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Recent Trends and Advances in Nanotechnology: An Overview

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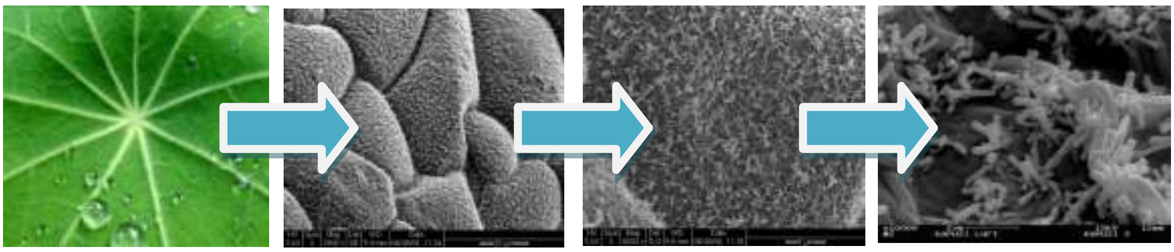
ABSTRACT:
Nanotechnology is an emerging sciences that involves creation and use of structure, devices and system that have novel properties and function because of their small size, Research and Development. Nanotechnology is define as Sciences and Engineering involved in design, system, characteristics and application of materials and devices whose smallest function is at least one dimension is on nanometer scale. Nanotechnology is very active globally and mostly used in Hundreds of products. It is mostly being developed for use in drug deliveries, biomedicines, and other development, application and also for environmental applications. This is rapidly growing and large future market. It covers each and every area in field of science, research, development, technology. The article present an Introduction to Nanotechnology and different technologies such as nanomaterials, nanotubes, nanofibers, nanofluids, nanocrystals, etc. that have effect on human life and environment in future.

Key words: Nanotechnology, Nanomedicines, Nanoparticles

I. INTRODUCTION:

History of Nanotechnology:

The term ”nanotechnology” was created by Norio Taniguchi of Tokyo University in 1974 to describe the precision manufacture of materials with nanometer tolerances, but its origins date back to Richard Feynman’s 1959 talk “There’s Plenty of Room at the Bottom” in which he proposed the direct manipulation of individual atoms as a more powerful form of synthetic chemistry. Eric Drexler of MIT expanded Taniguchi’s definition and popularised nanotechnology in his 1986 book “Engines of Creation: The Coming Era of Nanotechnology”. (Dinauer N et al., 2005 and Widder K et al., 1979).
The term, "nanotechnology," was proposed by K. Eric Drexler. Technically speaking, Nanotechnology refers to a field of applied science and technology whose theme is the control of matter on the atomic and molecular scale, generally 100 nanometers or smaller, and the fabrication of devices or materials that lie within that size range.



MACRO **MICRO** **NANO**

Figure no: 1. Size of Particles

Modern industrial nanotechnology had its origins in the 1930s, in processes used to create silver coatings for photographic film; and chemists have been making polymers, which are large molecules made up of nanoscale subunits, for many decades. However, the earliest known use of nanoparticles is in the ninth century during the Abbasid dynasty. Arab potters used nanoparticles in their glazes so that objects would change colour depending on the viewing angle (the so-called polychrome lustre).C. Zandonella et.al (2003). Today’s nanotechnology, i.e. the planned manipulation of

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materials and properties on a nanoscale, exploits the interaction of three technological streams:

1. New and improved control of the size and manipulation of nanoscale building blocks
2. New and improved characterisation of materials on a nanoscale (e.g., spatial resolution, chemical sensitivity)
3. New and improved understanding of the relationships between nanostructure and properties and how these can be engineered.

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, in order to understand and exploit properties that differ significantly from those on a larger scale. Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size on a nanometer scale.(Manivannan R. et.al, 2005.)

