International Journal of Advanced Technology in Engineering and Science
Vol. No.4, Issue No. 04, April 2016
www.ijates.com
ijates
ISSN 2348 - 7550

NANOTECHNOLOGY A NOVAL APPROACH FOR SCIENTIFIC DEVELOPMENT – MATERIAL SCIENCE

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ABSTRACT

Advanced nanotechnology offers unprecedented opportunities for progress—defeating poverty, starvation, and disease, opening up outer space, and expanding human capacities. But it also brings unprecedented risks—massive job displacement causing economic and social disruption, threats to civil liberties from ubiquitous surveillance, and the specter of devastating wars fought with far more powerful weapons of mass destruction. The challenge of achieving the goals and managing the risks of nanotechnology requires more than just brilliant molecular engineering. In addition to scientific and technical ingenuity, other disciplines and talents will be vitally important. No single approach will solve all problems or address all needs. The only answer is a collective answer, and that will demand an unprecedented collaboration—a network of leaders in business, government, academia, and NGOs. It will require participation from people of many nations, cultures, languages, and belief systems. Never before have we faced such a tremendous opportunity—and never before have the risks been so great. We must begin building bridges that will lead to safety and progress for the entire world; bridges that will develop common understanding, create lines of communication, and create a stable structure that will enable humankind to pass safely through the transition into the nano era. The aim of this paper is to provide updated, concise yet accurate information about nanotechnology in fields of high societal impact like environment, energy and medicine based on scientific literature and authoritative reports. This paper also include some visions of potential applications of nanotechnology, whilst keeping the discussion at a realistic level. The authors made an attempt with the purpose of supporting environmental NGOs, trade unions, as well as other groups in learning about nanotechnology and its potentials in these diverse areas of applicati ons. The authors' intention is to help those groups forming a balanced view of nanotechnology, so to promote a constructive dialogue about this emerging technology. Other aspects of this discussion, such as potential environmental risks of nanomaterials, health and safety aspects, and ethical/societal concerns related to nanotechnology.

Keywords: Nanotechnology, nanomaterials, nanoparticles, scientific development, material science.

I. INTRODUCTION

- Nanoparticles are defined as particulate dispersions or solid particles with a size in the range of 10-1000nm.
- The drug dissolved, entrapped, encapsulated or attached to a nanoparticles matrix.

- Depending upon to the method of preparation, nanoparticles, nanospheres or nanocapsules can be obtained.
- Nanocapsules are systems in which the drug is confined to a cavity surrounded by a unique polymer membrane, while nanospheres are matrix systems in which the drug is physically and uniformly dispersed.

II. DEFINATION

- **Nanotechnology** is the study of manipulating matter on an atomic scale.
- **Nanotechnology** refers to the constructing and engineering of the functional systems at very micro level or we can say at atomic level.
- A **Nanometer** is one billionth of a meter, roughly the width of three or four atoms. The average human hair is about 25,000 nanometers wide.

III. HISTORY

- The first ever concept was presented in 1959 by the famous professor of physics **Dr. Richard P.Feynman.**
- Invention of the **scanning tunneling microscope** in 1981 and the discovery of **fullerene**(C60) in 1985 lead to the emergence of **nanotechnology.**
- The early 2000s also saw the beginnings of commercial applications of nanotechnology, although these were limited to bulk application of nanomaterials.
- **Silver nano** platform for using silver- nanoparticles as an **antibacterial agent** , **nanoparticle-based transparent sunscreens**, and **carbon nanotubes** for stain-resistant textiles.

IV. TOOLS AND TECHNOLOGY

- The early 2000s also saw the beginnings of commercial applications of nanotechnology, although these were limited to bulk application of nanomaterials.
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V. CARBON NANOTUBE

- Carbon nanotubes are allotropes of carbon with a cylindrical nanostructure.
- They have length-to-diameter ratio of upto 132,000,000:1.
- Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene.

Properties

- Highest strength to weight ratio, helps in creating *light weight spacecrafts*.
- Easily penetrate membranes such as cell walls. Helps in *cancer treatment*.
- Electrical resistance changes significantly when other molecules attach themselves to the carbon atoms. Helps in developing *sensors* that can detect chemical vapours.

Application

- **Easton-Bell Sports, Inc.** using CNT in making bicycle component.
- **Zyvex Technologies** using CNT for manufacturing of light weight boats.
- Replacing transistors from the silicon chips as they are small and emits less heat.
- In electric cables and wires
- In solar cells
- In fabrics

Nanorods (quantum dots)

- **Nanorods** are one morphology of nanoscale objects.
- Dimensions range from 1–100 nm.
- They may be synthesized from metals or semiconducting materials.
- A combination of ligands act as shape control agents and bond to different facets of the nanorod with different strengths. This allows different faces of the nanorod to grow at different rates, producing an elongated object.

