Review Article

Nanotechnology: Needs and Applications

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ABSTRACT

Nanotechnology is currently one of the most important chapters of medical research. For many decades, nanotechnology has been developed with cooperation from researchers in several fields of studies including physics, chemistry, biology, material science, engineering, and computer science. It is predicted that nanotechnology (NT) will bring revolutionary changes in many areas, with the potential for both great benefits and great risks. The application of nanotechnology in construction presents a myriad of opportunities and challenges. Applications of nanotechnology in medicine and especially in cancer diagnosis and treatment will be discussed. Nanotechnology has potential applications in agricultural and food engineering such as exploring biological life processes, monitoring plant and animal health, analyzing and determining product qualities, developing novel materials from agricultural products, and reducing environmental pollutions. Nanotechnology provides the field of medicine with promising hopes for assistance in diagnostic and treatment technologies as well as improving quality of life.

Keywords: Nanotechnology, drug delivery, medical research.

INTRODUCTION

Nanotechnology (sometimes shortened to "nanotech") is the manipulation of matter on an atomic and molecular scale. Generally, nanotechnology works with materials, devices, and other structures with at least one dimension sized from 1 to 100 nanometers. Quantum mechanical effects are important at this quantum-realm scale. With a variety of potential applications, nanotechnology is a key technology for the future and governments have invested billions of dollars in its research. Through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars. The European Union has invested 1.2 billion and Japan 750 million dollars.[1] Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, 'nanotechnology' refers to the projected ability to construct items from the bottom up, using techniques and tools being developed today to make complete, high performance products.

When K. Eric Drexler (right) popularized the word 'nanotechnology' in the 1980's, he was talking about building machines on the scale of molecules, a few nanometers wide-motors, robot arms, and even whole computers, far smaller than a cell. Drexler spent the next ten years describing and analyzing these incredible devices, and responding to accusations of science fiction. Meanwhile, mundane technology was developing the ability to build simple structures on a molecular scale.

Nanotechnology is the science of developing very small materials, devices, structures, and Systems at the atomic, molecular, or macromolecular level. It is also called "molecular manufacturing". The size of nonmaterial's and devices are generally in the range of 1 to 100 nm (10-9 to 10-7 m) [2]

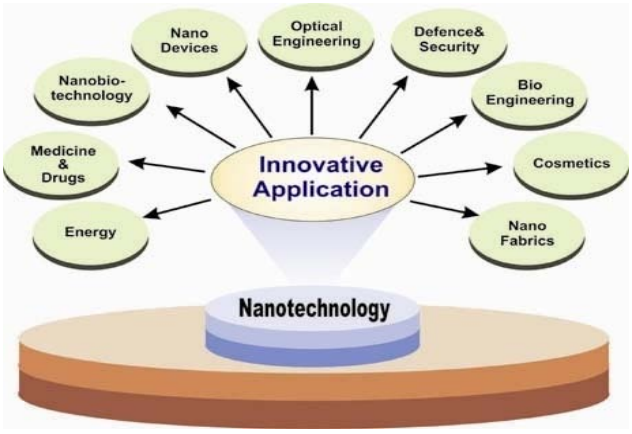

Figure 1: Various application of nanotechnology.

ASSEMBLY APPROACHES

There are two main approaches for the synthesis of nano-engineered materials. They can be classified on the basis of how molecules are assembled to achieve the desired product.

1. Top – down technique

The top – down technique begins with taking a macroscopic material (the finished product) and then incorporating smaller scale details into them. The molecules are rearranged to get the desired property. This approach is still not viable as many of the devices used to operate at nanolevel are still being developed.

2. Bottom – up approach

The bottom – up approach begins by designing and synthesizing custom made molecules that have the ability to self- replicate. These molecules are then organized into higher macro-scale structures. The molecules self replicate upon the change in specific physical or chemical property that triggers the self replication. This can be a change in temperature, pressure, application of electricity or a chemical. The self replication of molecule has to be carefully controlled so it does not go out of hand.