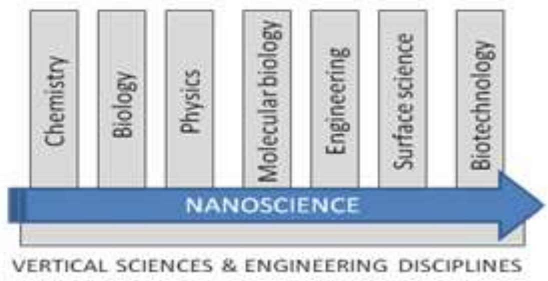
Nanoscale materials have been used for decades in applications ranging from window glass and sunglasses to car bumpers and paints. Now, however, the convergence of scientific disciplines (chemistry, biology, electronics, physics, engineering etc.) is leading to a multiplication of applications in materials manufacturing, computer chips, medical diagnosis and health care, energy, biotechnology, space exploration, security and so on. Hence, nanotechnology is expected to have a significant impact on our economy and society within the next 10 to 15 years, growing in importance over the longer term as further scientific and technology breakthroughs are achieved. On a nanoscale, i.e. from around 100nm down to the size of atoms (approximately 0.2 nm) the properties of materials can be very different from those on a larger scale. (A. vaseastita et.al 2005).

A nanometer (nm) is one thousand millionth of a meter. A single human hair is about 80,000 nm wide, a red blood cell is approximately 7,000 nm wide, a DNA molecule 2 to 2.5 nm, and a water molecule almost 0.3 nm.

Nanotechnology involves research and technology development at the atomic, molecular or macromolecular levels in the range of approximately 1-100 nanometers to provide fundamental understanding of phenomena and materials at the nanoscale. The nanometer scale is about a billionth of a meter. In comparision, a human hair is about 10,000 nanometers in diameter.

Basically nanotechnology is used to create structures, devices and systems that have novel properties and functions because of their minute size. Actually, the matter shows unusual physical and chemical properties due to increase in surface area compared to volume as particles get smaller in size & this is called quantum size effect.

Nanotechnology uses two main kinds of microscopy. The first involves a stationary sample in line with a high-speed electron gun. Both the scanning electron microscope (SEM) and transmission electron microscope (TEM) are based on this technique. The second class of microscopy involves a stationary scanner and a moving sample. The two microscopes in this class are the atomic force microscope (AFM) and the scanning tunnelling microscope.
(C. Baker et.al 2005).



Nanoscience is a horizontal- integrating interdisciplinary science that cuts across all vertical sciences and engineering disciplines.

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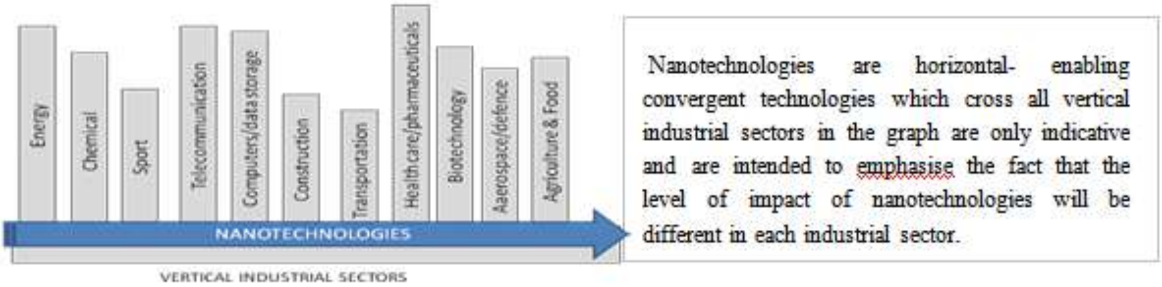

Figure no. 2: Comparison of Nanoscience and Nanotechnology

Nanoparticles and Nano materials:

Pharmaceutical nanoparticles are defined as solid, with at least one dimension that is submicron-sized (less than 100 nm in diameter) drug carrier that may or may not be biodegradable. They are subionised colloidal structure composed of synthetic nd semisynthetic polymers. The drug is dissolved, entrapped encapsulated or attached to nanoparticle matrix. The term nanoparticle is a combined name for both nanospheres and nanocapsules. Nanospheres are matrix system in which drug is uniformly dispersed, while nanocapsules are the system in which the drug is surrounded by a unique polymeric membrane.(Luisa F. et.al 2010).

