Journal of Advanced Research in Nanoscience and Nanotechnology
Volume 2, Issue 2 - 2020, Pg. No. 6-11
Peer Reviewed Journal

Article

Applications of Nanoscience and Nanotechnology with its Future Scope

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How to cite this article:
Soni RA, Rana RS. Applications of Nanoscience and Nanotechnology with its Future Scope. *J Adv Res Nanosci Nanotech* 2020; 2(2): 6-11.

Date of Submission: 2020-09-23
Date of Acceptance: 2020-10-19

ABSTRACT

Nanotechnology, which is approximately 1 to 100 nanometers, is science, engineering, and technology. The ability to see and control individual atoms and molecules is part of nanoscience and nanotechnology. The age of nanotechnology was born when scientists had the right tools such as the microscope scan tunnelling (STM) and Atomic Force (AFM). Modern nanoscience and nanotechnology, although quite new, have been used for centuries in nanoscale materials. Scientists and engineers today find a broadrange in deliberate nanoscale materials to use their improved properties, including greater strength, light weight, improved light spectrum control and increased chemical reactivity than their large counterparts. This paper gives a highlight of nanoscience and its applications.

Keywords: Nanotechnology, Nanoscience, Nanometer, Feynman, STM, AFM

Introduction

The study and application of very small items in nanoscience and nana-technology can be applied in all other science fields like chemistry, biology, physics. At an American Physical Society meeting at the California Institute of Technology (CalTech), on December 29, 1959, long before nanotechnology was used, the ideas and ideas behind nano-science and nanotechnology started with a talk "Long Away At The Bottom" by the physicist Richard. Feynman described in his talk a process through which scientists could manipulate and control individual atoms and molecules. More than a decade later, Professor Norio Taniguchi coined the term nanotechnology in his explorations of ultra-precision machining.[1] It was only in 1981 that modern nanotechnology began with the development of the tunnelling scan microscope capable of "seeing" individual atoms.

25,400,000 nanometersin an inch are available. A newsletter is around 100,000 nanometres.If a marble had a nanometer on a comparative scale, then one metre was the Earth's size. The atoms are the food, the clothes we wear, buildings and houses in which we live and our own bodies. Each thing in Earth consists of atoms.But it is impossible to see with the naked eye something as small as an atom. Indeed, the microscopes that usually occur in high school courses are impossible to see. Relatively recently, 30 years ago, microscopes were invented for nanoscale viewing. Around the stained-glass windows of the mediaeval Churches hundreds of years ago, alternative gold and silver particles created colour. At that time, the artists did not know that they actually modified the composition of the materials with which they collaborated by the process they used to produce these wonderful works of art.

Nanotechnology-Molecular Scale Engineering

Nanotechnological advances have been based on microscopic progress. The Scanning Tunneling Microscope (patented in 1982) also enabling molecules to be imaged allows researchers, through the seizure and movement of individual atoms, to manipulate them. This is the essence of 'bottom-up' or molecular nanotechnology-the concept of Atom-by-Atom molecular structures.

The vision of controlled molecular production through the self-replicating 'assembly' Some people are claiming that nanotechnical engineering can ultimately lead to a miniaturisation to the molecular level of controlled production as in human cells , for example by breaking up enzymes and rearranging links holding molecules together. The vision is to produce 'nanomaterials,' new products that will revolutionise building construction, medicines, space exploration and computing, with a potentially self replicating 'assemblers' - small devices operating together, like miniature version factory assembled lines.[2]

The nano-transport belt, 'DNA robots' and molecular structures spinning While some warn that self-replicating 'nanobots' represent a huge threat to humans, others reject that idea as impossible. Theory is well ahead of current truths. However, a recent production of a nano-flow belt which moves particle streams over a nanospace is a significant breakthrough, along with the development of a 'DNA robot,' which has 10 nanometers long to 'walk on' a pavement made of DNA too. The discovery of spinning molecular structures is further important, which indicates the potential of molecular power production and controllable movements.

Production Top-Down

In the 'top-down' approach that still dominates the field, material parts are machined to form nanoscale structures.

Knowledge of nanotechnology is growing quickly. Nevertheless, there are relatively few nanoparticles on the market today. The problems already on sale, health, food safety and environment, do not address the above-mentioned issues in general. Rather they focused on consumer applications, such as enhanced sunshades, crack-resistant paints and scratch-resistant spectacle lenses. Nanotechnology is an enabling technology, as is electricity and the internal combustion engine. Therefore, a range of innovations are expected to precipitate.[3]

Applications and Benefits

In numerous fields of technologies and industries, nanotechnology contributes significantly to improving, even revolutionising: information technology, home security, medical science, transport , energy, food security , environmental sciences, etc. The following is a sample of the fast-growing list of nanotechnology benefits and applications.