FOUR GENERATIONS

Mihail (Mike) Roco of the U.S. National Nanotechnology Initiative has described *four generations* of nanotechnology development (see chart below). The current era, as Roco depicts it, is that of passive nanostructures, materials designed to perform one task. The second phase, which we are just entering, introduces active nanostructures for multitasking; for example, actuators, drug delivery devices, and sensors. The third generation is expected to begin emerging around 2010 and will feature nanosystems with thousands of interacting components. A few years after that, the first integrated nanosystems, functioning (according to Roco) much like a mammalian cell with hierarchical systems within systems, are expected to be developed.

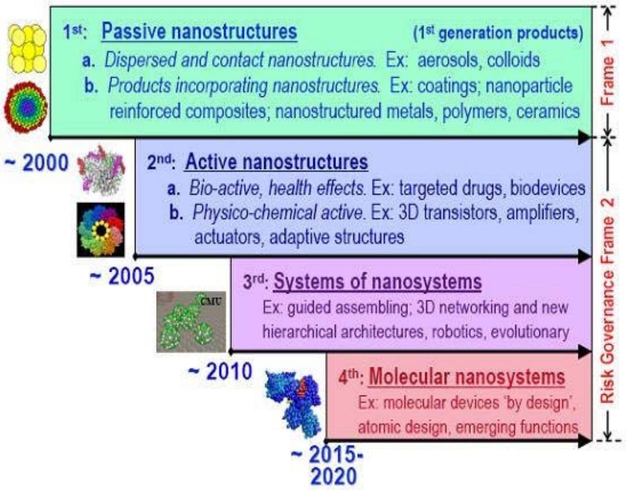

Figure 2: Four generations of Nanotechnology

NANOTECHNOLOGY IN AGRICULTURAL AND FOOD ENGINEERING

The potential applications of nanotechnology in agricultural and food engineering are envisioned in the following areas:

(a) Molecular and cellular biology

(b) Nanobiotechnology

(c) BioMEMS

(d) Nanobioprocessing.

(a) Molecular and cellular biology

Nanotechnology facilitates good understanding on the cellular level of biological mechanisms and thus helps to explore novel applications of biological systems. It helps to develop tools and devices to explore the cell biology. Developing tools and devices to understand the nature, behavior, and interactions of biological cells and molecules will open up new opportunities in animal and plant-reproductive science, disease diagnostics and prevention, and agricultural waste treatments and utilization.

(b) Nanobiotechnology

Nanobiomaterials are developed utilizing DNA molecules as the basic building units using nucleic acid engineering. The DNA molecules can be modified to develop novel biomaterials such as nanowires and nanomembranes that can be used for nanofiltration processes.[3]

(c) BioMEMS (micro-electro mechanical systems)

The use of MEMS can be extended for biological applications by combining the MEMS technology with biological sensors. The development of sensors at the nanoscale helps to detect traces of chemical and biological contaminants from samples utilizing biological processes. The sensors will have wide applications in drug delivery systems in plants and animals. The use of these sensors will enhance agricultural production and can be used for rapid detection of pathogens and contaminants during agricultural production and processing and from the environment. They can be used to monitor the shelf life of agricultural and food products. The biosensors at the nanoscale help to implant them in animals and plants. They can in turn help to detect diseases causing pathogens before the symptoms appear externally and affect the entire herds of animals or plants in a field. It has a potential application to determine environment air and water characteristics and to reduce pollution problems.

Smart Treatment systems- This method utilizes MEMS systems to carry the molecular coded drugs to deliver the drugs to the infection site. These systems are designed to be site specific based on chemical analysis. The smart treatment delivery systems have applications in plant and animal science to minimize the use of unwanted nutrient application, growth regulators, pesticides, and antibiotics. They in turn increase the efficiency of the systems as the delivery systems can be regulated to deliver nutrients and chemicals where and when they are needed.