Classification of nanoparticles:

1. Based on Dimensions: 0-D, 1-D, 2-D, 3-D
2. Based on Morphology: High and low aspect ratio particles
3. Based on Nanocomposition: Single and multiple composition
4. Based on Uniformity and agglomeration:

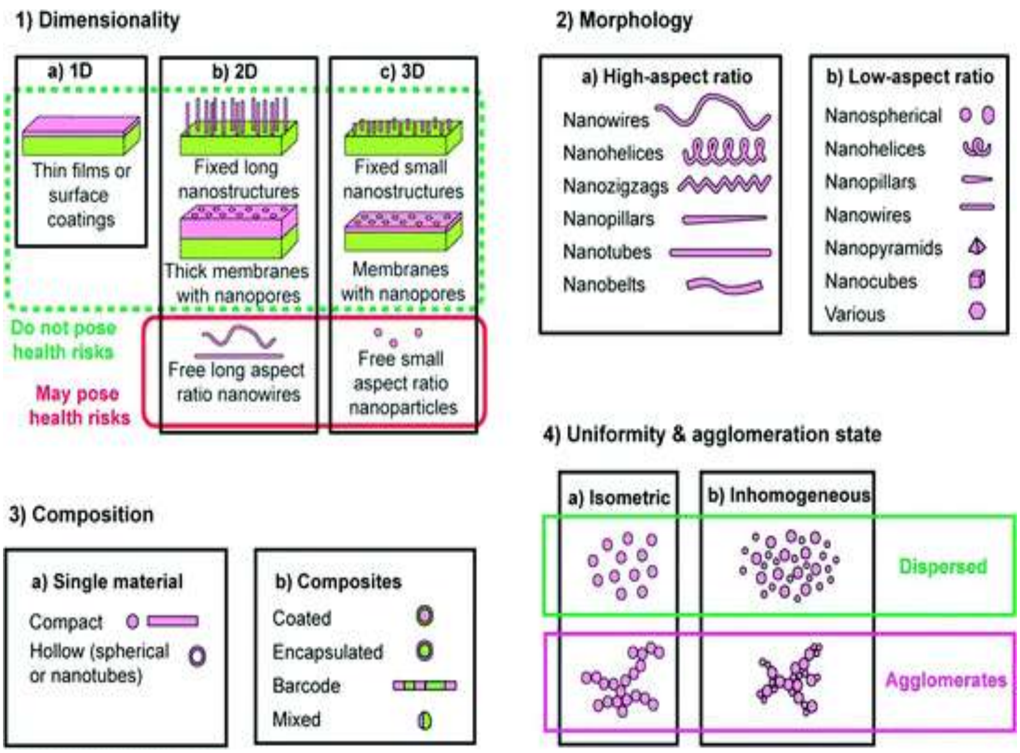

Figure No. 3 : Classification of Nanoparticles

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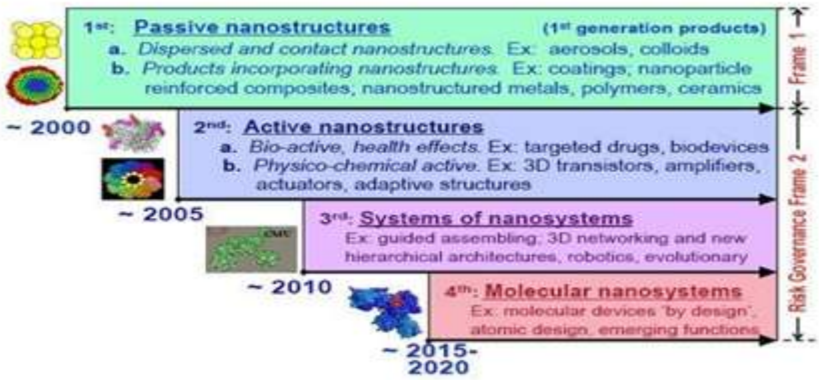

Figure No. 4: Representing the four generations of nanoparticles.

NanoMaterials:

A nanomaterial is an object that has at least one dimension in the nanometre scale (approximately 1- 100nm). Nanomaterials are categorised according to their dimensions. Due to their small size, nanomaterials have a high specific surface area in relation to the volume. Consequently, the particle surface energy is increased, making the nanomaterials much more reactive. Nanomaterials have a tendency to adsorb biomolecules, e.g., proteins, lipids, among others, when in contact with the biological fluids.