Materials and Processes every Day

Nanotechnology offers many advantages because the structures of materials on an exceedingly small scale can be tailored to achieve specific properties so the toolkit in the materials science can be expanded substantially. Materials can be made more powerful, lighter, durable, reactive, sieving or better electrician, among many other features, with the help of nanotechnology.[4] Many daily commercial products that rely on nanoscale materials and processes are currently on the market and in daily use:

Nanoscale additives or surface treatment materials can provide light ballistic energy deflection or resist skinny wrinkling, staidness and bacterial growth in personal body armour.

Clear nanoscale films can be water-repellent and reflecting, self-cleaning, ultraviolet or infrared-proof, anti-scratch, antimicrobial, scratch-resistant or electro-conductive, in the case of eyeglasses, computers and camera displaying, windows and other surfaces.

Nano-scale materials set up to assist "smart fabrics," that are washable, durable, outfitted with variable nanoscale sensors and electronics with health monitoring capability, solar energy collection and measure energy harvesting. Lighting of cars , trucks, aircraft, boats and space ships could save fuel.In baseball bats, rackets, bike bikes, motorcycle helmets, automotive parts, baggage as well as power tool housings, nanoscale additives in polymer composite materials are used to create them lightweight, strong and flexible.[5] Nanotube sheets for use in next-generation air vehicles are now being manufactured. The combination of light weight and conductivity, for example, produces them ideal for electromagnetic protections and thermal management applications.

Nanocomponents of Nasa's High-Resolution Micrograph

High resolution image of a nanocomposite polymer-silicate. It has improved thermal , mechanical and barrier properties and can be used on aircraft, automobile fuel storage tanks as well as aerospace components in food and beverage containers. (NASA 's image grace).

Cells of wood chips and maize stalks, unfertilized perennial grasses, etc., are transformed from the nanoscience of enzymes to fuel ethanol. Potential applications in a comprehensivevariety of industrial sectors have been exhibited by cellulosic nanomaterials, involving electronics, construction, packaging, food, energy, healthcare and defence.[6] The projections for cellulosic nanomaterials are lower than many other nanomaterials, with anremarkable strength-to-weight relationship, among moreattributes.

Nanomotive materials in car products include high power charging battery systems, heat control materials, low rolling resistance tyres, high efficiency/ low cost sensors and electronics, smart thin film solar panels and fuel additives for cleaner exhaust and expanded range of material.

Nanomotive products have a high-quality rechargeable battery control system.

There is a significantly greater strength of nanostructured ceramic coatings than traditional wear-resistant coatings for machine parts. The usage of moving parts from power tools to industrial machinery is also substantial for reduction in the wear and tear of nanotechnology-functioning grades and engine oils.

Catalysts are more often used to boost chemical reactions with nanoparticles. This reduces the amount of catalytic material needed to achieve the desired results, save money and reduce pollutants. The petroleum refinement and auto catalytic converters are two major applications.

Superior domestic materials are made of nano-engineered materials such as graders and stain removers, environmental sensors, air purifiers and philtres, anti-bacterial cleansing products and specialty paints and sealants, self-cleaning housing paints that resist to dirt and marking.

Nanoscale materials are also incorporated to enhance performance in a variety of personal care products. For years, titanium dioxide and zinc oxides in nanoscale sunscreen have been used to protect against the sun and appear invisible on the skin.

Electronics and IT Applications

Nanotechnology has made a major impact to computing and electronics advances, resulting in faster, smaller and more mobile systems that can operate and department storebigger and higher amounts of data. These applications are continuallydeveloping:Transistors have been reduced and reduced through nanotechnology, the basic switches that empower all contemporary computing. A typical transistor of 130 to 250 nanometers was built at the turn of the century. The Intel nanometer was developed by Intel in 2014, the first nanometer transistor was established by IBM in 2015 and a one nanoscale transistor was demonstrated by a Lawrence Berkeley National Lab in 2016.[7] Smaller, faster and better transistors might mean that the whole memory of your computer is stored on a single small chip soon. Computers can “boot” nearly instantly using a Magnetic Random Access Memory (MRAM). MRAM is enabled by magnetic tunnel nanometer-scale interfaces which can save data fast and efficiently during the system shut-down or allow the features of resume play.Ultra-high definition displays and TVs are now sold with quantum points for more energy-efficient and dynamic colours.