(d) Nanobioprocessing

Bioprocessing is used in agricultural and food engineering to create desired materials utilizing the biological materials and processes. The nanotechnology offer devices and mechanism by which the bioprocessing can be monitored to increase the efficiency of bioprocessing and to enhance the quality of end products. The functional behaviour of microbial organisms under different conditions and their interactions with the environments can be determined using cellular and molecular studies. The results will help to enhance bioprocessing of agricultural and food materials and to effectively use microbes for removal of contaminants from soil, water, and air.[4]

MICRO AND NANOTECHNOLOGY IN TISSUE ENGINEERING

Tissue engineering (TE) is a rapidly growing scientific area that aims to create, repair, and/or replace tissues and organs by using combinations of cells, biomaterials, and/or biologically active molecules.[5,6] Most of the presently existing TE techniques rely on the use of macrostructured porous scaffolds, which act as supports for the initial cell attachment and subsequent tissue formation, both in vitro and *in vivo*[7-9]. This kind of approach has been successful to a certain extent in producing relatively simple constructs relying on the intrinsic natural capability of cells and tissues to self-regenerate, remodel, and adapt. For this reason, cells have been the most significant factor in the generation of the tissue itself[10]. However, this natural capability of cells for adapting to its surrounding environment has limitations and that is the main reason why TE has not been able to generate complex thick tissues so far[11]. In fact, one of the most important drawbacks of the currently available constructs in TE approaches is related to the lack of means to generate effective oxygen and nutrient dispersion pathways that can reach a whole construct homogenously and, therefore, enable the functionality/ viability of the construct upon implementation.

Micro and nanofabrication is the general term used for describing the processes of fabricating miniature micro or nanoscaled structures by using macro scale devices. The earliest microfabricated devices consisted of semiconductor integrated circuits and were fabricated by simple surface treatments or methods such as lithography or chemical vapor deposition[12,13]. Apart from integrated circuits, which are mainly two-dimensional, these technologies are commonly used in the production of devices such as microelectromechanical systems (MEMS)[14,15], laser diodes[16], flat panel displays[17], or fuel cells.

Micro and Nanotechnologies in the Development of Enhanced Constructs for Tissue Engineering

Several materials have been developed with osteoinductive and osteoconductive surface topographies intended to lead to the formation of new bone in the case of fracture or disease. Further investigations have shown increased osteoblast functions, such as cell proliferation and activity, when cultured onto nanofeatured surfaces[18]. Moreover, reports have shown that the osteoclasts (bone-resorbing cells) activity[19,20] was also influenced by the topographical micro- and nanosized cues. The advent of micro- and nanotechnologies associated with TE holds a great promise also for cartilage tissue regeneration. Currently, researchers suggest that TE strategies combined with nanopatterned materials can be useful for obtaining functional regeneration of cartilage tissue. The rationale is based on mimicking as closely as possible the natural composition and properties of cartilage. A study reports that micro patterned hyaluronic acid (HA) surfaces induced higher adhesion, migration and alignment of knee articular cartilage chondrocytes when compared to homogenous surfaces. Moreover, the patterned surfaces were shown to promote cell differentiation into chondrocytes.[21]

Similarly, Erik Petersen and his colleagues reported that cells cultured onto a microarray of micropatterned surfaces maintained their morphology and their ability to retain important phenotypic aspects of the chondrocytes[22].

The ability to direct cell attachment and orientation, with the possibility to create fluidically isolated compartments, points out to the distinctive advantage of micro- and nanotechnologies for neural tissue regeneration over the regular culture conditions. A very promising work that went deeper into the issue of synaptic signaling presented results that established that synapses forming on confining geometry of the micro pattern are physiologically normal and capable of performing plastic modulations, demonstrating their

Usefulness as a model for signal processing by neuronal networks[23]. Essential parameters within a neural TE strategy are being further exploited by means of micro- and nanotechnologies, such as the cell orientation, allowing for mimicking the microcircuitry that is encountered in the native tissue. A work of Christopher Bettinger and coworkers reports the use of a flexible and biodegradable substrate of poly (glycerol– sebacate) with rounded features that could further elucidate the mechanism of cell alignment and contact Guidance.[24]

DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF NANOTECHNOLOGY IN CANCER

Cancer (malignant neoplasm) is the kind of disease where abnormal cells are dividing in uncontrolled manner and eventually invade surrounding tissues, destroying them. In some cases cancer can spread in to distal location in the body forming metastases. Cancer cells can be carried within lymph or blood. [25]