Nanomaterials can be of two types:

1. **Non-intentionally made nanomaterials**", which refers to nano-sized particles or materials that belong naturally to the environment (e.g., proteins, viruses, nanoparticles produced during volcanic eruptions, etc.) or that are produced by human activity without intention (such as nanoparticles produced from diesel combustion).
2. "**Intentionally made**" nanomaterials, which means nanomaterials produced deliberatelythrough a defined fabrication process.

The definition of nanotechnologies does not generally include "non-intentionally made nanomaterials", and is therefore limited to "intentionally made nanomaterials".(Gengy et.al 2007).

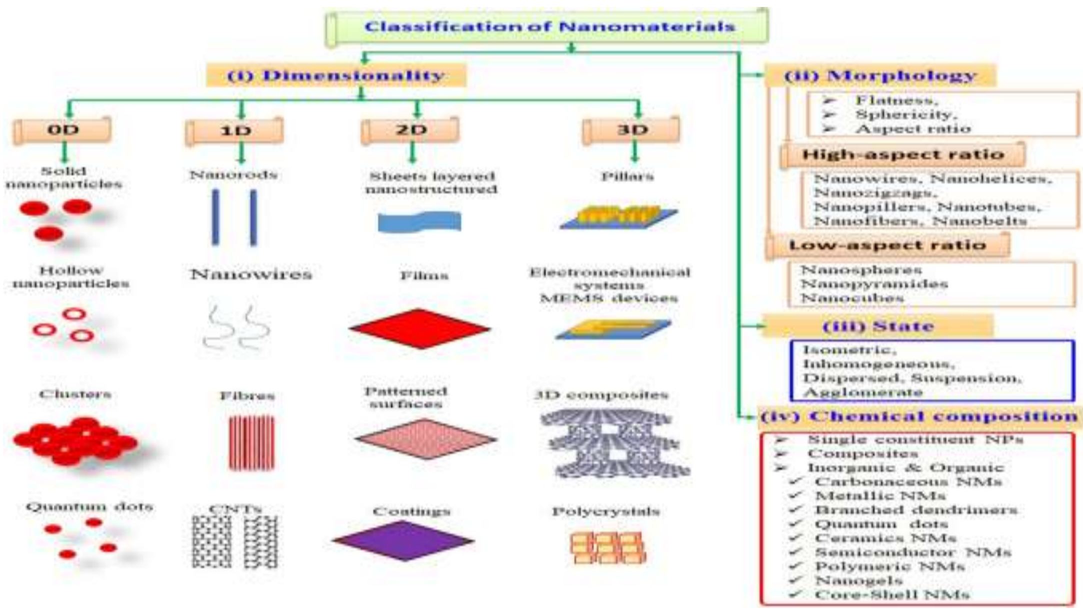

Figure No. 5: NanoMaterials

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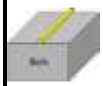
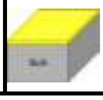
Nanomaterial Dimension	Nanomaterial Type	Example
All three dimensions < 100 nm	Nanoparticles, Quantum dots, nanoshells, nanorings, microcapsules	
Two dimensions < 100 nm	Nanotubes, fibres, nanowires	
One dimension < 100 nm	Thin films, layers and coatings	

