# A REVIEW ON NANOTECHNOLOGY AND ITS APPLICATIONS

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## Abstract

*Nanotechnology is defined as the design and fabrication of materials, devices and systems with control at nanometer dimensions. It is the study of extremely small structures, having size of 0.1to100nm. In this paper we present an introduction to the principles and advances made in the fields of nanoscience and nanotechnology including inventions, discoveries and design and study of molecular building blocks studied through nanoscience and applied in nanotechnology. Nanoscience is the study of systems in nanoscale and nanotechnology is the ability to systematically organize and manipulate properties and behavior of matter in the atomic and molecular levels. Through nanoscience and nanotechnology it has become possible to study and create very useful functional devices, materials and systems on the 1 to 100 nanometer (one billionth of a meter) length scale. The reasons why nanoscale has become so important are presented. An application of Nanotechnology in various fields such as health and medicine, electronics, energy and environment, is discussed in detail. Applications of nano particles in drug delivery, protein and peptide delivery, cancer are explained. Applications of various nano systems in cancer therapy such as carbon nanotube, dendrimers, nanocrystal, nano wire, nano shells etc. Are given. Nano pharmaceuticals can be used to detect diseases at much earlier stages.*

## Paper Identification

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### Introduction

Nanotechnology is the ability to build micro and macro materials and products with atomic precision. Nanoscience is study of properties and behavior of condensed materials in nanoscale, study of natural nanoscale phenomena such as the fascinating field of bio-systems, and investigating the peculiarities of nanosystems. Therefore nanoscience and nanotechnologies deal with at least clusters of atoms of 1nmsize. The upper limit is normally 100 nm, but this is a “fluid” limit; often objects with greater dimensions (even 200nm) are defined as nanomaterials. Nanoscience is not just the science of the small, but the science in which materials with small dimension show new physical phenomena, collectively called quantum effects, which are size- dependent and dramatically

different from the properties of macro-scale materials. Nanoscience is the study of materials that exhibit remarkable properties, functionality and phenomena due to the influence of small dimensions

**What are nano materials and what are its types**

A nanomaterial is an object that has at least one dimension in the nanometre scale (approximately 1-100nm).

Nanomaterials can be of two types:

- **"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).
- **"intentionally made"** nanomaterials, which means nanomaterials produced deliberately through a defined fabrication process.

The definition of nanotechnologies does not generally include "non-intentionally made nanomaterials", and is therefore limited to "intentionally made nanomaterials".

**Historical development of nano technology**

The first mention of term nano technology is usually connected with the well known lecture of Mr. R. Feynman, the professor of californian institute of technology delivered in 1959 at the session of American physical society. In this lecture he called "there is a lot of space down there" for the first time possibility to create nano sized products with the use of atoms as building particles was considered.

The word "nano technology" was first of all introduced into scientific world by N. Taniguchi at the international conference on industrial production in Tokyo 1974.

In the second half of 1980's to the early 1990's a number of important discoveries were made which created an essential impact on further development of nano technology in 1991 first nano technology program of national scientific fund started to operate in USA. In 2001 national nano technological initiative (NNI) of USA was approved.

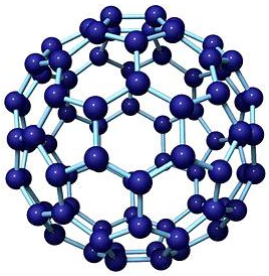
**Applications of nano technology:**

The different fields that find potential applications of nanotechnology are as follows:

Scanning Tunneling Microscope (STM): It is an instrument for imaging surfaces at atomic level. Its development in 1981 earned its inventors, GerdBining and Heinrich Rohrer the noble prize in Physics in 1986. For an STM, good resolution is considered to be 0.1 nm lateral resolution and 0.01 nm depth resolution. With this resolution, individual atoms within materials are routinely imagined and manipulated. The STM can be used not only in ultra-high vacuum but also in air, water and various other liquid or gas ambients and at temperatures ranging from zero kelvin to over 10000 C.STM is based on concept of quantum tunneling.