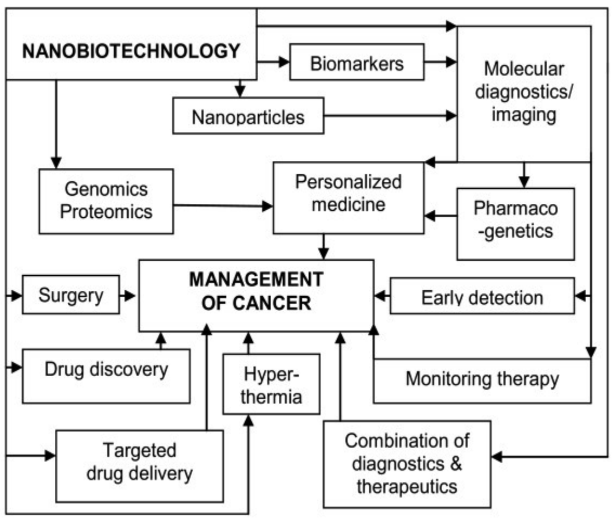

Figure 3: Role of nanotechnology in cancer diagnosis.

The use of nanotechnology in the management of cancer is currently the most important fragment of nanomedicine. It is complementary to already existing technologies, seems to be very useful in biomarkers research, brings better sensitivity to tests and can be used for tumour imaging. Nanoparticles of superparamagnetic iron oxide (SPIONs) – iron oxide core with a hydrophilic coat can be applied as a contrast agent for MRI; they can alter magnetic field gradients in target tissue.[26] They are lymphotropic and when administered intravenously.

Another strategy would be the use of Quantum Dots (QD) with appropriate ligand, administered systemically. Visible fluorescence should be assessed after stimulation with near-infrared light. Quantum Dots are however not in use in vivo because of toxicity (contain heavy metals). SPIONs can be applied for detection of sentinel lymph nodes (SLN) in breast cancer. Injected subcutaneously they alter node color to black and make them easily detectable using hand-held magnetometer or MRI.

APPLICATION IN MEDICAL SCIENCE

Drug Delivery System

Nanobots are robots that carry out a very specific function and are just several nanometers wide. They can be used very effectively for drug delivery. Normally, drugs work through the entire body before they reach the disease-affected area. Using nanotechnology, the drug can be targeted to a precise location which would make the drug much more effective and reduce the chances of possible side-effects.

Disease Diagnosis and Prevention

Nanobiotech scientists have successfully produced microchips that are coated with human molecules. The chip is designed to emit an electrical impulse signal when the molecules detect signs of a disease. Special sensor nanobots can be inserted into the blood under the skin where they check blood contents and warn of any possible diseases. They can also be used to monitor the sugar level in the blood.Quantum dots are nanomaterials that glow very brightly when illuminated by ultraviolet light. They can be coated with a material that makes the dots attach specifically to the molecule they want to track. Quantum dots bind themselves to proteins unique to cancer cells, literally bringing tumors to light.

Preventing diseases

a. Heart-attack prevention - Nanobots can also be used to prevent heart-attacks. Heart-attacks are caused by fat deposits blocking the blood vessels. Nanobots can be made for removing these fat deposits.

b. Frying tumors - Nanomaterials have also been investigated into treating cancer. The therapy is based on “cooking tumors” principle. Iron nanoparticles are taken as oral pills and they attach to the tumor. Then a magnetic field is applied and this causes the nanoparticles to heat up and literally cook the tumors from inside out.

APPLICATIONS OF NANOTECHNOLOGY IN ELECTRONICS

The collection of synthesis techniques collectively known as Nanotechnology presents many opportunities to reshape the electronics industry from top to bottom.

Nanotechnology can offer us:

- Uniform particles: metal, oxide, ceramics, composite.
- Reactive particles: as above.
- Unusual optical, thermal and electronic properties: phosphors, heat pipes, percolation based conductors.
- Self assembly: liquid-based, vapor based or even by diffusion in the solid state.
- Nano-structured materials: tubes, balls, hooks, surfaces.