Table no. 1 Dimension of nanomaterials

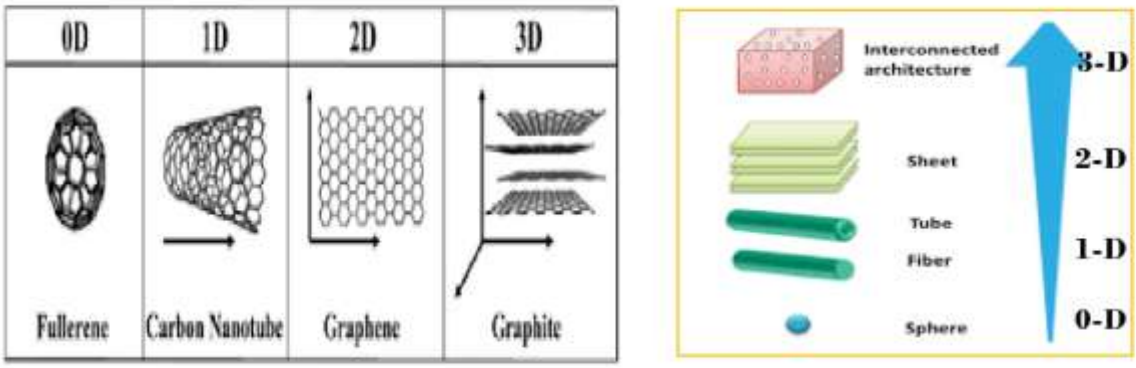


Figure No. 6: Nanomaterial dimensions

0-D	1-D	2-D	3-D
Material within nanoscale (no dimension or 0-D). It can be amorphous or crystalline (single crystalline or polycrystalline), can composed of single	One dimension outside the nanoscale. Exhibit needle like-shaped, the material including nanotubes, nanorods, and nanowires. It can be amorphous or crystalline (single	Two of the dimension not confine to nanoscale, exhibit plate-like shape, the material including nanofilms, nanolayers and nanocoating. It can be amorphous or	Three dimension not confined to the nanoscale, material possess a nanocrystalline structure, bulk

Table no. 2 Characteristics of dimensions

Advantages :

1. Site specific deliver of drugs.
2. Nanoparticles help to achieve maximum therapeutic response within adverse effect
3. Active and passive drug targeting can be achieved by manipulating the particle size and surface characteristics of nanoparticles
4. It can be administered by parenteral, oral, nasal, ocular routes.
5. By attaching specific ligands onto their surfaces, nanoparticles can be used for directing the drug to the specific target size

Disadvanntages:

1. Limited to drug loading.
2. Susceptible to bursting and leakage of content.

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3. Small size and large surface are can lead to particle aggregation.(Chorney et.al 2002. And Couvreur P. et.al 1995)

Sr. no	Nanorods	Nanowires	Nanotubes
1	Nanorods similar to nanotube but without internal surface. Less versatile than nanotube	Nanowires have typically diameters of a few tens of nm, but the lengths are not bounded.	Nanotubes are also like nanowires, in terms of diameter, but hollow and with a standard aspect ratio (length divided by width) of 3–5. Exist as single-or multi-walled.
2	carbon, metal oxide, metal	ceramic, metal oxide, metal	carbon; single-walled carbon nano tubes (SWCNT), multi-walled carbon nanotube (MWCNT)
3	drug delivery, bioimaging, photothermaltherapy nanocapacitors, etc.	magnetic devices, nanowires battery, nanogenerator, semiconductor, etc.	scaffolds or templates for the building

Table no. 3 : Different Nanomaterials

A) Nanofluids: These are dilute liquid suspensions of nanoparticles with at least one of their principal dimensions smaller than 100 nm. From previous investigations, nanofluids have been found to possess enhanced thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity and convective heat transfer coefficients compared to those of base fluids like oil or water.

The effects of several important factors such as particle size and shapes, clustering of particles, temperature of the fluid, and dissociation of surfactant on the effective thermal conductivity of nanofluids have not been studied adequately. Nanofluids are a new class of advanced heat transfer fluids engineered by dispersing nanoparticles smaller than 100nm in diameter in conventional heat transfer fluids.

Adavantages:

1. Compared with suspended particle of millimetre or micrometer dimension which are were used in base fluids to enhance heat transfer of such fluids, nanofluids exhibits higher thermal conductivity.
2. Many types of particles such as metallic and non metallic can be added into fluids.
3. Micro and millimetre sized particles tend to settle rapidly, but nanoparticle can remain suspended in base fluids for longer time.
4. Heat transfer capabilities improves with relative larger surface area of nanoparticles

Disadvantages:

1. Processing cots.
2. Agglomeration at higher pH value and also at high temperature
3. Maintain sufficient pressure and velocity of fluids.

A) Nanocrystals: technologies have been introduced as advantageous, universal formulation approaches for the BCS class II and IV drugs. Nanocrystals, with greater surface to volume ratio, can effectively increase both the dissolution rate and saturation solubility of active ingredients The Nanocrystals is suitable drug delivery system for all commonly used routes of administration such as oral, IV, SC, and IM and topical application. Nanocrystals can also be incorporated into the tablets, capsules, fast- melts and lyophilized for sterile product applications.

