 2000.

8. National Cancer Institute, Cancer Nanotechnology : Going small for big advances, *NIH publication*, Jan 2004.

9. I. Brigger, C. Bubernet& P. Couvreur, " *Advanced Drug Delivery Reviews*, 2002, 54 : 631-651.

10. Roy I, Ohulchanskyy TY, Pudavar HE, Bergey EJ, Oseroff AR, Morgan J, Dougherty TJ, Prasad PN.. *J Am Chem Soc.* 2003;**125**: 7860–7865.

11. Reich DH, Tanase M, Hultgren A, Bauer LA, Chen CS, Meyer GJ. *J Appl Phys.* 2003; **93**: 7275–7280.

12. Weissleder R, Elizondo G, Wittenburg J, Rabito CA, Bengele HH, Josephson L.. *Radiology*. 1990;**175**:489–493.
13. D.P. O'Neal, L.R. Hirsch, N.J. Halas, J.D. Payne & J.L. West, *Cancer Letters*,2004, 209,171-176.
14. J. Brabury, Lancet Oncology, 2003 4, 711.
15. M.L. Brongersma, Nature Materials, 2 2003,296-297.
16. Transportation Research Board (2012) Nanotechnology in concrete materials: a synopsis. Transportation research circular number E-C170.
17. Zhu R, Liu XN, Hu GK, Sun CT, Huang GL (2014) Negative refraction of elastic waves at the deep-subwavelength in a single-phase metamaterial. Nature Communications.
18. Ugwu OO, Arop JB, Nwoji CU, Osadebe N (2013) Nanotechnology as a preventive engineering solution to highway infrastructure failures.JConstrEngManag August: 987-993.
19. Pacheco-Torgal F, Jalali S (2011) Nanotechnology: advantages and drawbacks in the field of construction and building materials.Construction and Building Materials 25:582-590.
20. Gohardani O, Elola MC, Elizetxea C (2014) Potential and prospective implementation of carbon nanotubes on next generation aircraft and space vehicles: a review of current and expected applications in aerospace sciences.Progress in Aerospace Sciences 70:42-68.
21. Malucelli G, Carosio F, Alongi J, Fina A, Frache A (2014) Materials engineering for surface-confined flame retardancy. Mat SciEng R Rep 84:1-20.