Some of the most revolutionary applications in nanotechnology are in the semiconductor areas. As the semiconductor roadmaps look out towards 2015 and below 20 nm features, the need for different structures is becoming apparent. Imagine doping a Carbon or Silicon nanotube, coating it with differently doped materials, assembling it (preferably self-assembling it) in an array. Imagine creating quantum dots that can store a single electron charge.

APPLICATION OF NANOTECHNOLOGY IN BUILDING MATERIALS

Two nano-sized particles that stand out in their application to construction materials are titanium dioxide (TiO2) and carbon nanotubes (CNT’s). Knowledge at the nanoscale of the structure and characteristics of materials (otherwise known as characterization)[27] will promote the development of new applications and new products to repair or improve the properties of construction materials. For example, the structure of the fundamental calcium-silicate-hydrate (C-S-H) gel which is responsible for the mechanical and physical properties of cement pastes, including shrinkage, creep, porosity, permeability and elasticity, can be modified to obtain better durability. A further type of nanoparticle, which has remarkable properties, is the carbon nano tube (CNT) and current research is being carried out to investigate the benefits of adding CNT’s to concrete.[28] Nano-silica addition to cement based materials can also control the degradation of the fundamental C-S-H (calcium-silicate- hydrate) reaction of concrete caused by calcium leaching in water as well as block water penetration and therefore lead to improvements in durability[29]. Another type of nano particle added to concrete to improve its properties is titanium dioxide (TiO_2). TiO_2 is a white pigment and can be used as an excellent reflective coating. Two relatively new products that are available today are Sandvik Nanoflex and MMFX2 steel .Both are corrosion resistant, but have different mechanical properties and are the result of different applications of nano technology. Waterproofing of building materials has been a problem since last 1000 years. The problem has not been addressed completely due to lack of understanding at nano level of the building material. The new development in science & technology has allowed using the latest nano technology to produce eco-friendly.[30] Organo-Silicon products to waterproof practically all the different kinds of building materials. The nano technology has ensured that service life of this approach will lead to life cycles beyond 20 to 30 years of very economic cost[31].

APPLICATION OF NANOTECHNOLOGY IN FASHION DESIGNING

Cotton fibers are also chemically heterogeneous since different crops exhibit different properties depending on the conditions of the soil, weather, and processing. The availability of positively charged substrates allows the use of self-assembly techniques, driven by electrostatic interactions, to modify the surface of cotton. Metal nanoparticles can be produced using diverse routes such as reverse-micelle synthesis, colloidal assemblies, laser-beam processing, mechanical grinding, and many others methods.

COMPUTER SCIENCE FOR NANOTECHNOLOGY

Computer science offers more opportunities for nanotechnology. Soft computing techniques such asswarm intelligence, genetic algorithms and cellular automata can enable systems with desirable emergent properties, for example growth, self-repair, and complex networks[32]. Recently, M. C. Roco of the National Nanotechnology Initiative (NNI), an organisation officially founded in 2001 to initiate the coordination among agencies of nanometre-scale science and technology in the USA, gave a timeline for nanotechnology to reach commercialization.[33] Later, from the year 2010, nanotechnology should enter the third generation. It is estimated that system of nanosystems, for example: guided molecular assembling systems, 3D networking and new system architectures for nanosystems, robotics and supramolecular devices, would be developed. Finally, from the year 2020, the fourth generation of nanotechnology should be the generation of molecular nanosystems, which would integrate evolutionary systems to design molecules as devices or components at atomic levels. An exciting new development at the time of writing is a project called PACE (programmable artificial cell evolution). This large interdisciplinary project aims to create a "nano-scale artificial protocell able to selfreplicate and evolve under controlled conditions".[34]

NANOTECHNOLOGY IN WATER TREATMENT

A strong influence of photochemistry on waste-water treatment, air purification and energy storage devices is to be expected. Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane. Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm ("nanofiltration") and may be composed of nanotubes. Nanofiltration is mainly used for the removal of ions or the separation of different fluids. On a larger scale, the membrane filtration technique is named ultrafiltration, which works down to between 10 and 100 nm. sing nanoscale particles increases the efficiency to absorb the contaminants and is comparatively inexpensive compared to traditional precipitation and filtration methods. Some water-treatment devices incorporating nanotechnology are already on the market, with more in development. Low-cost nanostructured separation membranes methods have been shown to be effective in producing potable water in a recent study. [35]