Drug nanocrystals are crystals with a size in the nanometer range, which means they are nanoparticles with a crystalline character. Dispersion of drug nanocrystals in liquid media leads to so called “Nanosuspensions” (in contrast to

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"micro suspensions" or "macro suspensions"). In general the dispersed particles need to be stabilized, such as by surfactants or polymeric stabilizers. Dispersion media can be water, aqueous solutions or nonaqueous media (eg, liquid polyethylene glycol [PEG], oils). Depending on the production technology, processing of drug microcrystals to drug nanoparticles can lead to an either crystalline or to an amorphous product, especially when applying precipitation. In the strictest sense, such an amorphous drug nanoparticle should not be called nanocrystals

ADVANTAGES:

1. It can be given by any route of administration.
2. Enhanced solubility and bioavailability of drug.
3. Reduced tissue irritation in case of subcutaneous/intramuscular administration.
4. Rapid dissolution & tissue targeting can be achieved by IV route of administration.
5. Oral administration of Nano suspension provide rapid onset, reduced fed/fasted ratio & improved bioavailability.
6. The absorption form absorption window can be increased, due to reduction in particle size.
7. It can be incorporated in tablets, pellets, hydrogel & suppositories are suitable for various routes of administration.
8. Increasing the amorphous fraction in the particles leading to a potential change in the crystalline structure & higher solubility.
9. Possibility of surface-modification of Nanosuspension for site specific delivery.
10. Higher drug loading can be achieved.
11. Long term physical and chemical stability (due to absence of Ostwald ripening

DISADVANTAGES:

1. Physical stability, sedimentation & compaction can cause problems.
2. It is bulky sufficient care must be taken during handling & transport.
3. Uniform & accurate dose cannot be achieved

B) Nanofibers: NanoFiber is diameter in nanometer range. Nanofibers are a nanomaterial with one dimension less than 100 nm. Wide range of polymers such as polyvinyl alcohol, gelatin, collagen, chitosan and carboxymethylcelulose can be subjected to electro spinning technique to produce nanofibers. Nanofibers have large specific surface area with small pore size and theseunique properties showing opportunities in management of wound care applications. Nanofibers exhibit low density, large surface area to mass, high pore volume, and tight pore size make the nanofibers nonwoven for wide range of filtration application.

ADVANTAGES:

1. It uses nanoporous membrane as templates.
2. Simple and cost effective, produce single long fiber.
3. Controls the pore sized and structures and ranges of shapes and sizes.

DISADVANTAGES:

1. It is limited to viscoelastic materials, depending upon the orifice size of mould which leads to difficulties in obtaining fibers of diameter less than 100nm.
2. Uniform porosity cannot be maintained.
3. They undergo several difficulties in making a large volume of scaffholds.

C) Nanooptics: This area of nanoscience, called **nanophotonics**, is nanostructured matter controls the interactions"Good reasons to work on nanooptics.

1. Nanooptics is one of the megatrends of our society (Nano =€$)
2. Nanooptics enables fundamentally new light-matter-interaction
3. Nanooptics promotes research of new technologies and methods.
4. Nanooptics breaks barriers and opens up new areas ofscience and engineering.
5. Nanooptics is a dynamics research field
6. Nanooptics is an area where many fields of science converge into the interdisciplinary research field of nanoscience

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Application of Nanotechnology in Science and Environmental Science