❑ USES:

- In display technologies, because the reflectivity of the rods can be changed by changing their orientation with an applied electric field.
- In microelectromechanical systems (MEMS).
- In cancer therapeutics.

VI. NANO BOOTS

- Close to the scale of 10^{-9}.
- Largely in R&d phase .
- Nanobots of 1.5 nanometers across, capable of counting specific molecules in a chemical sample.
- Since nanorobots would be microscopic in size, it would probably be necessary for very large numbers of them to work together to perform microscopic and macroscopic tasks.
- Capable of replication using environmental resources.
- **Application**:
  - Detection of toxic components in environment.
  - In drug delivery.
  - Biomedical instrumention.

VII. APPROACH IN NANO TECHNOLOGY

1. **Bottom up:**

In the bottom up approach different materials and devices are constructed from molecular components of their own. They chemically assemble themselves by recognizing the molecules of their own breed.

- Examples of molecular self assembly are **Watson crick base pairing , nano-lithoghraphy** .

2. **Top down:**

In top down approach nano objects and materials are created by larger entities without bouncing its atomic reactions usually top down approach is practiced less as compared to the bottom up approach.

- **Solid-state techniques** can also be used to create devices known as **nanoelectromechanical systems** or NEMS, which are related to **microelctromechanical systems** or MEMS.
- MEMS became practical once they could be fabricated using modified semiconductor device fabrication technologies, normally used to make electronics.

VIII. MATERIAL USED

- Zinc oxide:
  - Dirt repellent, hydrophobic , cosmetics & stain resistant.
- Silver ion:
  - Healing property
  - Aluminum silicate:
  - Scratch resistance
- Gold ion:
  - Chip fabrication, drug delivery.

Nanotechnology Global Market Overview

- Governments has invested USD$40 billion for the year 2008, and USD9.75 billion had been invested in following year 2009.
- European Union (27 members + Seventh Framework Programme)
- Russia
- United States
- Japan
- China
- The estimated rapid growth for 17% of the global market for the nanotechnologies by 2015 for the areas in healthcare and pharmaceuticals applications
- The corporations in the world was invested USD$41bn on nanotechnology R&D for the year 2010 on areas like defence, semiconductors, pharmaceutical and health care, aviation and food

Nanotechnology Analysis

Nanotechnology developed in synthetic biology, Nano biotechnology, cost-effective carbon capture, quantum information systems, Geoengineering and other emerging and converging technologies (combination of biotechnology, ICT, nanotechnology and cognitive science)

BUILDING BLOCKS	COMPONENTS	END-USE PRODUCTS
Metal/Organometallics	Catalysts	Fuels, Chemicals
Metal Oxides	Nanoparticle coatings, UV Block Dispersions, Chemical Mechanical Polishing (CMP) slurry additives	Sunscreens, Cosmetics, High performance coating, CMP slurries
Silicon Quantum dots	Films and encapsulation	Solar cells, *in vitro* diagnostics, Gene expression assay, Medical imaging
Nanowhiskers	Fabric coating	Moisture wicking apparel, Stain resistant apparel
Carbon Nanotubes	Scanning probe tip, Field emitting devices, Polymer additives, Carbon composite fillers, Electrodes, Transistors	Aerospace, Displays (experimental), Sporting goods, Electronics, Non-volatile memory, Automobiles, "Super" capacitors, Atomic force microscope
Inorganic Nanostructure	Coated thin films	Solar cells, Displays
Organic Molecules	Self-assembling structures	Molecular memory, Solar cells
Gold core oligonucleotides	Reagents	Bio-defence, *in vitro* diagnostics
Nanoscale porous silicon	Medical implants	Drug delivery, *in vivo* diagnostics

Application Of Nanotechnology

IX. NANOTECHNOLOGY IN DRUGS(CANCER)

- Provide new options for drug delivery and drug therapies.

- Enable drugs to be delivered to precisely the right location in the body and release drug doses on a predetermined schedule for optimal treatment.
- Attach the drug to a nanosized carrier.
- They become localized at the disease site, i.e cancer tumour.
- Then they release medicine that kills the tumour.
- Current treatment is through radiotherapy or chemotherapy.
- Nanobots can clear the blockage in arteries.