NANOTECHNOLOGY FOR CATALYSIS

Chemical catalysis benefits especially from nanoparticles, due to the extremely large surface to volume ratio. The application potential of nanoparticles in catalysis ranges from fuel cell to catalytic converters and photocatalytic devices. Catalysis is also important for the production of chemicals.In a short-term perspective, chemistry will provide novel "nanomaterials" and in the long run, superior processes such as "self-assembly" will enable energy and time preserving strategies. In a sense, all chemical synthesis can be understood in terms of nanotechnology, because of its ability to manufacture certain molecules. Thus, chemistry forms a base for nanotechnology providing tailor-made molecules, polymers, etcetera, as well as clusters and nanoparticles. Platinum nanoparticle are now being considered in the next generation of automotive catalytic converters because the very high surface area of nanoparticles could reduce the amount of platinum required.[36]

NANOTECHNOLOGY AND CONSTRUCTIONS

Nanoparticles and steel

Steel has been widely available material and has a major role in the construction industry. The use of nanotechnology in steel helps to improve the properties of steel. The fatigue, which led to the structural failure of steel due to cyclic loading, such as in bridges or towers.The current steel designs are based on the reduction in the allowable stress, service life or regular inspection regime. This has a significant impact on the life-cycle costs of structures and limits the effective use of resources. The nano-size steel produce stronger steel cables which can be in bridge construction. Also this stronger cable material would reduce the costs and period of construction, especially in suspension bridges as the cables are run from end to end of the span. This would require high strength joints which lead to the need for high strength bolts.

Nanoparticles in glass

Glass is also an important material in construction. Research is being carried out on the application of nanotechnology to glass. Titanium dioxide (TiO_2) nanoparticles are used to coat glazing since it has sterilizing and anti-fouling properties. The particles catalyze powerful reactions which break down organic pollutants, volatile organic compounds and bacterial membranes. The TiO_2 is hydrophilic (attraction to water) which can attract rain drops which then wash off the dirt particles. Thus the introduction of nanotechnology in the Glass industry, incorporates the self cleaning property of glass.

Nanoparticles in coatings

A coating is an important area in construction coatings are extensively used to paint the walls, doors, and windows. Coatings should provide a protective layer which is bound to the base material to produce a surface of the desired protective or functional properties. Nanoparticle based systems can provide better adhesion and transparency. The TiO_2 coating captures and breaks down organic and inorganic air pollutants by a photocatalytic process, which leads to putting roads to good environmental use.

NANOTECHNOLOGY AND CONSUMER GOODS

Nanotechnology is already impacting the field of consumer goods, providing products with novel functions ranging from easy-to-clean to scratch-resistan New foods are among the nanotechnology-created consumer products coming onto the market at the rate of 3 to 4 per week, according to the Project on Emerging Nanotechnologies (PEN), based on an inventory it has drawn up of 609 known or claimed nano-products. On PEN's list are three foods—a brand of canola cooking oil called Canola Active Oil, a tea called Nanotea and a chocolate diet shake called Nanoceuticals Slim Shake Chocolate.

According to company information posted on PEN's Web site, the canola oil, by Shemen Industries of Israel, contains an additive called "nanodrops" designed to carry vitamins, minerals and phytochemical through the digestive system and urea.[37]

ENERGY APPLICATIONS OF NANOTECHNOLOGY

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources.

Reduction of energy consumption

A reduction of energy consumption can be reached by better insulation systems, by the use of more efficient lighting or combustion systems, and by use of lighter and stronger materials in the transportation sector. Currently used light bulbs only convert approximately 5% of the electrical energy into light. Nanotechnological approaches like light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination.

Increasing the efficiency of energy production

Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy. Commercially available solar cells have much lower efficiencies (15-20%). Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of bandgaps.