Flexible, foldable, rolling and stretchable electronics cover various sectors and are integrated into a wide range of products, including wearable equipment, medical applications, aerospace and the Internet of things. For example, semiconductor nanomembranes for use on smartphone and e-reader displays were developed for the use of flexible electronics. Different types of electronics are used with nanomaterials such as graphene and cellulosic nanomaterials, to enable wearable and tattoo sensing, clothing-sewn photovoltaics and roller-coated electronics. Making electronics flat, flexible, easy, unbreakable, highly efficient opens the door to numerous intelligent products.[8] Flash memory chips for smart phones and thumb drives are further computing products and electronic products; ultra-responsive hearing aids; antimicrobial or antibacterial coverage on keyboards and mobile phone boxes; conductive inks for RFID/ smart card/ smart packaging in printed electronics as well as flexible screens for eBook readers. Nanoparticle copper suspensions have been developed for safer, cheaper and more reliable use in the assembly process as an alternative to plumbed solder and other dangerous materials.

Applications for Medical and Care

The medical instruments, expertise and therapies accessible for clinicians are already being expanded by nanotechnology. The natural dimension of biological phenomena is used by nanomedicine, nanotechnology application in medicine, to develop precise solutions for preventing, diagnosing and treating disease. Some examples of recent progress in this field are provided below:

The gold nanoparticles are also clinically examined as potential therapies of cancer and other disease for commercial use as probes for targeted nucleic acid sequences.Better nanotechnology imaging and diagnostic tools are paving the way for earlier diagnosis, more personalised treatment options and improved success rates.The diagnosis and treatment of atherosclerosis or plaque build-up in the arteries have been studied for nanotechnology. The researchers have developed a nanoparticle that mimics “good” cholesterol, called HDL, which helps to reduce plaque levels.[9] The design and development of advanced solid state nanopore materials can enable the development of new gene sequencing technologies that allow for low cost and high velocity single molecule detection with minimal preparation of samples and instruments.

A variety of therapies have been developed by Nanotechnology researchers to encapsulate or otherwise help nanoparticles deliver medications directly to cancer cells and minimise the risk of tissue damage for the healthy. This can change the way doctors treat cancer and reduce the toxic effects of chemotherapy dramatically.

Nanotechnology research cover several areas of application, including the development of bone and neural tissue engineering for regenerative medicines. For example, the crystal mineral structure of human bones can be imitated with new materials or used as resin for dental use. Researchers seek ways to build complex tissue to one day cultivate human transplant organs. Further studies show that neurons grow well on the conducting graphic surface. Initial studies show that the graphic nanoribbons help to repair spinal cord injuries.

Researchers in nanomedicine are investigating ways to improve the vaccines of nanotechnology, including delivery of vaccines without needle use. Researchers are also working on creating an annual flu vaccine universal scaffold that would cover more strains and require fewer annual resources to be developed.

Nanotechnology is a research field that focuses on the building of 'things' on the scale of atoms and molecules, generally materials and devices. One-billionth of a metre is a nanometer, ten times its diameter. The human skin is 80,000 nanometers in diameter on average. The ordinary physics and chemistry rules no longer apply at these scales.[4] The characteristics of materials , for example their colour, strength, conductivity and reactivity, can vary significantly from nanoscale to macro. The 'nanotubes' of carbon are 100 fold stronger than steel and sixfold lighter.

The potential to increase energy efficiency, contribute to environmental cleaning and resolve serious health problems is acclaimed by nanotechnology. It is said that manufacturing production can be substantially increased at considerably lower cost. Nanotechnical products are smaller, cheaper, lighter and still more efficient. Nanotechnological advocates claim that they require less energy and less raw materials for the manufacture.

In June 1999, the US House Committee on Science on the benefits of nanotechnologies was addressed by Richard Smalley, Nobel Prize-winner in Chemistry. "It is, at least, equivalent to the combined influences of the microelectronics, health imaging, computer-aided engineering and manmade polyps developed in this century that Nanotechnology has an effect on human health, wealth and lives".[6]

Health and Sanitation Impacts of Nanotechnology

As a tool for health research, nanotechnology is already helpful. At the US Massachusetts Technology Institute researchers used 'optical pinions' to study the elasticity of red blood cells that are infected by the malaria parasite-pairs of minuscule glass beads have been combined or moved apart using laser beams. The technology helps scientists understand better how malaria spreads across the body.[11]

Nanotechnology for Improving the Supply of Drugs

However, nanotechnology could also lead one day to cheaper, more reliable drug delivery systems. The materials constructed on a nanoscale, for example, can provide encapsulation systems that slowly and controlled protect and secrete the included drugs. In countries with insufficient storage and distribution networks and in patients with complex medical regimes who cannot afford to visit long distances in medical care, this could be a valuable alternative. This could be a solution.