**Carbon nano products**

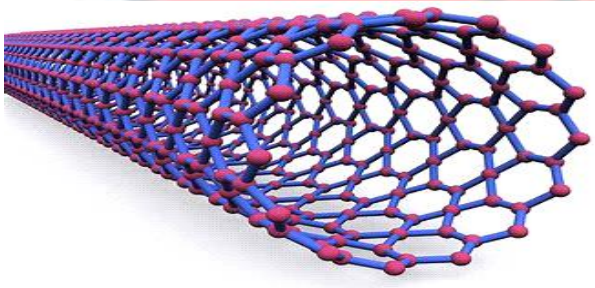
**Fullerene (a Buckyballs):** Buckminsterfullerene (or fullerene), C60, is a nano allotrope of carbon, which was discovered in 1985 by Kroto and collaborators (Kroto, et al., 1985). These investigators used laser evaporation of graphite and they found Cn clusters (with n>20 and even-numbers) of which the most common were found to be C60 and C70. For this discovery, Curl, Kroto and Smalley were awarded the 1996 Nobel Prize in Chemistry. Later fullerenes with larger number of carbon atoms (C76, C80, C240, etc.) were also synthesized. It has unique features that make it ideal for photoresists, organic photovoltaics, organic photo detectors etc. They can behave as a superconductors. They are exceptional radical scavengers.



**Fullerenes**

**Carbon nano tubes**

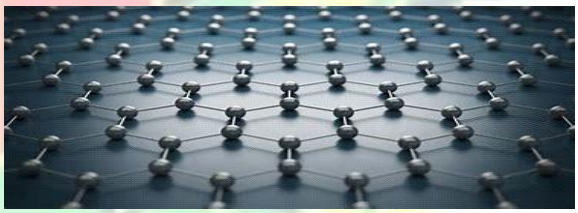
Carbon nanotubes are made of carbon with diameters typically measured in nanometers. They were discovered independently by lijima and Ichihashi and Bethune et al in carbon arc chambers similar to those used to produce fullerenes. Single wall nanotubes are one of the allotropes of carbon intermediate between fullerenes and flat graphene. Carbon nanotubes can exhibit electrical conductivity. They also have exceptional tensile strength and thermal conductivity. In addition they can be chemically modified. These properties are expected to be valuable in many areas of technology such as electronics, optics and composite materials. Individual carbon nanotubes naturally align themselves into ropes held together by relatively weak vanderwaals forces. Bulk carbon nanotubes have been used as composite fibres in polymers to improve the mechanical , thermal and electrical properties of the bulk product.



**Carbon nanotubes**

**Graphene**

Graphene is a single layer of carbon atoms, tightly bound in a hexagonal honey comb lattice. It is the thinnest compound known, the strongest compound discovered, the best conductor of heat at room temperature. Since the discovery of graphene, applications within different scientific disciplines have exploded, with huge gains being made particularly in high frequency electronics, bio, chemical and magnetic sensors, photodetectors and energy storage and energy generation. Graphene is also being used to boost not only the capacity and charge rate of batteries but also the longevity. With graphene tin oxide as an anode in lithium ion batteries for example, batteries lasts much longer and with almost no reduction in storage capacity between charges. This means that batteries can be developed to last much longer and at higher capacity. Also it means that electronic devices may be charged within seconds. Another use for graphene is that in paint. Graphene is highly inert and so can act as a corrosion barrier between oxygen and water diffusion. Thus future vehicles can be made corrosion resistant as graphene can be made to be grown onto metal surface.



**Graphene**

**Nonotechnology in medicine**

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials and biological devices to nanoelectronic biosensors and even possible future applications of molecular nano technology such as biological medicines. Some nanotechnology based drugs that are commercially available or in human clinical trial include:

Abraxane, approved by the US food and drug administration to treat breast cancer non small cell lung cancer and pancreatic cancer is the nanoparticle albumin bound paclitexal.

Doxil was originally approved by FDA for the use on HIV related Kaposi's sarcoma. It is now being used to also treat ovarian cancer and multiple myeloma. The drug is encased in liposomes which helps to extend the

life of the drug that is being distributed. Liposomes are self assembling, spherical, closed colloidal structure that are composed of lipid bilayers that surround an aqueous space. The liposomes also helps to increase the damage that the drug does to the heart muscle specifically.

Onivyde, used to treat pancreatic cancer, was approved by FDA in October 2015.

Rapamune is a nanocrystal-based drug that was approved by FDA in 2000 to prevent organ rejection after transplantation. The nanocrystal components allow for increased drug solubility and dissolution rate leading

**Imaging**

In vivo imaging is another area where tools ad devices are being developed. Using nanoparticle contrast agents, images such as ultrasound and MRI have a favourable distribution and improved contrast. In cardiovascular imaging, nanoparticles have potential to aid visualization of blood pooling, ischemia, angiogenesis, atherosclerosis, and focal areas where inflammation is present.

**Sensing:**

Nanotechnology on a chip is one more dimension of lab on a chip technology. Magnetic nanoparticles, bound to a suitable antibody are used to label specific molecules, structures or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample. Sensor test chips containing thousands of nanowires, able to detect proteins and other biomarkers left behind by cancer cells could enable the detection and diagnosis of cancer in the early stages from a few drops of patient's blood. Nanotechnology is helping to advance the use of arthroscopes, which are pencil sized devices that are used in surgeries with lights and cameras so surgeons can do the surgeries with small incisions. Smaller the incision faster is the healing time.