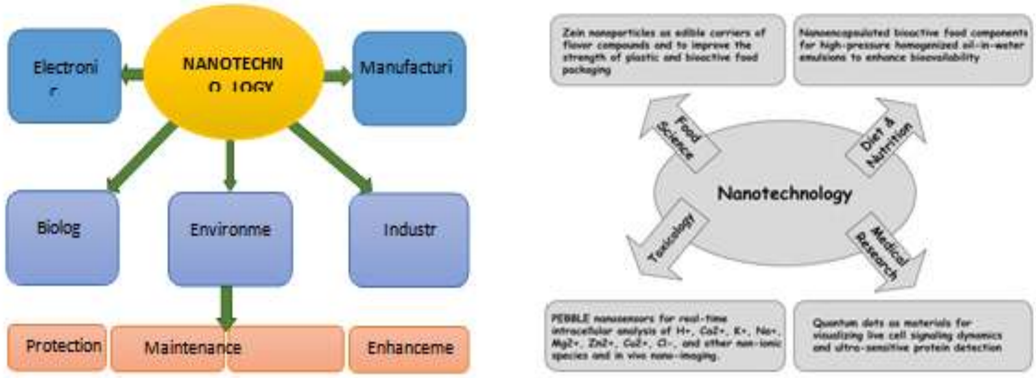

Figure No. 7: Application of nanotechnology

Nanotechnology is already being used in numerous new kinds of batteries that are less flammable, quicker- charging, more efficient, lighter weight, and that have a higher power density and hold electrical charge longer. One new lithium-ion battery type uses a common, nontoxic virus in an environmentally benign production process. Nanostructured materials are being pursued to greatly improve hydrogen membrane and storage materials and the catalysts needed to realize fuel cells for alternative transportation technologies at reduced cost. Researchers are also working to develop a safe, lightweight hydrogen fuel tank. Various Nano science- based options are being pursued to convert waste heat in computers, automobiles, homes, power plants, to usable electrical power

Application of nanotechnology in environmental science is categorized into four parts: remediation, protection, maintenance, and enhancement. Among these four, remediation is known as the most rapid growing category, protection and maintenance make the main part of nanotechnology application in environmental science, while environmental enhancement represents the smallest part of nanotechnology application categories. Nanoparticles can be utilized in air and water treatment, mesoporous elements for green chemistry, catalytic applications and environmental molecular science. Along with decreasing the size of the particles, they gain new chemical, electronic and physical properties. Advantages include improved adsorption and unique catalytic properties that can accelerate oxidation or reduction reactions with different contaminants for particle that are less than 10 nm. Nanotechnology is also able to improve the environment via presenting influential control and preventing of contamination. For environmental treatment, different implementations of nanotechnology have been successfully implemented at the laboratory scale. However, mostly these applications need confirmation of their effectiveness and safety in the field. Traditional remediation technologies have indicated confined efficacy in reduction of the concentration of contaminations in air, water, and soil. According to Boehm nanomaterials can act more remarkably and influentially as filtration media in comparison with bigger particles with the same chemicals.

With medical nanotechnology, treatment would be more efficient and precise. Instead of opening the whole body area for surgical purposes, a microscopic nanotool would spare the patient from bloody and risky surgical process. With nanotechnology in the medical field, treatment would be precise, eliminating trial-and-error drug prescription. Disease vector and pest detection control. Nanoscale sensors for pest detection, and improved pesticides, insecticides, and insect repellents.

Nanotechnology can actually revolutionized a lot of electronic products as nanotransistors, nano diodes, quantum computers etc. and their procedures and applications. The development of more effective energy producing, energy absorbing and storage products in smaller and more efficient devices is possible with this technology. Such items like batteries, solar cells and fuel cells can be made smaller and more effective.

Nano-molecular structures to make asphalt and concrete more resistant to water;

materials to block ultraviolet and infrared radiation; materials for cheaper and durable housing, surfaces, coatings, glues, concrete, and heat and light exclusion; and self- cleaning for windows, mirrors and toilets.

II. CONCLUSION:

Nanotechnology entails the measurement, prediction and construction of materials on the scale of atoms and molecules. These days, scientists and engineers are taking control of atoms and molecules individually, manipulating them and putting them to use with an extraordinary degree of precision. Though its contributions may seem small at the moment, as funding and manpower continue, this will provide result and innovations. With all the potential that nanotechnology brings, humans must be ready to accept it. We must be ready to properly utilize that which we have discovered. If nanotechnology grows with current rate, it will touch the life of nearly every person on the planet in the next few years and it will be the great advancement in earth's history.

Nanotechnology-empowered medication conveyance is opening planned future in pharmaceutics. The rise of nanotechnology is probably going to essentially affect drug conveyance area, influencing pretty much every course of organization from oral to injectable. Nano-empowered medication conveyance additionally makes it feasible for medications to pervade through cell dividers, which is of basic significance to the normal development of hereditary medication throughout the following not many years.

The nanotechnology imagines a world where new items are planned at the nuclear and atomic level; give reasonable, practical strategies for tying sustainable power sources and keeping the climate clean. These days, a considerable lot of researchers and specialists are discovering better approaches to utilize nanotechnology to work on the world. There are various uses of nanotechnology including gadgets, science, compound designing and advanced mechanics hardware. It has opened logical Inquiry to the degree of nanoparticles and offers a universe of new chances.

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