Enhanced Water Purification System Nanoscale Filters

Nano-scale structured philtres are the promise of more economical, durable and cleanable water purification systems. Other technology similar in many countries, including India and Bangladesh, might take in or neutralise toxic materials, for example arsenic, that poison water tables.

Safety of Food-Use of Nanosensors in Fertiliser Crops and Nanoparticles

The tiny sensors offer the possibility to monitor and measure the productivity of crops and livestock pathogens. Furthermore, nanoparticles may increase fertiliser efficiency. In the 2014 reports, however, the Swiss insurance company SwissRe warned that the ability to penetrate deep soil layers and travel larger distances could also be increased by potentially toxic substances such as fertilisers.[3]

Renewable and Sustainable Energy Nanotechnology Methods

Nano-technology applications could provide more clean and cheaper sources of electricity for renewable and sustainable energy sources , such as solar and fuel cells. This would improve the health of both people and the environment.

Applications for Energy

Nanotechnology is used in traditional energy sources and greatly improves alternative energy approaches to meet the growing worldwide demand for energy. Many researchers are exploring ways to develop clean , affordable and renewable energy sources, as well as ways to reduce energy consumption and environmental toxicity:[2] The efficiency of fuel production from raw oil materials is improved by nanotechnology by better catalytic methods. It also allows lower consumption of fuel by higher combustion and reduced friction in vehicles and power plants.The use of gas elevator valves for offshore operations , for example, nanotechnology or the use of nanoparticles to detect microscopic downwell pipeline fractures, has also been applied to extraction of petrol and gas.Researchers investigate the "scrubber" and membranes of carbon nanotubes to separate carbon dioxide from the exhaust system.

Nanosys Flexible Solar Cell

Nanoparticles are incorporated in new solar panel films to create light, flexible solar cells. Researchers are developing carbon nanoid-containing wires that have significantly lower resistance than those used today in the electricity grid, reducing the power loss of transmission.To make the sunshine to electricity efficient and future promising low-cost solar energy, nanotechnology can be incorporated into solar panels. Because they can use print-like fabrication processes, the nanostructured solar cells could be manufactured and installed more cheaply than discreet panels in flexible rolls. More recent research suggests that future solar transformers may even be "paintable."

Nanotechnology is already being used to develop many new batteries that can be charged faster, more efficient, lightweight, more powerful and have longer loads of electricity.An epoxy with carbon nanotubes is used to make windmill blades which are longer, firmer and lighter than other blades so that windmills can generate more electricity. For power harvesting, researchers are developing thin-film solar electric panels, which can be fitted on computer cases and piezoelectric flexible nanowire tissues to generate useful power on mobile devices from light, friction and/or body heat. Likewise, various nanoscience-based options for converting waste heat into electricity are being pursued, in computers, cars, homes, power plants etc. The number and types of use are growing in energy efficiency and energy saving products. Besides the above mentioned, nanotechnology enables more efficient lighting systems; lighter and strengthened transport chassis materials; less energy consumption in advanced electronics; and light-responsive smart glass coatings.[11]

Nanoparticles and Toxicity Concerns

Research has shown that nanomaterials, known as 'buckypballs' ('buckyballs') induce brain damage to fish, accumulate in the nasal cavities, the lungs and the brain of rats A toxicologist at Liverpool University in the UK, Vyvyan Howard has warned that the small size of nanoparticles can make them toxic and warns that complete hazard analyses are necessary prior to the approval of production.

Environmental Concerns Regarding Nanoparticles

Several stakeholders, including the Canadian ETC Group and SwissRe, have voiced concern about the release of small particles that can travelvery far into the environment due to their small size. You warn that we still don't know the environmental effects of these particles or the chemicals they will trigger when they meet other particles. However, the same groups agree with advocates of nanotechnology who feel that the field could provide "cleaner" and ultimately purer technology. However, mainly due to the lack of research on the potential threats to health, society and the environment posed by nanotechnology.