**Blood purification**

The blood purification process is based on functionalized iron oxide or carbon coated metal nanoparticles with ferromagnetic or supermagnetic properties. Binding agents such as proteins, antibodies , antibiotics or synthetic ligands are covalently linked to particle surface. Applying an external magnetic field gradient allows exerting a a force on nanoparticles. Hence the particles can be separated from the bulk fluid thereby cleaning it from the contaminants. This approach offers new therapeutic possibilities for the treatment of systematic infections such as sepsis by directly removing the pathogen. It can also be used to remove cytokins or endotoxins selectively or for the dialysis of compounds which are not accessible by traditional dialysis methods.

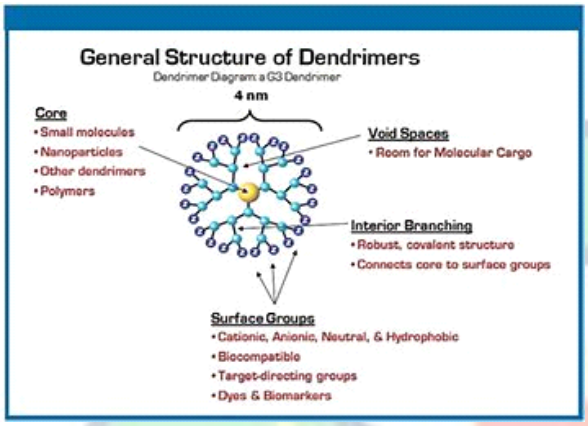
**Tissue engineering:**

Nanotechnology may be used as part of tissue engineering to help reproduce or repair or reshape damaged tissue using suitable nanomaterials-based scaffolds and growth factors. Tissue engineering if successful may replace conventional treatments like organ transplants or artificial implants.

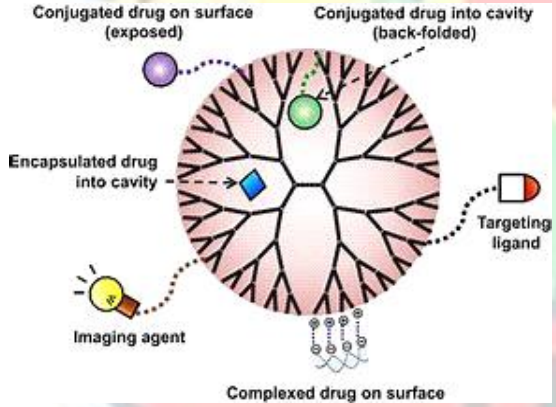
**Dendrimers**

Dendrimers represents a class of novel polymers having unique molecular architectures charactersized by their repetitively branched structure with a high degree of molecular uniformity, low polydispersity and properties that make them attractive materials for the development of nano medicines. The dendrimer drug delivery can be achieved by coupling a drug through one of the two approaches. Hydrophobic drugs can be complexed within hydrophobic dendrimer interior to make them water soluble or drugs can be covalently bonded onto the surface of dendrimer. These are prime candidates for the host guest chemistry. Dendrimers with hydrophobic core and hydrophilic periphery have shown to exhibit micelle like behaviour. This analogy highlighted the utility of dendrimers as solubilizing agents. The majority of drugs available in pharmaceutical industry are hydrophobic in nature and

this property in particular creates major formulation problems. This can be solved by dendrimetric scaffolding which can be used to encapsulate as well as to solubilize the drugs because of capability of such scaffolds to participate in extensive hydrogen bonding with water. These have also been explored for the delivery of anti cancer drugs.




**Structure of Dendrimers**




**Action of dendrimers**

**Summary and Conclusions**

Nano materials have increased surface area and nano scale effects. Nanomaterials have unique physicochemical and biological properties as compared to their larger counterparts. Results of research and developments in these fields are entering into all aspects of our lives including, but not limited to, aerospace, agriculture, defense, energy, environment, materials, manufacturing, medicine, etc. It is truly an atomic and molecular approach for building biologically, chemically and physically stable structures one atom or one molecule at a time. Presently some of the active nanoscience and nanotechnology research areas include nanolithography, nanodevices, nanocomputers, nanopowders, nanostructured catalysts and nanoporous materials, molecular manufacturing, nanolayers, molecular nanotechnology, medicine and cancer prediction, prevention and treatment through nanotechnology, nanobiology. The properties of nano materials can greatly influence their interactions with bio molecules and cells, due to their peculiar size, shape, chemical composition, surface structure, charge, solubility and agglomeration.

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