Nanotechnology in Fabrics

- The properties of familiar materials are being changed by manufacturers who are adding nano-sized components to conventional materials to improve performance.
  - For example, some clothing manufacturers are making water and stain repellent clothing using nano-sized whiskers in the fabric that cause water to bead up on the surface.
  - In manufacturing bullet proof jackets.
  - Making spill & dirt resistant, antimicrobial, antibacterial fabrics.

X. NANOTECNOLOGY IN MOBILES

- Morph, a nanotechnology concept device developed by Nokia Research Center (NRC) and the University of Cambridge (UK).
- The Morph will be super hydrophobic making it extremely dirt repellent.
- It will be able to charge itself from available light sources using photovoltaic nanowire grass covering it's surface.
- Nanoscale electronics also allow stretching. Nokia envisage that a nanoscale mesh of fibers will allow our mobile devices to be bent, stretched and folded into any number of conceivable shapes.

XI. NANOTECHNOLOGY IN ELECTRONICS

- Electrodes made from nanowires enable flat panel displays to be flexible as well as thinner than current flat panel displays.
  - Nanolithography is used for fabrication of chips.
  - The transistors are made of nanowires, that are assembled on glass or thin films of flexible plastic.
  - E-paper, displays on sunglasses and map on car windshields.

XII. NANOTECHNOLOGY IN COMPUTER

- The silicon transistors in your computer may be replaced by transistors based on carbon nanotubes.
- A carbon nanotube is a molecule in form of a hollow cylinder with a diameter of around a nanometer which consists of pure carbon.
- Nanorods is a upcoming technology in the displays techniques due to less consumption of electricity and less heat emission.
- Size of the microprocessors are reduced to greater extend.

- Researchers at North Carolina State University says that growing arrays of magnetic nanoparticles, called **nanodots.**
- Hewett Packard is developing a memory device that uses nanowires coated with titanium dioxide.
- One group of these nanowires is deposited parallel to another group.
- When a perpendicular nanowire is laid over a group of parallel wires, at each intersection a device called a **memristor** is formed.
- A memristor can be used as a single-component memory cell in an integrated circuit.
- By reducing the diameter of the nanowires, researchers believe memristor memory chips can achieve higher memory density than flash memory chips.
- Magnetic nanowires made of an alloy of iron and nickel are being used to create dense memory devices.
- Chips produced by Intel before "i" series processors were between 65nm -45nm.
- Later with the help of nanotechnolgy 22nm chips were made which itself is a milestone.
- **Advantages of using carbon nanotubes:**
- **Faster and smaller-** carbon nanotubes can be used to produce smaller and faster components.
- This will also result in computers that consume **less energy.**
- High speed and high capacity memory.
- Allows circuits to be more accurate on the atomic level.

XIII. OTHER USES

- Cutting tools made of nanocrystalline materials, such as tungsten carbide, tantalum carbide and titanium carbide, are more wear and erosion-resistant, and last longer than their conventional counterparts.
- Silver nanocrystals have been embedded in bandages to kill bacteria and prevent infection.
- Nanoparticulate-based synthetic bone
  - Formed by manipulating calcium and phosphate at the molecular level.
  - Aerogels lightest known solid due to good insulating properties is used in space suits and are proposed to use in space craft.

XIV. NANOTECHNOLOGY IN INDIA

- IIT Mumbai is the premier organization in the field of nanotechnology.
- Research in the field of health, environment, medicines are still on.
- Starting in 2001 the Government of India launched the Nano Science and Technology Initiative (NSTI).
- Then in 2007 the Nanoscience and Technology Mission 2007 was initiated with an allocation of Rupees 1000 crores for a period of five years.
- The main objectives of the Nano Mission are:- basic research promotion, - infrastructure development for carrying out front-ranking research, - development of nano technologies and their applications, - human resource development and - international collaborations.

XV. POSSIBILITIES FOR FUTURE

- Nanotechnology may make it possible to manufacture lighter, stronger, and programmable materials that
  - require less energy to produce than conventional material
  - and that promise greater fuel efficiency in land transportation, ships, aircraft, and space vehicles.
  - The future of nanotechnology could very well include the use of nanorobotics.
- These nanorobots have the potential to take on human tasks as well as tasks that humans could never complete. The rebuilding of the depleted ozone layer could potentially be able to be performed.
- There would be an entire nano surgical field to help cure everything from natural aging to diabetes to bone spurs.
- There would be almost nothing that couldn't be repaired (eventually) with the introduction of nano surgery.

XVI. CONCLUSION

- Nanoparticulate systems have great potentials, being able to convert poorly soluble, poorly absorbed and labile biological active substance into promising deliverable drugs.
- Generally nanoparticle have relatively higher intracellular uptake compared to microparticles and available to a wide range of biological targets due to their small size and relative mobility.

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