Ethics and Socio-economic Research

"While the science of nanotechnology is advancing, ethical issues lie behind. We believe that there are risks of deterioration in nanotechnology if a serious study of its ethical, environmental , economic, legal and social implications does not attain speed of advancement in the Science Science Service," said[12] Mnyusiwalla, Abdallah Daar and Peter Singer, from University of Toronto, Canada in 2003.

Risk Assessment and Nanotechnology Concerns

Several NGOs are requesting more risk assessments or a moratorium on nanotechnology in Canada's ETC Group. Submitting concerns about the following aspects of nanotechnology, including the Center for Responsible Nanotechnology, based in the United States:

- The toxicity of bulk materials, such as solid silver, does not prevent nanoparticles from toxicity.
- Nanoparticles may remain in the environment and accumulate.
- The food chain might accumulate.
- Unforeseen human health effects could occur.
- Public debate on application, use and regulation of nanotechnology has not been adequatelyengaged.
- 'Grey Goo': Minor nanotechnology generated robots may be able to replicate themselves.
- The applications benefiting developing countries are side-line if rich countries are the main drivers for the development of nanotechnology.
- Nanotechnology research can progress more quickly than systems can be implemented in order to regulate their applications and applications without rapid action.

Conclusion

The Debate on Nanotechnology is the Way Forward

To assess the role of nanotechnology and guide its progress, scientists, governments, civil society organisations and the broad public need to be involved across the sectors. Besides how nanotechnology can improve energy efficiency (see the previous section), it also offers many ways to detect and clean up pollutants:

The need for affordable, clean drinking water could be supported by nanotechnology through fast, low-cost detection and treatment of water impurities.The cleaning of industrial water contaminants in groundwater is being done using nanoparticles by chemical reactions that harms pollutants. This process cost less than processes requiring water to be pumped out of the floor for treatment. Researchers have creating a "paper towel," a nanofabric, which can be absorbed by 20 times its weight by small wires of potassium manganese oxide in the oil for use in clean-up. Furthermore, researchers have used magnets to remove the oil mechanically from the water to place magnetic water-repelled nanoparticles into oil spills.

Nanotechnology-capable sensors and solutions now have much higher sensitivity in air and ground than ever before for the detection and recognition of chemical and biological agents. Researchers are investigating particles such as self-assembled mesoporeal support monolayers (SAMMSTM), dendrimers and carbon nanotubes to find out how their unique chemical and physical properties can be applied in different forms of toxic site remediation. NASA has developed another sensor for the purpose of monitoring fire quality by smartphone extension firefighters.

Future Benefits

Nanotechnology offers the pledge to develop multifunctional materials to help build and keep vehicles, aircraft , spacecraft and ships lighter, safer, smarter and more efficient. Nanotechnology also offers several ways to improve infrastructure for transport:

As already discussed, nano-components in automotive products include structural components of polymer nano-composites, high-power battery systems, temperature control thermo-electric materials and pneus, high efficiency/ low-cost sensors and electronics, smart solar panels for thin-film and improved fuel additions and catalytic converter, for cleaner waste as well as for other products. Nano engineering and their recycled forms of aluminium, stainless steel, asphalted materials, concrete and other cemented materials promises to improve road and transport components performance, resilience and longevity whilst reducing their life cycle costs. Innovative capabilities may be incorporated into the materials of traditional infrastructure such as self-repairing or energy generation or transmission.[13]

The structural integrity and performance of bridges, guns, tracks, parking structures and pavements over time can be continuously monitored cost-effectively with nanoscale sensors and devices. Nanoelectronics' nanoscale sensors, communication devices, as well as other nanoelectronic innovations may provide an enhanced transport infrastructure that can communicate with vehicle based systems to help drivers keep lane position, prevent collisions, adjust travel routes to avoid congestion and improve onboard electronic driver interfaces.

The use of lightweight and high-strength materials enhanced by nanotechnology would benefit from "game changing" in almost all cars. For example, a 20% reduction in the weight of a commercial jet aircraft could result in a 15 % reduction in its fuel consumption. A preparatory NASA analysis indicates that developing and utilising state-of-the-art nanomaterial with twice the strength of conventional composites reduces a launch vehicle's gross weight by as much as 63%. In addition to saving considerable energy needed for launching spacecraft into orbit, the development of single stage orbital launch vehicles would also be enabled, further lowered launch costs , increased reliability of operations and opened up the door to alternative propulsion concepts.

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