The degree of efficiency of the internal combustion engine is about 30-40% at present. Nanotechnology could improve combustion by designing specific catalysts with maximized surface area. In 2005, scientists at the University of Toronto developed a spray-on nanoparticle substance that, when applied to a surface, instantly transforms it into a solar collector.[38]

Nuclear Accident Cleanup and Waste Storage

Nanomaterials deployed by swarm robotics may be helpful for decontaminating a site of a nuclear accident which poses hazards to humans because of high levels of radiation and radioactive particles. Hot nuclear compounds such as Corium or melting fuel rods may be contained in "bubbles" made from nanomaterials that are designed to isolate the harmful effects of nuclear activity occurring inside of them from the outside environment that organisms inhabit.

ADVANTAGES AND DISADVANTAGES OF NANOTECHNOLOGY

While nanotechnology is seen as the way of the future and is a technology that a lot of people think will bring a lot of benefit for all who will be using it, nothing is ever perfect and there will always be pros and cons to everything. The advantages and disadvantages of nanotechnology can be easily enumerated, and here are some of them:

Advantages of Nanotechnology

To enumerate the advantages and disadvantages of nanotechnology, let us first run through the good things this technology brings:

Nanotechnology can actually revolutionize a lot of electronic products, procedures, and applications. The areas that benefit from the continued development of nanotechnology when it comes to electronic products include nano transistors, nano diodes, OLED, plasma displays, quantum computers, and many more.

Nanotechnology can also benefit the energy sector. The development of more effective energy-producing, energy-absorbing, and energy storage products in smaller and more efficient devices is possible with this technology. Such items like batteries, fuel cells, and solar cells can be built smaller but can be made to be more effective with this technology.

Another industry that can benefit from nanotechnology is the manufacturing sector that will need materials like nanotubes, aero gels, nano particles, and other similar items to produce their products with. These materials are often stronger, more durable, and lighter than those that are not produced with the help of nanotechnology.

In the medical world, nanotechnology is also seen as a boon since these can help with creating what is called smart drugs. These help cure people faster and without the side effects that other traditional drugs have. You will also find that the research of nanotechnology in medicine is now focusing on areas like tissue regeneration, bone repair, immunity and even cures for such ailments like cancer, diabetes, and other life threatening diseases.

Disadvantages of Nanotechnology

When tackling the advantages and disadvantages of nanotechnology, you will also need to point out what can be seen as the negative side of this technology:

Included in the list of disadvantages of this science and its development is the possible loss of jobs in the traditional farming and manufacturing industry.

You will also find that the development of nanotechnology can also bring about the crash of certain markets due to the lowering of the value of oil and diamonds due to the possibility of developing alternative sources of energy that are more efficient and won't require the use of fossil fuels. This can also mean that since people can now develop products at the molecular level, diamonds will also lose its value since it can now be mass produced.

Atomic weapons can now be more accessible and made to be more powerful and more destructive. These can also become more accessible with nanotechnology.

Since these particles are very small, problems can actually arise from the inhalation of these minute particles, much like the problems a person gets from inhaling minute asbestos particles.

Presently, nanotechnology is very expensive and developing it can cost you a lot of money. It is also pretty difficult to manufacture, which is probably why products made with nanotechnology are more expensive.

CONCLUSION

Nanotechnology is the science of developing novel materials and devices at the nanoscale. It has been widely used in various fields. It has potential for diverse applications in agricultural and food engineering that needs to be studied extensively through research. The current major challenge of micro- and nanotechnologies in TE is therefore the extension of the micro/nano architectures to macro scale devices which are large enough for substituting/regenerating tissues. To build those devices, the production technologies need to be improved in order to become faster and more effective and at the same time not compromising the level of detail of the structures produced. The application of nanotechnology in construction presents a myriad of opportunities and challenges. The use of micro nano materials (MNMs) in the construction industry should be considered not only for enhancing material properties and functions but also in the context of energy conservation. Nanotechnology in modern medicine and nanomedicine is in infancy, having the potential to change medical research dramatically in the 21st century. Nanomedical devices can be applied for analytical, imaging, detection, diagnostic and therapeutic purposes and procedures, such as targeting cancer, drug delivery, improving cell-material interactions, scaffolds for tissue engineering, and gene delivery systems, and provide innovative opportunities in the fight against incurable diseases.

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